BIOSECURITY NEW ZEALAND

Import Risk Analysis: Fresh stonefruit from Idaho, Oregon and Washington

DRAFT FOR PUBLIC CONSULTATION

26 January 2009

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Executive summary

The United States Department of Agriculture (USDA) and the Northwest Horticultural Council (NHC) have requested access to export fresh stonefruit – apricots, peaches, plums and nectarines – from the Pacific Northwest States of Idaho, Oregon and Washington to New Zealand. There are currently Import Health Standards (IHSs) issued for the import into New Zealand of cherries (*Prunus avium*) from the Pacific Northwest States of Idaho, Oregon and Washington (4 July 2005) and for the import of peaches/nectarines (*Prunus persica* and *P.p.* var. *nucipersica*) from California (9 June 2000). This import risk analysis examines the biosecurity risks associated with the importation of fresh stonefruit from the Pacific Northwest.

Three hundred and sixty organisms were identified as associated with fresh stonefruit from the Pacific Northwest. Of these, 45 species were considered to be potential hazards for which risk assessments were carried out. These species were assessed on the likelihood of entry, exposure and establishment within New Zealand and their potential impact on the economy, the environment and human health.

As a result of these assessments, 27 species were found to be hazards associated with fresh stonefruit from the Pacific Northwest for which risk management measures are justified. These pests include two spider mites, two beetles, two tephritid fruit flies, two predatory bugs, an armoured scale insect, three plant bugs, a mealybug, eight moths, a lacewing, two thrips, a fungus and two viral diseases (Table 1).

Table 1: Numbers of potential hazards and hazards associated with stonefruit from the Pacific Northwest.

Group	Associated organisms	Potential hazards	Hazards
Mites	18	4	2
Beetles (Coleoptera)	51	3	2
Flies (Diptera)	8	2	2
Hemiptera (aphids, bugs, mealybugs, scale, whiteflies)	81	10	7
Sawflies, ants, wasps (Hymenoptera)	3	0	0
Butterflies and moths (Lepidoptera)	61	15	8
Lacewings (Neuroptera)	1	1	1
Orthoptera	3	0	0
Thrips (Thysanoptera)	12	2	2
Bacteria	7	1	0
Fungi	94	4	1
Phytoplasmas	2	0	0
Viruses and viroids	19	3	2
Total	360	45	27

Within the risk assessment sections (Chapters 5-14), a number of measures have been considered. Table 2 summarises the options available for each hazard organism. For each pest a number of options have been given: in many cases a combination of these are likely to constitute a systems approach to reducing risk.

Table 2. Summary of management options

Hazard organism	Pest free areas	Orchard management, harvest and post-harvest processing	Removal of alternate hosts	Post harvest inspection	Cold treatment	Agreed treatment	Use of resistant cultivars
MITES							
Tetranychus mcdanieli	N	Y		Y	N		
Tetranychus pacificus	N	Y		Y	N		
INSECTS							
Coleoptera (beetles)							
Hippodamia convergens	N	Y		Y			
Anthonomus quadrigibbus	Y	Y		N (eggs) Y (damage)			
Diptera (flies)							
Rhagoletis completa	N	Y	Y	N		Y	
Rhagoletis pomonella	Y	Y		N		Y	
Hemiptera (predatory and plant bugs, scale insects, mealybugs)							
Orius insidiosus	N	Y		Y		Y	
Orius tristicolor	N	Y		Y		Y	
Pseudaulacaspis pentagona	Y	Y		Y		Y	
Lygus elisus	N	Y		N (eggs) Y (adults)		Y	
Lygus hesperus	N	Y		N (eggs) Y (adults)		Y	
Lygus lineolaris	N	Y		N (eggs) Y (adults)		Y	
Pseudococcus maritimus	Y	Y		N (crawlers) Y (eggs and adults)			
Lepidoptera (moths)							
Anarsia lineatella	N	Y		Y (damage)		Y	
Amyelois transitella	N	Y		Y	Y	Y	
Argyrotaenia citrana	Y	Y		Y	N		
Choristoneura rosaceana	Y	Y		Y	N		
Cydia latiferreana	N	Y		N	Y	Y	
Grapholita packardi	N	Y		N	Y	Y	
Grapholita prunivora	N	Y		N	Y	Y	
Pandemis pyrusana	Y	Y		Y	N		
Neuroptera (Lacewings)							
Chrysopa species	N	Y		Y			
Thysanoptera (thrips)							
Frankliniella tritici	N	Y		N		Y	

Taeniothrips inconsequens	N	Y		N	Y	
FUNGI						
Taphrina communis	Y	Y		Y		Y
VIRUSES						
Apricot ring pox	Y	Y	Y	Y		
Cherry rasp leaf nepovirus	Y	Y		Y		

Area freedom from plum pox virus (PPV) and a range of tephritid fruit flies has been recognised in this analysis. APHIS must inform MAF Biosecurity New Zealand immediately of any change in the status of these pests, so that measures can be taken against them, and also against vectors of PPV.

Possible risk management measures are discussed in Chapter 5 and a range of options for reducing the risk are presented for each hazard in the following chapters. There is uncertainty around the efficacy of some measures therefore it is likely this may result in residual unmanaged risk.

1. Background and risk analysis process

1.1. Background and scope

The United States Department of Agriculture (USDA) and the Northwest Horticultural Council (NHC) have requested access for USA Pacific Northwest stonefruit to New Zealand. There are currently IHSs issued for

- the import of peaches/nectarines (*Prunus persica* and *P.p.* var. *nucipersica*) from California (9 June 2000).
- the import into New Zealand of cherries (*Prunus avium*) from the Pacific Northwest States of Idaho, Oregon and Washington (4 July 2005).

The NHC requested an extension of the current Californian protocol for peach and nectarine exports. This protocol was developed prior to 2006 and MAF policy requires that new requests follow the Risk Analysis Procedures published in April 2006. This risk analysis was completed to support the development of a new IHS.

This Import Risk Analysis covers the importation of fresh stone fruit (plum, apricot, peach, nectarine) for consumption from the Pacific Northwest (PNW) into New Zealand. For the purposes of this analysis "fresh fruit" means the fruit complete with skin, flesh and stone, not including attached stems or leaves.

The scientific names of the commodities are:

- apricot (*Prunus armeniaca* L.)
- peach (*Prunus persica* (L.) Batsch)
- plum (*Prunus domestica* L.)
- nectarine (*Prunus persica* (L.) Batsch var. *nucipersica* (Suckow) C. K. Schneid.)

The geographical area (referred to henceforth as the Pacific Northwest) is defined as the Northwestern USA states of Washington, Oregon and Idaho.

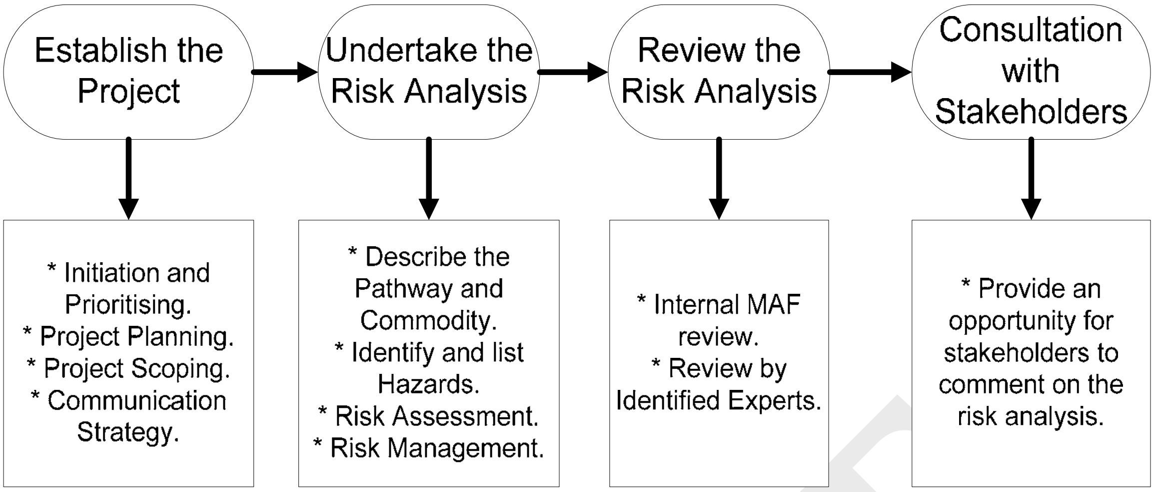
The scope of the risk analysis includes:

- identification of potential hazards associated with fresh stonefruit for consumption imported from the Pacific Northwest
- assessment of the risks of the identified potential hazards. This includes the likelihood of entry, exposure and establishment and likely consequences of each potential hazard
- analysis of the identified risks against possible mitigation options
- peer review of the draft risk analysis
- consultation on the completed risk analysis.

1.2. Risk analysis process

The risk analysis process leading to the final risk analysis document is summarised in Figure 1. For a more detailed description refer to the MAF Biosecurity New Zealand Risk Analysis Procedures available on the website (www.maf.govt.nz).

Figure 1: A summary of the Biosecurity New Zealand risk analysis development process



1.2.1. Commodity and pathway description

The first step in the risk analysis process is to describe the entry pathway of the commodity. This includes relevant information on:

- the country of origin, including characteristics such as climate, relevant agricultural practices, phytosanitary systems
- pre-export processing and transport systems
- export and transit conditions, including packaging, mode and method of shipping
- nature and method of transport and storage on arrival in New Zealand
- New Zealand's climate and relevant agricultural practices.

1.2.2. Hazard identification

To effectively manage the risks associated with imported risk goods, unwanted organisms or diseases which could be introduced by the risk goods into New Zealand and are capable of, or potentially capable of, causing harm, are identified. A list of organisms and diseases likely to be associated with the pathway (that is associated with the commodity) is assembled. Organisms that may be associated with material that is contaminating the risk good, if that contaminating material can not be easily separated from the goods on import, are also considered.

Each organism is dealt with separately with a reasoned, logical and referenced discussion of its relevant epidemiology including an assessment of its likely presence in the exporting country. A conclusion is then reached as to whether the commodity under consideration is a potential vehicle for introduction of the organism/disease into the importing country. If it is, the organism is classified as a potential hazard for further consideration in the risk analysis.

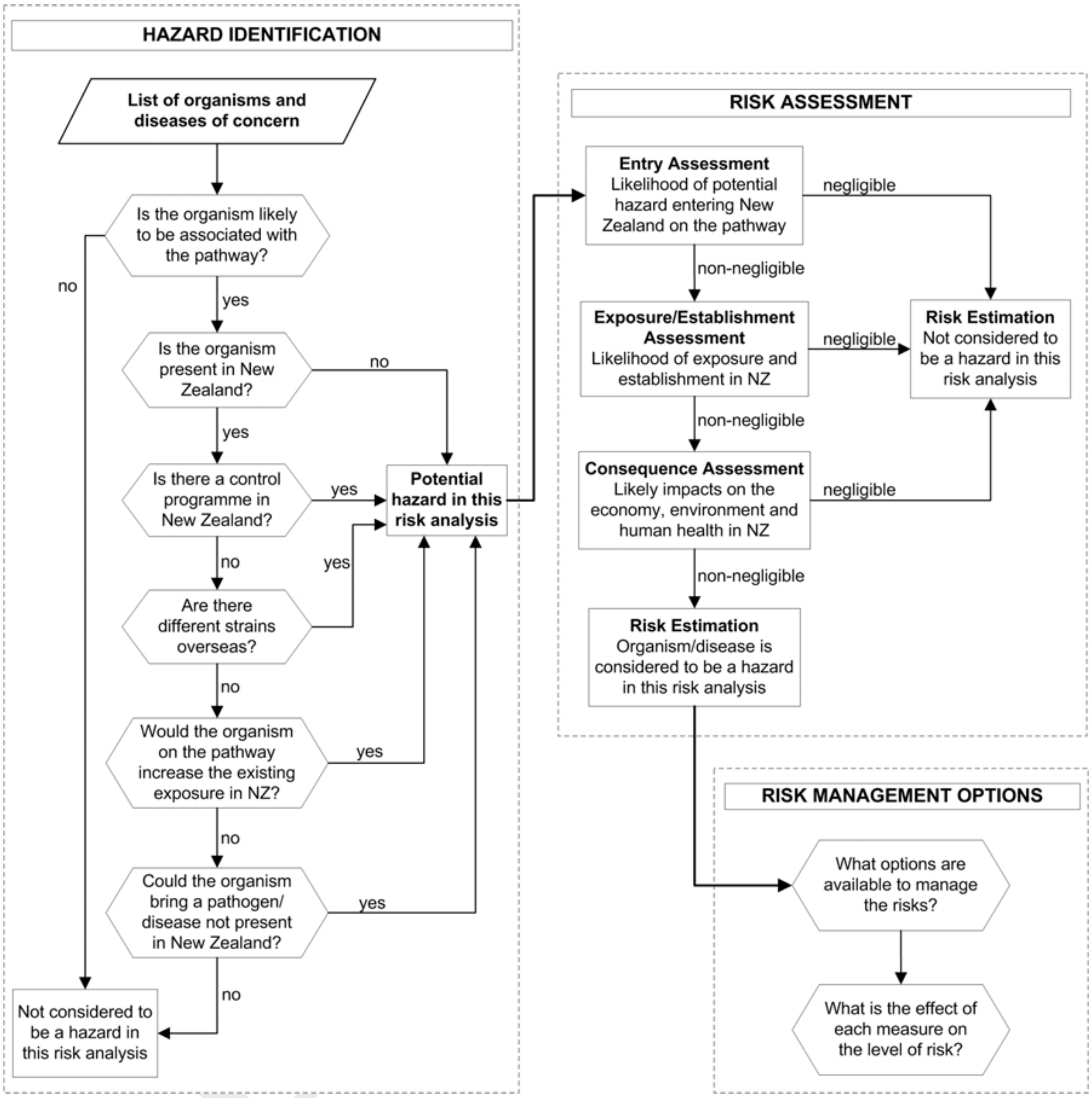
1.2.3. Risk assessment of potential hazards

A risk assessment evaluates the likelihood and the biological, environmental, human health, and economic consequences of the entry, establishment and exposure of a potential hazard to New Zealand. The aim is to identify hazards which present an unacceptable level of risk, for which risk management measures are required. A risk assessment consists of four steps:

- assessment of likelihood of entry
- assessment of likelihood of exposure and establishment
- assessment of consequences
- risk estimation.

The risk estimation is a summary of the conclusions arising from the entry, exposure and establishment, and consequence assessments, which estimates the likelihood of the potential hazard entering the risk analysis area and resulting in adverse consequences. If the estimated risk is not negligible, the potential hazard is classified as an actual hazard and risk management measures may be required. This process is illustrated in Figure 2.

Figure 2: Diagrammatic representation of the risk analysis process



1.2.4. Assessment of uncertainties

The uncertainties and assumptions identified during the preceding hazard identification and risk assessment stages are summarised. An analysis of these uncertainties and assumptions can then be completed to identify which are critical to the outcomes of the risk analysis. Critical uncertainties or assumptions can then be considered for further research with the aim of reducing the uncertainty or removing the assumption.

Where there is significant uncertainty in the estimated risk, a precautionary approach to managing risk may be adopted. In these circumstances, the measures should be reviewed as soon as additional information becomes available and be consistent with other measures where equivalent uncertainties exist.

1.2.5. Risk management

Risk management in the context of risk analysis is the process of deciding measures to effectively manage the risks posed by the hazard/s associated with the commodity or organisms under consideration.
Since zero-risk is not a reasonable option, the guiding principle for risk management should be to manage risk to achieve the required level of protection that can be justified and is feasible within the limits of available options and resources. Risk management (in the analytical sense) is the process of identifying ways to react to a risk, evaluating the efficacy of these actions, and identifying the most appropriate options.

The uncertainty noted in the assessments of economic consequences and probability of introduction should also be considered and included in the consideration of risk management options. Where there is significant uncertainty, a precautionary approach may be adopted. However, the measures selected must nevertheless be based on a risk assessment that takes account of the available scientific information. In these circumstances, the measures should be reviewed as soon as additional information becomes available. It is not acceptable to simply conclude that, because there is significant uncertainty, measures will be selected on the basis of a precautionary approach. The rationale for selecting measures must be made apparent.

Each hazard or group of hazards should be dealt with separately using the following framework:

Risk evaluation
If the risk estimate, determined in the risk assessment, is non-negligible, measures can be justified.

Option evaluation
Measures that are expected to be effective against the hazard species are considered. A package of risk management measures is likely to be required to address the risk from all identified hazards.

1.2.6. Conclusion of risk management

The result of the risk management procedure will be either that no measures are identified which are considered appropriate, or the selection of one or more management options that have been found to lower the risk associated with the hazard/s to an acceptable level. These management options form the basis of regulations or requirements specified with an import health standard.

1.2.7. Review and consultation

Peer review is a fundamental component of a risk analysis to ensure it is based on the most up-to-date and credible information available. Each analysis must be submitted to a peer review process involving appropriate staff within those government departments with applicable biosecurity responsibilities, plus recognised and relevant experts from New Zealand or overseas. The critique provided by the reviewers, where appropriate, is incorporated into the analysis. If suggestions arising from the critique are not adopted the rationale must be fully explained and documented.

Once a risk analysis has been peer reviewed and the critiques addressed, the risk analysis is then published and released for public consultation. The period for public consultation is usually six weeks from the date of publication.

All submissions received from stakeholders are analysed and compiled into a review. Either a document will be developed containing the results of the review or recommended modifications to the risk analysis itself will be edited to comply with the modifications.

2. Commodity and pathway description

2.1. Commodity description

Taxonomic treatment of *Prunus*

Prunus is an economically important genus of trees and shrubs, containing over 360 described species and subspecies spread throughout the northern temperate regions of the world (USDA, ARS 2008). Among the cultivated species are *Prunus armeniaca* L. (apricot), *P. avium* L. (sweet cherry), *P. domestica* L. (plum), *P. dulcis* (Mill.) D. A. Webb (almond), *P. persica* (L.) Batsch var. *persica* (peach) and *P. persica* (L.) Batsch var. *nucipersica* (Suckow) C. K. Schneid. (nectarine). Flowering cherries of section *Pseudocerasus* Koehne (subgenus *Cerasus* Pers.) are well-known ornamentals and a few species such as black cherry (*Prunus serotina* Ehrh.) are valued for timber (Elias 1980). The genus is traditionally placed within the rose family, Rosaceae, subfamily Amygdaloideae. Molecular phylogenies have confirmed the monophyly of the genus and indicated that is divided into two groups: 1) the subgenera *Padus* + *Laurocerasus* + *Cerasus* and 2) the subgenera *Amygdalus* + *Prunus*, and sections *Microcerasus* (subgenus *Cerasus*) and *Penarmeniaca* (Bortiri *et al.* 2001). The genera *Exochorda*, *Oemleria*, and *Prinsepia* are closely related to *Prunus* and a Eurasian origin of the genus is supported by molecular studies (Bortiri *et al*. 2001).

The flowers of *Prunus* species are usually white to pink, with five petals and five sepals. They are borne singly, or in umbels of two to six or more on racemes. The fruit is a "drupe" type with a relatively large stone (Bortiri *et al*. 2001). Leaves are simple and usually lanceolate, unlobed and toothed along the margin.

Table 2: Common and scientific names of commodities

Common name	Subgenus	Scientific name and authority
Apricot	*Prunus*	*Prunus armeniaca* L.
Plum	*Prunus*	*Prunus domestica* L.
Peach	*Amygdalus*	*Prunus persica* (L.) Batsch var. *persica*
Nectarine	*Amygdalus*	*Prunus persica* (L.) Batsch var. *nucipersica* (Suckow) C. K. Schneid.

Prunus armeniaca (apricot) is native to north-eastern China. The species has similar cold hardiness to peach, but requires more winter chilling and blooms very early. Commercial production is restricted to warm, dry regions of the Pacific Coast in the USA. The largest producers of apricots are Turkey and Iran**.**

Prunus domestica ("European" plum) is native to the Caucasus Mountains in Eurasia. This species is as cold hardy as pears, with chilling requirements similar to those of apples. Prunes are oval, blue-purple, freestone cultivars with high sugar content that dry without fermenting

Prunus persica (peach and nectarine) is native to warm regions of China. Except for apple, *P. persica* is the most widely planted temperate-zone fruit tree. The species prefers hot, dry summer climates and is the least cold hardy of temperate-zone fruit trees. It also requires the least winter chilling, so can be grown in lower latitudes. It is the most short lived temperate-zone fruit tree and is self-fertile. The largest producer of peaches and nectarines is China. Nectarines are fuzzless peaches due to single gene mutation (WSU 2004).

2.2. Pacific Northwest – climate and geography[1]

Pacific Northwest (general)

[1] All geographic information from Netstate.com http://www.netstate.com/states/geography/or_geography.htm), except average annual precipitation figures from The National Atlas of the United States of America (http://nationalatlas.gov/).

The Pacific Northwest is a diverse geographic region dominated by several mountain ranges including the Coast Mountains, the Cascade Range, the Olympic Mountains, the Columbia Mountains and the Rocky Mountains. The highest peak is Mt. Rainier, in the Washington Cascades (4390m). The Columbia Plateau, a broad plateau immediately inland of the Cascades, narrows and rises progressively northwards. The Columbia River cuts around the rim of the Columbia Plateau and through the Cascade Range out to the Pacific Ocean. Climatic conditions over the Pacific Northwest are widely variable. Oceanic climate or marine west coast climate predominates in many coastal areas, typically between the ocean and high mountain ranges. Alpine climate dominates in the high mountains; while east of the higher mountains the climate is semi-arid to arid, especially in rainshadow areas, for example the Harney Basin of Oregon.

The contiguous Pacific Northwest states of Idaho, Washington and Oregon make up an area of (very roughly) 770 km long and 900 km wide. This area is bordered to the north by Canada; to the west by the Pacific Ocean; to the south by the states of California, Nevada and Utah and to the east by Montana and Wyoming.

Washington is about 580 km long and 386 km wide. It is bordered by Canada in the north; Oregon in the south; Idaho on the east and by the Pacific Ocean on the west. The highest point in Washington is Mt. Rainier at 4392m above sea level (asl) and the mean elevation is 518m asl. Longitude ranges from 116° 57'W to 124° 48'W and latitude from 45° 32'N to 49°N. Temperatures range from 47.7° C (August 1961) to -44°C (December 1968). Average monthly temperatures range from a high of 28.8°C to a low of -6.6°C. Washington can be divided into six geographic land areas; the Olympic Mountains, the Coast Range, the Puget Sound Lowlands, the Cascade Mountains, the Columbia Plateau, and the Rocky Mountains. Annual precipitation ranges between 25 to 75cm (the Columbia Plateau and Rocky Mountains) and 250 to 450cm (Olympic Mountains and Coast Range and the Cascade Mountains), with a state average of 96 cm.
Climate Match: Washington Park Arboretum in Seattle, Washington has a climate match index (CMI) of 0.88 (Fagan *et al.* 2008), indicating a high climatic similarity to New Zealand growing conditions.

Oregon is about 580 km long and 420 km wide. It is bordered by Washington in the north; California and Nevada in the south; Idaho in the east and by the Pacific Ocean in the west. The highest point (Mount Hood) is 3425m asl, and the mean elevation is 1005m asl. Longitude ranges from 116° 45'W to 124° 30'W and latitude from 42°N to 46° 15'N . Temperatures range from 48.3° C (August 1938) to -47.7°C (February 1933). Average monthly temperatures range from a high of 28.1°C to a low of 0.4°C.
Oregon's geography can be divided into six areas; the Coast Range, the Willamette Lowland, the Cascade Mountains, the Klamath Mountains, the Columbia Plateau, and the Basin and Range Region
The average annual precipitation for Oregon is 69 cm.

Idaho is about 770 km long and 490 km wide. It is bordered by Canada in the north; Nevada and Utah in the south; Montana and Wyoming in the east and by Washington and Oregon on the west. The highest point (Borah Peak) is 3859m asl, the lowest point is 216m asl and the mean elevation is 1524m asl. Longitude ranges from 111° W to 117° W and latitude from 42° N to 49° N. Temperatures range from 47.7°C (July 1934) to -51°C (January 1943). Average monthly temperatures range from a high of 32.5°C to a low of -9.3°C. Idaho can be divided into three major land regions geographically; the Rocky Mountains, the Columbia Plateau and the Basin and Ridge Region.

Annual precipitation ranges between 25 to 75cm (the Columbia Plateau) and 250 to 450cm (Olympic Mountains and Coast Range and the Cascade Mountains) with a state average of 32 cm.

2.3. Pacific Northwest –stonefruit production statistics

Stonefruit production is an important industry in the US, with a total value of around US$1.011 billion in 2006 (Source: National Agriculture Statistics Service). California is the major producer.

Washington State is the main producer in the Pacific Northwest, producing 5,900 tons (utilised production, US tonnes) of apricots (utilised production is the amount sold plus the quantities used where grown and held in storage), 3,600 tons of prunes/plums, 20,900 tons of peaches and 11, 500 tons of nectarines in 2005. In 2006 Washington produced 5,200 tons of apricots, 5,400 tons of prunes/plums, 23,000 tons of peaches and 10, 300 tons of nectarines (Source: USDA/NASS, Washington Field Office). Oregon produced 1,500 tons of prunes/plums and 2,700 tons of peaches in 2005 and 7,500 tons of prunes/plums and 3,200 tons of peaches in 2004 (Source: Oregon Agricultural Statistics). Idaho produced 1, 950 tons of prunes/plums and 8,000 tons of peaches in 2005 and 3,920 tons of prunes/plums and 8,500 tons of peaches in 2004 (Source: Idaho Annual Crop Summary).

Total stonefruit production in the US was approximately 291 thousand acres in 2006, with a total yield of approximately 1.493 million metric tonnes. Of this production, 61 per cent of the yield was comprised of peaches, 14 per cent nectarines, 12 per cent prunes, 10 per cent plums and 3 per cent apricots (Source: National Agriculture Statistics Service).

The stonefruit harvest in the Pacific Northwest takes place from June to September, with approximately 70 per cent occurring in July and August.

2.4. Pacific Northwest – stonefruit production and post harvest practices

See Section 4.2.

2.5. International transportation of commodity

After packing, fruit is further chilled to around 1°C to stop the ripening process and is kept around this temperature during transport to maintain the cold chain (Curtis *et al.* 1992, California Tree Fruit Agreement 2007). Fruit will be transported to New Zealand by air or sea, which will take a few days to 3 weeks (Maersk Line 2008).

2.6. Distribution of the commodity within New Zealand

Stonefruit imported from the Pacific Northwest is likely to arrive in New Zealand from June until late October (midwinter to early spring). From the border, fruit would be transported to the main city centres in New Zealand, either to wholesalers or retailers, and from there to the food service industry or to individual consumers. Retailers are more likely to be located in urban areas than wholesalers. Waste is potentially generated at any of these points, with wholesalers and retailers potentially disposing of unmarketable fruit, and consumers disposing of waste or uneaten fruit. Because stone fruit skin is generally eaten, limited amounts of waste material would be generated from good quality consumed fruit, apart from the stone. Fruit that is culled or unsold by wholesalers and retailers is likely to be to be put into a rubbish bin or skip (closed or open) and be taken to landfill. Waste disposed of by consumers is likely to be discarded in domestic or public rubbish bins, compost, rubbish dumps or randomly onto the roadside or in reserves. Infested fruit/remains disposed of as bagged waste into landfill or into sewage via domestic waste disposal would have a negligible likelihood of exposure. Infested fruit/remains disposed of into domestic compost, or randomly by the roadside would have a higher likelihood of exposure to a suitable host.

There is very little information available regarding domestic and industry pathways and practices. A survey carried out in the United Kingdom showed that between 15 and 25% of households compost at home (Ventour 2008), but data for New Zealand does not appear to be available.

2.7. New Zealand – climate and geography

New Zealand is situated in the South Pacific and ranges from 34˚ 00’ S and 166˚ 00’ E to 48˚ 00’ S and 179˚ 00’E. It has a maritime climate which varies from warm subtropical in the far north to cool temperate in the far south, with severe alpine conditions in the mountainous areas. Mountain chains extending the length of New Zealand’s South Island provide a barrier for the prevailing westerly winds, dividing the country into two separate climatic regions. The West Coast of the South Island is the wettest and the area to the east of the mountains, just over 100 km away, is the driest (NIWA 2006).

Annual rainfall in most parts of the country is between 600 and 1600 mm, with a dry period during the summer. At four locations on the west coast of the South Island (Westport, Hokitika, Mt Cook and Milford Sound) mean annual rainfall was between 2200 mm and 6800 mm for the period 1971-2000 (NIWA 2006). Rainfall is higher in winter than summer in the northern and central areas of New Zealand, whereas for much of southern New Zealand rainfall is lowest in winter. Mean annual temperatures range from 10°C in the south to 16°C in the north. The coldest month is usually July, and the warmest month usually January or February. Inland and to the east of the ranges the variation between summer and winter temperatures is up to 14°C. Temperatures also drop about 0.7°C for every 100 m of altitude (NIWA 2006).

Sunshine hours are relatively high in places sheltered from the west and most of New Zealand would have at least 2000 hours annually. Most snow falls in the mountain areas. Snow rarely falls at the coast of the North Island and west of the South Island, although the east and south coasts of the South Island may experience some snow in winter. Frosts can occur anywhere, and usually form on cold nights with clear skies and little wind (NIWA 2006).

2.8. New Zealand – stonefruit production

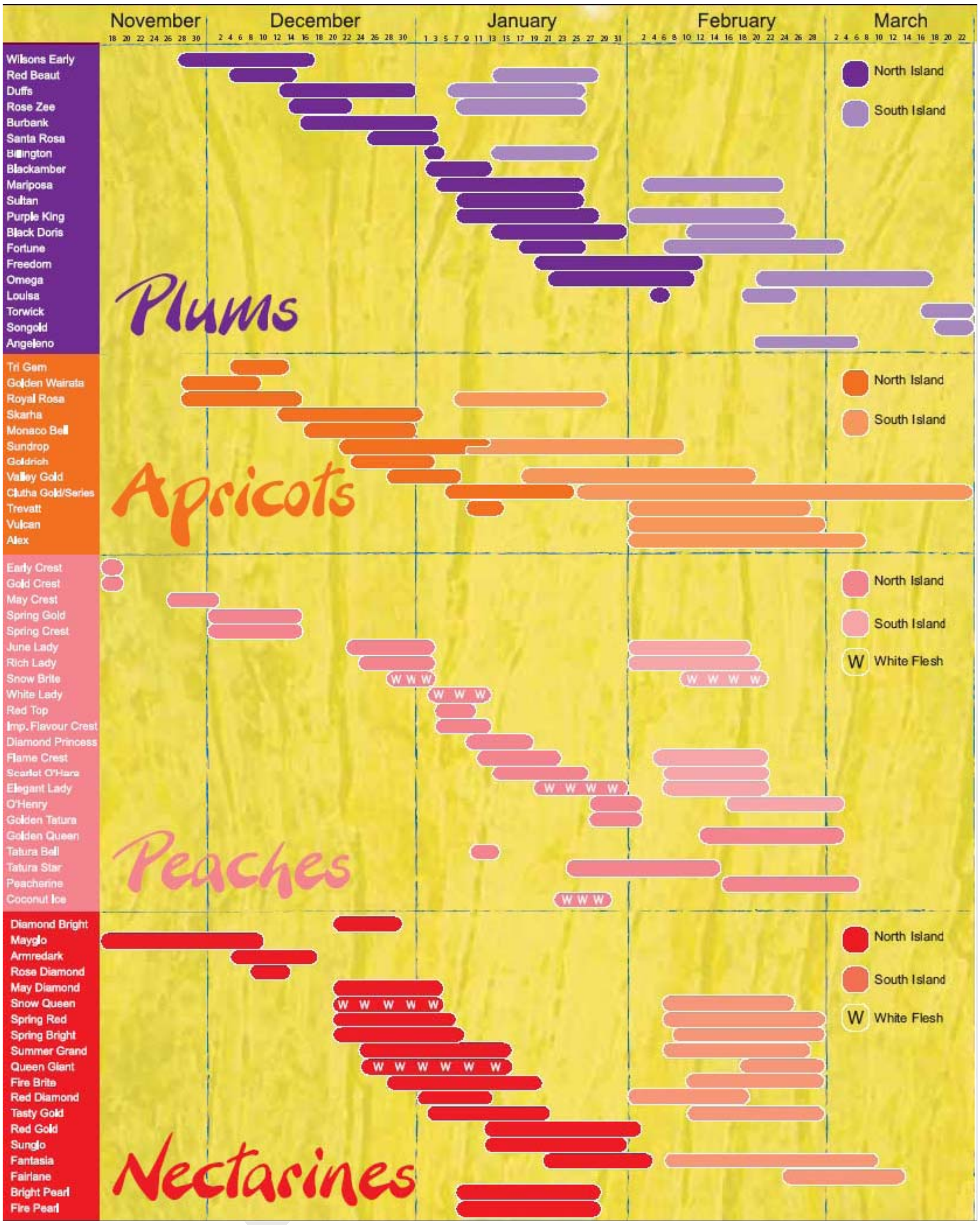
Stonefruit (apricots, cherries, peaches, plums and nectarines) is New Zealand’s fourth largest fruit crop, following kiwifruit, pipfruit and avocados. There are three main growing areas:

- Hawkes Bay. This region produces about 30% of the crop and is predominantly focused on the local market, with very little being exported. Due to the warmer winters, no cherries are produced in this area, but this may change as more low chill cherry varieties become available.
- Marlborough. This is the is the smallest region, producing about 10% of the crop, however its early start to the cherry season gives it a niche into the pre-Christmas market into Japan.
- Central Otago, the main growing region, which produces 80% of all cherries and 50% of all stonefruit exported.

Due to the climatic variation fruit can be provided from from late November (Hawkes Bay) through to late March (Central Otago). Figure 3 details the production periods for the listed varieties during the New Zealand stone fruit season.

Summerfruit New Zealand Inc (SNZ) is the national body representing the interests of all New Zealand growers, marketers and exporters of cherries, nectarines, peaches, plums and apricots. The industry has an established SummerGreen Integrated Fruit Production programme (Aitken *et al.* 2007).

Figure 3: Production periods for stonefruit in New Zealand (from Summerfruit New Zealand website at http://www.summerfruitnz.co.nz



Stonefruit production is expanding, with current production covering approximately 3000 hectares and 550 growers. Local markets take 60% of the product with Taiwan, Australia and the USA taking another 25% — over 2300 tonnes of fruit were exported in the 2003/04 season. Cherries account for 18% of exports, nectarines 41%, apricots 35% and peaches 6% (by volume). Processing (i.e non-fresh) accounts for 10 to 15% of production, mainly peaches with some apricots and nectarines but very few cherries or plums (Summerfruit New Zealand 2006).

Table 3: New Zealand Summerfruit export volume (2004/2005, 2005/2006, 2006/2007) (kg)

	2004/2005	2005/2006	2006/2007
Apricots	973 193	941 439	1 871 862
Cherries	831 244	780 068	656 327
Peaches	4 435	5 885	9 066
Plums	10 155	16 466	33 119
Nectarines	65 664	40 749	11 507

Table 4: New Zealand Summerfruit sales by destination (2006/2007) (kg)

	Cherries	Apricots	Peaches	Nectarines	Plums
Domestic	684 887	2 901 630	3 196 286	3 925 248	2 400 997
Taiwan	319 770	901	2 528	0	0
Australia	21 066	1 171 151	2 112	7 800	0
Japan	22 813	0	0	0	0
USA	21 387	298 862	0	0	26 109
Hong Kong	5 059	4 981	822	0	0
Singapore	20 483	2 702	0	0	0
Korea	146 207	0	0	0	0
Thailand	72 992	1 602	0	0	0
Pacific	1 175	2 064	3 404	3 707	7 010
Europe	3 468	41 673	200	0	0
UK	10 740	322 006	0	0	0
Export Total	656 327	1 871 862	9 066	11 507	33 119

Table 5: New Zealand Summerfruit sales by destination (2004/2005) (kg)

	Cherries	Apricots	Peaches	Nectarines	Plums
Domestic	766 275	2 704 488	3 531 038	5 001 347	1 820 046
Taiwan	477 621	160	0	54 160	0
Australia	31 790	451 284	0	0	0
USA	142 315	270 438	0	0	6 625
Hong Kong	600	60	0	0	100
Singapore	11 911	251	0	0	0
Korea	83 652	0	0	0	0
Thailand	22 451	0	0	0	0
Pacific	1 801	2 080	3 711	11 504	3 430
Europe	15 071	45 251	724	0	0
UK	27 277	201 059			
Export Total	831 244	973 193	4 435	65 664	10 155

In 2006/2007, export sales were estimated to account for 18 % of total summerfruit production by volume (including cherries), up from 12% in 2005/2006. Apricots accounted for the bulk of this increase. The total export value was NZ $17.5 million FOB (free on board) in 2005/2006, up from $15 million FOB in 2005/2006 (nearly 20% of value) (Source: Summerfruit New Zealand 2006).

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3. Hazard identification

3.1. Identification of hazards

A list of organisms and diseases likely to be associated with stone fruit from the Pacific Northwest (that is the biosecurity risk pathway) was compiled by using

- pest lists supplied by the WSDA and USDA
- information derived from literature searches, including but not limited to: CAB abstracts, Farr *et al.* (1989), Pennycook (1989), Ogawa *et al.* (1995)
- database searches, including but not limited to: CPCI 2008, Farr *et al.* (2008), Brunt *et al.* (1996), ScaleNet 2008, Robinson *et al*. (2008), Migeon and Dorkeld (2006)
- internet searches
- a review of organism interception records on previously imported stonefruit (Quancargo database, laboratory databases).

This list included organisms or diseases for which, for various reasons, the biosecurity risk was not clear. Organisms on the list were screened and were classed as potential hazards if they were likely to be present on the importation pathway (fresh stonefruit from the PNW for consumption) and were either not known to be present in New Zealand, or if they met any of the following criteria:

- present in New Zealand but vectors of pathogens or parasites that are not present in New Zealand
- known to have strains that do not occur in New Zealand
- of restricted distribution in New Zealand
- under official control in New Zealand.

The list, although probably not exhaustive, is certainly extensive, and covers most organisms likely to be carried by fresh stonefruit for consumption from the Pacific Northwest.

In the process of identification of hazards associated with fresh stonefruit for consumption:

- 360 organisms were associated with the stonefruit hosts and potentially present in the Pacific Northwest (for example, stated distributions such as “northwestern USA”)
- 140 were excluded because no evidence of their presence in the Pacific Northwest states could be found and/or they were recorded as present in New Zealand
- of those present in New Zealand, 10 were known pathogen vectors, so were given further consideration (see Appendix 4, Vector Analysis)
- all those organisms for which no host association or no association with mature fruit could be demonstrated were excluded[2]
- 45 remaining organisms were considered potential hazards, that is present in the Pacific Northwest, absent from New Zealand and likely to be on the commodity (fresh stonefruit). The risks involved in importing these organisms were assessed.

Nematodes

A number of nematodes known to be associated with *Prunus* species were found during the hazard identification process. Nematodes are most often associated with plant roots, or plant parts other than fruit. A few (*e.g. Schistonchus*, various diplogasterids) are found in figs, but it is assumed that these nematodes require an insect vector to get into the fruit. A number of nematodes are seed-borne (e.g. *Anguina*, *Ditylenchus*), but these are not known from fruit seeds (Zeng Zhao and Kerrie Davies, personal communication, July 2007).

[2] Excluding three groups of predatory insects, which were included because of consistent interceptions at the border.

Therefore, no nematodes were given further consideration in the analysis.

3.2. Review of organism interception records

Table 6 shows the volume of stonefruit fresh produce (by species) exported from the USA to New Zealand for the years 2003 to 2006. Plums, nectarines and peaches and apricots originate from California and cherries from the Pacific Northwest (mainly Washington), and from California from 2005.

Table 6: Volume of stonefruit fresh produce (by species) exported from the USA to New Zealand for the years 2003 to 2006

USA [to New Zealand] Fresh produce imports by quantity (kg)					
Botanical name	Commodity name	2003	2004	2005	2006
Prunus armeniaca	Apricot	57,229	14,288	6,993	6,899
Prunus avium	Cherry	76,884	25,743	33,478	59,483
Prunus domestica	Plum, European	514,110	414,885	513,861	463,914
Prunus persica	Nectarine	1,159,425	618,056	719,530	885,079
	Peach	257,514	262,001	123,548	88,450
	Peach/Nectarine	747,397	876,135	545,035	265,729
Prunus salicina	Plum	468,629	131,365	103,720	97,094
TOTAL		3,281,189	2,342,474	2,046,165	1,866,648

Organisms associated with importations of stonefruit from the USA by sea and air from 1/02/2003 to 1/10/2006, recorded as interceptions at the New Zealand border from the MAF Quancargo database are summarised in Table 7. The percentage of these importations infested with regulated pests ranged from zero to 69%.
Additional information on interceptions provided by a three month Standing Order by the Analysis and Profiling Group (MAF Biosecurity New Zealand) is given in Table 8. MAF Biosecurity New Zealand laboratory records also provided data. During this three month period all interceptions were identified, instead of the normal operational procedure by which only identifications required for biosecurity clearance are made.

Due to limitations involved in their collection, this data cannot be extrapolated to predict likely pest interception numbers for stonefruit from the Pacific Northwest, and have only been used in this analysis for hazard identification and analysis of likelihood of entry. Viability data, where available, was used in assessing the efficacy of treatments.

Table 7: Quancargo interceptions from imports of stonefruit from the USA by sea and air (1/02/2003 to 1/10/2006)

Organism name	Host	Number of interceptions*	Recorded as Viable?
Fungi and bacteria			
Alternaria sp. [1g]	Peach	1	Y[2]
Aureobasidium pullulans[1]	Nectarine	1	Y
Botryotinia fuckeliana[1]	peach	2	Y
Mucor sp. [1g]	apricot, peach	3	Y
Cladosporium cladosporioides[1]	peach/nectarine	4	Y
Peniciilium sp. [1g]	Peach	1	Y
Phoma sp. [1g]	Apricot	1	Y
Pseudomonas syringae pv syringae[1]	Apricot	1	Y
Invertebrates			
Anarsia lineatella	apricot, peach/nectarine, plum	5	
Anthicus sp. [1g]	Apricot	1	
Aphis gossypii[1v]	Plum	1	
Bondia comonana	Peach	1	
Brachycaudus schwartzi	Nectarine	1	
Bradysia sp. [1g]	apricot, peach/nectarine	3	

Organism name	Host	Number of interceptions*	Recorded as Viable?
Fungi and bacteria			
Carpophilus sp. [1g]	Nectarine	1	
Chrysopa sp.	apricot, peach/nectarine, plum	155	Y
Coccus longulus [1] (as *largulus*)	Plum	1	
Conotelus mexicanus	Apricot	1	
Corticaria sp [1g]	apricot, peach/nectarine	4	
Cydia sp. [1g]	Plum	1	
Diaspidiotus perniciosus[1]	peach/nectarine, plum	18	Y
Drosophila sp. [1g]	peach/nectarine	4	
Encarsia sp. [1g]	Plum	1	
Entomobrya sp. [1g]	peach/nectarine	3	
Entomobrya multifasciata[1]	peach/nectarine	1	
Cadra (*Ephestia*) *figulilella*	peach/nectarine	1	
Forficula auricularia[1]	peach/nectarine, plum	4	
Frankliniella sp. [1g]	peach/nectarine, apricot	3	
Frankliniella occidentalis [1v]	apricot, peach/nectarine, apricot	21	
Grapholita sp. [1g]	peach/nectarine, plum	3	
Grapholita molesta [1]	peach/nectarine	5	
Hippodamia convergens	Nectarine	1	
Liposcelis sp. [1g]	Nectarine	1	
Orius sp.	peach/nectarine	2	
Orius insidiosus	apricot, peach/nectarine	2	
Platynota stultana	peach/nectarine	2	
Quadraspidiotus juglans	peach/nectarine	3	Y
Seira sp. [1g]	Apricot	1	
Smittia verna[1]	Apricot	1	
Solenopsis invicta	Peach	1	
Thrips tabaci[1]	peach/nectarine	3	
Tribolium castaneum[1]	Apricot	1	
Mites and spiders			
Aculus cornutus[1]	Nectarine	1	
Amblyseius sp. [1g]	Nectarine		Y
Amblyseius sp. (?*fijiensis*)	peach/nectarine	3	Y
Euseius sp. [1g]	Nectarine	1	
Galendromus occidentalis [1]	Nectarine	1	
Neoseiulus sp. [1g]	peach/nectarine	4	
Phytoseius perseglovei group	Nectarine	1	
Tarsonemus sp. [1g]	peach/nectarine, plum	3	
Tarsonemus bakeri	peach/nectarine, plum	10	
Tarsonemus waitei[1]	Nectarine	3	
Tetranychus sp. [1g]	peach/nectarine, plum	15	Y
Tetranychus homorus	peach/nectarine	1	
Tetranychus mcdanieli	Nectarine	1	
Tetranychus urticae[1]	Plum	15	
Tetranychus pacificus	peach/nectarine, plum	6	
Typhlodromus sp. [1g]	peach/nectarine	12	
Typhlodromus pyri [1]	peach/nectarine	2	

*this is a minimum number
[1]species present in New Zealand; [1g] genus present in New Zealand; [1v] species present in New Zealand, vector
[2] diagnostics on live cultures

Table 8: Border interceptions of stonefruit from the USA identified by IDC according to a standing order during July, August, and September 2007

Organism	Taxonomy	Number of interceptions*
Fungi		
Alternaria alternata [1]	Ascomycetes: Pleosporaceae	1 live
Alternaria sp.[1g]	Ascomycetes: Pleosporaceae	3 live
Cladosporium cladosporioides [1]	Ascomycetes: Mycosphaerellaceae	3 live
Galactomyces geotrichum [1]	Saccharomycetes: Dipodascaceae	1 live
Phoma glomerata[1]	Ascomycetes: Pleosporales	2 alive

Insects		
Amyelois transitella	Lepidoptera: Pyralidae	1 dead
Carpophilus hemipterus	Coleoptera: Nitidulidae	1 dead
Cadra cautella [1]	Lepidoptera: Pyralidae	1 dead
Chrysopa sp.	Neuroptera: Chrysopidae	45 dead 4 alive
Cydia molesta[1]	Lepidoptera: Tortricidae	1 live
Diaspidiotus perniciosus [1]	Hemiptera: Diaspididae	>200, all states
Frankliniella occidentalis [1v]	Thysanoptera: Thripidae	1 dead
Liposcelis decolour	Psocoptera: Liposcelididae	unknown, dead
Psylla sp. [1g]	Hemiptera: Psyllidae	1 dead
Thrips tabaci [1v]	Thysanoptera: Thripidae	1 dead
Mites and spiders		
Marpissa sp. [1g]	Araneae: Salticidae	1 dead
Neoseiulus californicus	Acarina: Phytoseiidae	1 dead
Tetranychus sp. [1g]	Acarina: Tetranychidae	1 unknown
Typhlodromus sp. [1g]	Acarina: Phytoseiidae	1 live

*this is a minimum number

[1]species present in New Zealand; [1g] genus present in New Zealand; [1v] species present in New Zealand, vector

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4. Review of management options

4.1. Introduction

This chapter evaluates management options for organisms that may be considered an unacceptable biosecurity risk when associated with stonefruit imported from the Pacific Northwest of the USA. These management options can be either generic measures for a broad range of hazard organisms or specific measures that are targeted towards a few key hazard species.

The intention of the measures is that they will constitute elements of a systems approach, where the implementation of multiple safeguard actions in the exporting country result in the commodity meeting the phytosanitary standards of the importing country (Shannon 1994).

The following steps are included:

- consistent and effective management for reducing pest populations in the field and monitoring this management
- preventation of contamination after harvest
- culling in the packhouse of damaged and diseased fruit
- inspection and certification of the critical parts of the system based on effective traceback procedures
- shipping using methods that prevent reinfestation.

Approved treatments can be considered as a 'stand-alone' measure or can be combined with other measures as part of a systems approach to mitigate risk.

4.2. Production and post harvest measures

Stonefruit is produced in the Pacific Northwest using pest management systems designed to reduce the likelihood of fruit being infested with pests and pathogens before export. Existing commercial production, harvest and post harvest practices are outlined below and Appendix 5 outlines a typical schedule. Compliance to such a schedule may be ensured by a registration scheme, with all stonefruit for export sourced from commercial orchards registered with APHIS at the start of each season. Export orchards would maintain appropriate pest management programmes approved by APHIS to manage pests and diseases of quarantine concern to New Zealand. Registered growers would implement an orchard control programme involving in-field sanitation and appropriate pesticide applications, and keep records of control measures, such as systems for monitoring specific pests. Before harvesting, inspection and quarantine authorities would carry out an assessment over the operation of the quality management system of the orchard. APHIS should inform MAF Biosecurity New Zealand immediately on detection of any new pests of stonefruit that are of potential quarantine concern to New Zealand. It is assumed that all stonefruit exported from the Pacific Northwest into New Zealand will follow the industry quality standards for production, screening measures and pre-export inspection

4.2.1. Orchard management

Pest management systems include the implementation of cultural and chemical control programs. Control practices are based on knowledge of annual pest occurrence and on monitoring and scouting of existing pests prior to treatment. For example, information is available on the pest management program for plums in Oregon (Regional IPM Database 2001), and all stonefruit crops in Washington (WSU 2007). Specific practices in orchards will vary according to local conditions, but common stonefruit pests throughout the region include leafrollers, scale insects and mites. Common control treatments include the application of dormant sprays, including chemicals such as Lorsban® (active ingredient chlorpyrifos) for scale insects and leafrollers and other fungicides and insecticides. Monitoring or sampling populations and/or pheromone trapping and the subsequent use of day-degree modelling to predict optimum spray timing in addition to the application of (usually one) dormant spray for scale and leafrollers are recommended practices (Appendix 5). Additional measures can include pheromone-based mating disruption for some pests.

Cultural control methods include using whitewashing, paper trunk protectors and trunk shading with board to protect young, newly planted trees from sunburn. These protect trees from insects such as beetles, which are attracted to weakened, sunburned, or injured parts of the tree trunk and lay eggs in cracks on bark exposed to the sun (Regional IPM Database 2001). However, no quantitative data is available which indicates the efficacy of such field treatments.

In-field sanitation includes the removal of fallen fruits, debris, weeds and other undergrowth that can harbour diseases or pests from around and between trees.

4.2.2. Removal of alternate hosts

This measure could be used to mitigate the risks associated with alternate hosts of some pathogens, such as chokecherry for apricot ring pox or broadleaf weed control for cherry rasp leaf virus. A buffer zone can be developed around export orchards in a similar way to the requirement for a two kilometre buffer zone proposed by AQIS (2005).

4.2.3. Pest freedom

Pest free areas

Pest free areas might be applied to manage the risk posed by specific pests. The International Standards for Phytosanitary Measures (ISPM) number 4 (1995) describes the requirements for the establishment and use of pest free areas as a risk management option for meeting phytosanitary requirements for the import of plant material. A pest free area (PFA) is defined in the standard as “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 freedom is established by surveys and/or growing season inspections and maintained as necessary by other systems to prevent the entry of the pest into the place of production. The specific requirements (evidence and ongoing measures) required to establish a PFA are dependent on the biology of the pest, the history of infestation, and the history of control or eradication programmes. When sufficient information is available to support a PFA declaration, this measure is usually considered to provide a high level of protection depending on the epidemiological characteristics of the organism in question.

Pest free places of production and pest free production sites

An area can be declared a pest free place of production (PFPP) or a pest free production site (PFPS) under ISPM number 10 (1999). PFPP/PFPSs differ from PFAs in that they apply to a single place of production (PFPP) or site within a place of production (PFPS) rather than an entire area or country (PFA). PFPP/PFPSs may be located within an area where the pest is established, as long as the PFPP can be kept pest-free. There are a number of requirements to ensure that the PFPP/PFPS is pest-free:

- systems to establish pest freedom
- systems to maintain pest freedom
- verification of pest freedom

- product identity, consignment integrity and phytosanitary security
- establishment and maintenance of a buffer zone in some cases.

As with PFAs, the precise requirements are dependent on the biology and distribution of the pest organism.

Areas of low pest prevalence

An area can be declared as an area of low pest prevalence (ALPP) under ISPM number 22 (2005). An ALPP is defined as "an area, whether all of a country, part of a country, or all or parts of several countries, as identified by the competent authorities, in which a specified pest occurs at low levels and which is subject to effective surveillance, control or eradication measures". Thus in an ALPP the population of the pest is below a defined level, either because of a control programme, or because the pest is not naturally abundant. The presence of an ALPP, while not guaranteeing pest freedom, may reduce the risk of infection/infestation to a level that is acceptable.

4.2.4. Harvest and postharvest practices

Typically, harvest of a given cultivar covers about a 10-day period (Curtis *et al*. 1992). Fruit are harvested primarily into field crates or individual buckets and cooled to 20°C immediately after harvest (pre-cooling). Various cooling methods are used, such as running through chilled water, holding in a cold holding room, or forced-air cooling, in which the sides and tops of the bins are covered and large fans pull cold air through the bins (California Tree Fruit Agreement 2007). Each grower lot and variety of stone fruit is sampled and inspected on arrival at the packing house before cleaning and sorting. The FAO (2004) advocates that harvested fruit should be trimmed of any leaves or stem and well washed to remove any superficial dirt, plant debris, pests and pathogens.

The pre-cooled fruit is then dumped into large water vats. The USDA-PPQ Treatment Manual (2008) states that water used for washing, treatments and cooling must be fortified with sodium hypochlorite (household bleach) and constantly maintained at a chlorine level not to exceed 200ppm to minimise the transmission of pathogens within and between batches of fruit. Surfactants may be added to water to increase the washing efficacy. Surfactants break the surface tension, allowing water to reach otherwise protected areas such as under the calyx. The waxy coating on grape mealybugs and woolly aphids were reduced when in contact with an organosilicone surfactant (Hansen *et al*. 2006).

From here fruit is passed over rollers covered with a coarse brush which is mechanically rotated to remove extraneous trash material. It then passes through a second set of brushed rollers designed to remove surface fuzz. Fruit is then graded, both manually to remove damaged fruit and leaf trash and then electro-optically. Various computerised optical methods are used to assess the colour, size and weight of the fruit to sort them according to quality standards. Fruit is then directed to appropriate packing lines.

Industry quality standards have been developed for commercial stonefruit, which are graded according to the USDA Agriculture Marketing Service inspection and grade standards (USDA Agricultural Marketing Service). These define the minimum quality standards fruit must meet in order to be sold.

Apricots

Two grades (U.S. No.1 and U.S. No.2), each comprising of mature fruit of one variety. The characteristics of U.S. No.1 are well-formed fruit, free from russeting and scab, while U.S.

No.2 fruit are free from serious damage which seriously detracts from the appearance, or the edible/shipping quality of the apricot (USDA Agricultural Marketing Service).

Peaches

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

Plums/Prunes

Four grades (U.S. Fancy, U.S. No.1, U.S. Combination, and U.S. No.2). U.S. Fancy consists of well formed, clean, mature fruit of one variety, not overripe and free from damage and decay, with 95% of the surface of Italian type prunes purple in colour. The plums/prunes are graded similarly for U.S. No.1, except that for the Italian prune 75% of the surface must be purple. U.S. No.2 comprises plums or prunes not badly misshapen and free of serious damage, while U.S. Combination combines U.S. No.1 and U.S. No.2 with the requirement that a minimum of 75% meets the U.S. No.1 grade (USDA Agricultural Marketing Service).

Nectarines

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

Additional post-harvest practices which may be carried out to reduce the likelihood of entry of hazard organisms include:

- the application of coatings such as an approved food grade wax. An additional benefit of coating fruit is the decrease of moisture loss from the fruit during cool storage or during cold disinfestation treatment (Irtwange 2006).
- the use of insecticidal soaps. These have been proven commercially effective in reducing insect and mite populations on fruit before packing. An organosilicone wetting agent, Pulse, was shown to kill 99% of two-spotted spider mites (Tetranychus urticae) at 0.5% (v/v) when 100ppm of chlorine was present in the solution (Dentener & Peetz 1992).
- insecticidal and/or fungicidal dips can be used as part of the packhouse process. New treatments are always becoming available. For instance, Hollingworth (2005) has shown Limonene (an extract from Citrus peel) has promise as an in-field spray treatment or post harvest dip against mealybugs and scale as it can penetrate the insect’s waxy covering. The limiting factor is phytotoxicity to certain plants.

4.3. Pre-export measures

All packhouses intending to export stonefruit will be required to be registered with USDA for trace-back purposes. Qualified stonefruit should be packaged with brand new cartons. Packaging and labelling should comply with the conditions outlined in MAF Biosecurity New Zealand Standard 152-02: Importation and Clearance of Fresh Fruit and Vegetables into New Zealand. All packaging should be labelled to allow trace-back to lots and orchard blocks. Information concerning batch number, production date, place of origin, orchard number and processing plant code should be clearly marked on the cartons.

Packed product and packaging is to be protected from pest contamination during and after packing, during storage and during movement between locations. Packaged fruit should be placed in cold storage at a temperature of approximately 0°C as soon as possible.

Product for export that has been inspected and certified by USDA must be maintained in secure conditions that will prevent mixing with fruit for domestic consumption or export to other destinations. The objective of this procedure is to ensure that the phytosanitary status of the product is maintained during storage and movement

4.3.1. Visual inspection

Visual inspection can take place along the whole production and post harvest pathway. In-field monitoring and selection by certain criteria at harvest are considered good orchard practice, and the grading process provides another opportunity for screening. Fruit is then subject to formal phytosanitary inspection.

Visual inspection by a trained inspector can be used in three main ways for managing biosecurity risks on goods being imported into New Zealand, as:

- a biosecurity measure, where the attributes of the goods and hazard organism provide sufficient confidence that an inspection will be able to achieve the required level of detection efficacy
- an audit, where the attributes of the goods, hazard organisms and function being audited provide sufficient confidence that an inspection will confirm that risk management has achieved the required level of efficacy
- a biosecurity measure in a systems approach, where the other biosecurity measures are not able to provide sufficient efficacy alone or have significant levels of associated uncertainty.

The inspection requirements for fresh produce are outlined in MAF Biosecurity New Zealand Standard 152-02: Importation and Clearance of Fresh Fruit and Vegetables into New Zealand.

Pre-export lot inspection

MAF Biosecurity New Zealand may require that the exporting country's National Plant Protection Organisation (NPPO) sample and visually inspect the consignment for all regulated pests.

On arrival inspection

This may be carried out in the country of origin for pre-cleared shipments, in which case it is not repeated on arrival. However, it usually takes place on arrival in an approved transitional facility, as outlined in Appendix V of MAF Biosecurity New Zealand Standard 152.04.03F: Requirements for Holding and Processing Facilities for Uncleared Risk Goods.

The purpose of these inspections is to determine whether any potential quarantine pests are associated with the consignment. 600 Units of fruit are inspected from a line of greater than

1000 units, or 450 units from a line of 1000 units or less in total. For stonefruit, one inspection unit is defined as one fruit. Biometrically, if no pests are detected by the inspection, this sample size achieves a 95% confidence level that not more than 0.5% (1 in 200) of the units in the consignment are infested or infected. The assumptions around this are discussed in Section 7.6**.**

If no live pests are detected in the inspection sample, the consignment is considered with 95% confidence to be infested with pests at a level less than 1 in 200, and will be released for export or given biosecurity clearance if this rate of infestation is considered acceptable. The detection of live quarantine pests, or dead pests from pest free areas, pest free places of production, pest free production sites or areas of low pest prevalence, or other regulated articles, will result in the failure of the inspection lot. Detection of pests from pest free areas, pest free places of production, pest free production sites or areas of low pest prevalence will also result in the loss of the relevant pest status. Detection of live regulated pests (or dead ones under some circumstances) will result in the consignment being subjected to appropriate remedial action. This action would be any treatment known to be effective against the target pests. Currently, standard methyl bromide fumigation rates for external pests are considered sufficiently effective. However, other treatment options may be considered to provide an equivalent level of protection.

4.4. Specific treatment options

Disinfestation involves treatments that remove or kill hazard organisms that may be contaminating commodities. The objective of applied treatments is to ensure affected insect life stages receive a lethal treatment inducing sufficiently high mortality while the plant tissue is affected as little as possible (Mangan & Hallman 1998). Although all stages of the pest life cycle are targeted with disinfestation measures, evidence exists to show that the response of some life stages such as insect eggs to physical treatments varies with age (Corcoran 1993). Johnson and Wofford (1991) found that age was a significant factor in the response of two pyralid moths to cold treatment. In the case of tephritid fruit flies, susceptibility to cold in eggs of *Anastrepha suspensa* (Loew) decreased with age (Benschoter & Witherell 1984), and Moss and Jang (1991) reported that mortality of Mediterranean fruit fly eggs subjected to hot water immersion was also dependent on age.

4.4.1. Cold disinfestation

Cold disinfestation treatment is used as a control in various fruit and has the advantage of being applied in several ways. The treatment can be carried out in the exporting country; in transit; in the importing country; or through a combination of these options. The most frequently used temperature range is between 0 and 3°C (Mangan & Hallman 1998). Temperatures above 3ºC might not kill all insects associated with the commodity and temperatures below 0ºC may harm the commodity and make it difficult to sell.
Cold treatment is an effective quarantine measure for fruit flies on a wide range of fruits (De Lima *et al*. 2007; Heather *et al*. 1996; Paull 1994). Low temperature storage, between 0 and 2°C for up to 22 days, is accepted as a treatment for many fruits and vegetables infested with Mediterranean fruit fly and Queensland fruit fly for entry into the United States (Burditt & Balock 1985). Cold treatments at 1°C for 14 days or at 3°C for 14 days for Australian stonefruit were shown to be highly effective as quarantine treatments against Queensland fruit fly (NSW DPI 2007).

4.4.2. Vapour heat treatment

Vapour heat treatment (VHT) involves fruit being heated in humid air, at greater than 90% relative humidity, to temperatures possibly lethal for insects but non-injurious to the fruit

(Jacobi *et al*. 1993). The most frequently used temperature range for vapour heat treatment is between 43 and 49°C (Mangan & Hallman 1998). VHT differs from high temperature, forced air in that moisture accumulates on the surface of the fruit. The water droplets transfer heat more efficiently than air, allowing the fruit to heat quickly.

There is no efficacy data for vapour heat treatment of surface pests on stonefruit such as scales and mealybugs. Hansen *et al*. (1992) carried out experiments on removing surface pests from cut flowers in Hawaii and determined efficacy of VHT for scales, mealybugs, thrips and aphids after 2 hours at 45.2°C. These experiments suggested that this temperature and timeframe will kill all adult and nymphal stages of these groups and could therefore be an appropriate treatment to remove these organisms from stonefruit (Hansen *et al*. 1992). However, VHT may also increase physical injury to the fruit. Differences between varieties and maturity may influence fruit heat sensitivity, as well as the capacity for long term storage (Jacobi *et al*. 1993). These factors have to be considered when researching VHT for commercial and quarantine application.

4.4.3. Methyl bromide

Methyl bromide fumigation is a measure that might be applied to stonefruit and may prove effective against target pests. This fumigation treatment could be performed either pre-shipment or on-arrival as a quarantine measure.

Methyl bromide treatment schedules for surface insects are provided in the FAO Manual of Fumigation Control (FAO undated) and the USDA Treatment Manual (2004), and some evidence is available on the effectiveness of methyl bromide specifically on pests of stonefruit.

Methyl bromide fumigation was evaluated as a quarantine treatment for *Rhagoletis completa* on peaches (variety Flairtime) by Yokoyama *et al*. (1992). At LD50s and doses to cause 100% mortality of eggs and larvae, late 3rd-instar larvae were least susceptible. Complete mortality of 2203 late 3rd-instar larvae was attained in a large-scale test of a proposed quarantine treatment of 40 g/m^3 methyl bromide for 2 h at >=21° C and 50% (vol/vol) load under a forced-air system for peaches packed in 2-tray shipping containers for export to New Zealand. Organic bromide residues were <0.001 p.p.m. after 7 days in storage at 2.5° C. Inorganic bromide residues were below the U.S. tolerance level of 20 p.p.m. Hansen *et al*. (2000) developed a quarantine treatment against *Cydia pomonella* on sweet cherry for the Japanese market. Fumigation with methyl bromide at 0.064 oz/ft^3 (64 g/m^3) for 2 hours at 6° C resulted in complete mortality for all codling moth larvae. Fumigation at this concentration and temperature (alternative combinations were provided) was considered to be an efficacious quarantine treatment against this species in sweet cherries. Except for one variety, fumigation did not significantly influence fruit firmness, soluble solids, or titratable acids. Reduction in fruit and stem quality was more associated with temperature than with methyl bromide concentration.

However, fumigation with methyl bromide is being phased out of use as a biosecurity treatment and is known to negatively affect fruit and stem appearance (Retamales *et al*. 2003). Fumigation retarded fruit softening and increased the severity of mealiness and internal breakdown in nectarines stored for more than 3 weeks (Harman *et al*. 1990). Alternative treatments are being investigated, for example a new non-phytotoxic formulation of ethyl formate in carbon dioxide. This has been successfully tested against the most fumigation-resistant stages of light brown apple moth, Fuller's rose weevil, long and short tailed mealy bugs and redback spiders on table grapes. Fruit showed no signs of damage or loss in quality, even after several days of application (Horticulture Australia Ltd 2008).

4.4.4. Irradiation

The use of ionising treatments such as gamma and x-rays (irradiation) is gaining popularity as a quarantine treatment. Irradiation is an efficient, non-residue, broad spectrum disinfestation treatment that has been recognised for its quarantine potential in fresh produce. It is a low dose application that is tolerated well by most fresh commodities. The major commercial uses of ionising radiation for fruit and vegetables include the inhibition of sprouting (potatoes and onions) and the extension of shelf-life in strawberries (Frazier *et al*. 2006).

Under regulations managed by Food Standards Australia New Zealand (FSANZ), irradiated fruit is not permitted to be sold in New Zealand unless it has been through a pre-market safety assessment process conducted by FSANZ. However any interested stakeholder may apply to change the Australia New Zealand Food Standards Code to allow stone fruit or other fruit treated with irradiation for phytosanitary purposes to be sold in New Zealand (FSANZ 2008). Biosecurity New Zealand has approved the importation of irradiated tropical fruit from Queensland, Australia. FSANZ has approved and given food safety clearance to the use of irradiation as a phytosanitary treatment for the following imported fruit: mango, rambutan, longan, lychee, papaya, custard apple, breadfruit and carambola. Apart from these, the only products available in New Zealand and permitted to be irradiated in prescribed doses set out in the Foods Standards Code, are herbs and spices and herbal infusions, excluding tea.

Although irradiation can prolong the shelf life of foods where microbial spoilage is the limiting factor, fruits and vegetables generally do not retain satisfactory quality at the irradiation doses required (Lacroix & Vigneault 2007). Loss of firmness, colour changes and increased internal breakdown are evident in both apricots and peaches at irradiation doses above 600 Gy (Drake & Neven 1998).

Irradiation can be used with stonefruit as a quarantine treatment at 300 Gy or less with little quality loss (Drake and Neven 1998). For example, doses of 57 Gy and 92 Gy are recommended for quarantine disinfestation of host fruits of apple maggot (Hallman 2004) and plum curculio (Hallman 2003), respectively. Follett (2006) showed that irradiation treatment with a minimum absorbed dose of 150 Gy provides quarantine security to control white peach scale (*Pseudaulacaspis pentagona*) on exported papaya, as well as other commodities.

Based on existing data, Corcoran and Waddell (2003) state the following recommended doses for the listed arthropod pests (Table 9).

Table 9: Recommended irradiation treatment doses for particular Arthropod groups (after Corcoran & Waddell 2003)

Arthropod Pest Group	Recommended Treatment Dose (Gy)	Author(s)
Tephritidae (fruit flies)	150 (non-emergence treated eggs, larvae)	Bustos *et al*. 1992, Gould and Hallman 2004
Hemiptera (bugs, scales, mealybugs)	250 (sterility)	Hara *et al*. 2002, Follett 2006
Thysanoptera (thrips)	250 (sterility)	Dohino *et al*. 1996, Yalemar *et al*. 2001
Lepidoptera (moths, butterflies)	250 (non-emergence – treated eggs, larvae)	Follett & Lower 2000
Coleoptera (beetles)	250 (sterility)	Tilton *et al*. 1966, Todoriki *et al*. 2006
Acari (mites)	350 (sterility)	Lester and Petry 1995, Jadue *et al*. 1997

Under the ISPM No. 18 guidelines for irradiation use as a phytosanitary measure, live target pests may be found because mortality will rarely be technically justified as the required response. Irradiation can work by rendering pests sterile rather than killing them. It is essential the irradiation treatment ensures the pests are unable to reproduce. The guidelines suggest it is preferable that the pests are unable to emerge or escape the commodity unless they can be practically distinguished from non-irradiated pests (ISPM No.18 2003).

4.5. Assessment of residual risk

Residual risk can be described as the risk remaining after measures have been implemented, assuming that:

- the measures have been implemented in a manner that ensures they reduce the level of risk posed by the hazard(s) to a degree anticipated by the risk analysis
- the level of risk posed by the hazard(s) was determined accurately in the risk analysis.

The remaining risk while being acceptable may still result in what could be interpreted as failures in risk management.

Residual risk information in this case would be interception data from the stone fruit consignments coming into New Zealand from the USA. Ongoing surveillance programmes are also important sources of feedback data that influence the iterative nature of biosecurity decisions around the risk analysis and import health standard process.

4.6. Assumption and uncertainty around risk management measures

Considerable uncertainty exists around the efficacy of risk management measures. Interception data is one way of estimating efficacy, as records of live and dead organisms indicate the success of a treatment and the thresholds for growth and development of each individual organism. A sample audit is required to monitor efficacy. Currently this is 600 units of fruit/vegetable product per consignment. The assumption is that this monitoring will adequately record type and number of organisms associated with each fresh produce commodity.

This approach makes the following assumptions:

- the consignment is homogeneous (fruit are harvested inspected and packaged in similar conditions, and have received similar treatments before arrival into New Zealand). Heterogeneous or non-randomly distributed consignments would require a higher sampling rate to achieve the same confidence levels. Level of sampling depends on the degree of heterogeneity
- the samples are chosen randomly from the consignment
- the inspector is 100 percent likely to detect the pest if it is present in the sample. Some pests are difficult to detect because of their small size and cryptic behaviour
- it is acceptable that the sampling system is based on a level (percentage) of contamination rather than a level of surviving individuals

Interception records can rarely be used quantitatively because of limitations in the identification and recording processes.

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5. Analysis of potential hazards – Acari (mites)

This chapter assesses the biosecurity risks from mites that are potentially associated with stonefruit imported from the Pacific Northwest into New Zealand.

5.1. *Tarsonemus bakeri* (tarsonemid mite)

Scientific name: *Tarsonemus bakeri* Ewing, 1939 (Acari: Tarsonemidae)
Common name/s: tarsonemid mite

PNW status

Recorded from California (McGregor 1942). No literature has been found recording this species from the PNW, however it has once been intercepted on pears from Oregon in 2005 (Quancargo database, C2005/318019), so is presumed to be present in that state.

New Zealand status

Biosecurity Australia (2006) recorded this species as present in New Zealand, citing NZ MAF (2003). This appears to be incorrect. *T. bakeri* is not known to be present in New Zealand (not recorded by Zhang *et al.* 2000).

General geographical distribution

USA (Lindquist 1978). Wrongly recorded from Italy by Vacante and Nucifora (1986) (Nucifora & Vacante 2004).

Hosts

Intercepted on fresh peaches, plums and nectarines sea-freighted from California [Quancargo database: peaches (C2005/171065), plums (C2005/180493, C2005/229309, C2006/180841), nectarines (C2003/29047, C2004/177241, C2006/228780, C2006/229616, C2006/253838), peaches/nectarines (C2005/190707)]. Vacante and Nucifora (1986) recorded it from citrus in Italy, but Nucifora and Vacante (2004) reported that this was a misidentification of *Tarsonemus waitei*.

Plant parts affected

Buds (McGregor 1942); associated with fruit (Quancargo interception database).

Biology

There is little information available on this species. McGregor (1942) recorded it in Californian citrus groves, infesting buds and causing the tips to turn brown and die, and associated it with the spread of *Alternaria* fungus.

5.1.1.2. Hazard identification conclusion

There is some evidence that *T. bakeri* is present in the Pacific Northwest. It is not known to be present in New Zealand and has been intercepted on fresh imported stonefruit. It is therefore classed as a potential hazard in this analysis.

5.1.2. Risk assessment

5.1.2.1. Entry assessment

T. bakeri has frequently been intercepted on stonefruit consignments from California (Quancargo database). However, no literature records have been found recording *T. bakeri* from Washington, Oregon or Idaho. The only information locating this species in the Pacific Northwest is one interception record from Oregon, and this was on pear fruit. If this species is present in the Pacific Northwest, levels of contamination on stonefruit are likely to be extremely low.

The likelihood of entry is considered to be negligible, and this species is not classified as a hazard. Therefore risk management measures are not justified.

5.2. *Tetranychus* species (spider mites)

The species examined in this risk assessment have been grouped together because of their related biology and taxonomy. They are predicted to pose a similar risk and require similar mitigation measures. They are:

- *Tetranychus homorous* Pritchard & Baker 1955 (spider mite)
- *Tetranychus mcdanieli* McGregor, 1931 (McDaniel spider mite)
- *Tetranychus pacificus* (McGregor, 1919) (Pacific spider mite).

Tetranychus homorous

PNW status: *T. homorous* is known only from the far eastern United States (Pritchard & Baker 1955). No records have been found of this species in the Pacific Northwest, but it has been intercepted on a consignment of fresh peaches and nectarines air-freighted from California (Quancargo C2004/90467), indicating it is present in this state. Since there is no evidence that *T. homorous* is present in the Pacific Northwest, it is not treated as a potential hazard in this analysis.

PNW status

T. mcdanieli has been recorded from Washington (Pritchard & Baker 1955, Beers *et al.* 1998, CPCI 2008) and Oregon (Beers *et al.* 1998); *T. pacificus* has been recorded from Washington (CPCI 2008), Oregon (Pritchard & Baker 1955, CPCI 2008) and Idaho (Pritchard & Baker 1955)

New Zealand status

Neither species is known to be present in New Zealand (Z-Q. Zhang, pers. comm. 2008). Not recorded by: Zhang and Rhode (in press).

General geographical distribution

T. mcdanieli has been recorded from Canada, the USA (WA: CPCI 2008; CA: Beers *et al*. 1993) and Europe. *T. pacificus* has been recorded from Canada, the USA (AZ, CA, OR, UT, WA: CPCI 2008) and Mexico (Migeon & Dorkeld 2006).

Hosts

T. mcdanieli has been recorded from apricot, cherry, peach (Beers *et al.* 1993) and plum (Pritchard & Baker 1955); *T. pacificus* has also been recorded from apricot, cherry (Migeon & Dorkeld 2006), peach and plum (Bolland *et al.* 1998), and *Prunus* species are listed as major hosts by CPCI (2008).

T. pacificus and *T. macdanieli* have wide host ranges, with hosts in 24 and 10 plant families respectively (Migeon & Dorkeld 2006), including fruit trees and crops, amenity trees and weeds. The following hosts are listed by Migeon and Dorkeld (2006):

T. macdanieli: *Acer saccharum*, *Lonicera japonica* (Japanese honeysuckle, a noxious weed in the USA), *Thermopsis pinetorum* (pine thermopsis), *Morus* sp. (mulberry), *Phleum pratense* (meadow cat's-tail, a noxious weed), *Thalictrum fendleri*, *Fragaria virginiana* (Virginia strawberry), *Malus domestica*, *Prunus americana*, *P. avium*, *P. domestica*, *P. persica*, *Rubus idaeus* (raspberry), *Ribes* sp. (currant), *Ulmus americana* (American elm), *Vitis vinifera* (grape)

T. pacificus: *Amaranthus* sp. (pigweed), *Asarum* sp. (ginger), *Asclepias* sp. (milkweed), *Helianthus annuus* (sunflower) *Brassica* sp., *Ipomoea* sp., *Cucurbita pepo* (squash), *Cucurbita* sp., *Medicago sativa* (alfalfa), *Phaseolus* sp. (beans), *Robinia pseudoacacia* (black locust), *Thermopsis pinetorum* (pine thermopsis), *Trifolium* sp. (clover), *Vicia* sp., *Juglans californica* (California walnut), *Juglans regia* (walnut), *Marrubium vulgare* (horehound), *Salvia* sp. (sage), *Stachys* sp., *Magnolia fraseri* (mountain magnolia), *Gossypium* sp., *Malva* sp., *Melia azedarach* (chinaberry), *Ficus carica* (common fig), *Morus* sp., *Syringa* sp., *Bocconia frutescens* (tree poppy), *Eschscholtzia californica* (California poppy), *Zea mays* (corn), *Ceanothus fendleri*, *Rhamnus betulaefolia*, *Cotoneaster* sp., *Oemleria cerasiformis* (Indian plum), *Prunus armeniaca*, *P. avium*, *P. domestica*, *P. dulcis*, *P. persica, P. virginiana*, *Pyrus communis* (common pear), *Rubus* sp., *Citrus limon* (lemon), *C. paradisi* (grapefruit), *Philadelphus gordonianus*, *Philadelphus* sp., *Ribes* sp. (currant), *Solanum melongena* (eggplant), *Ulmus* sp., *Vitis vinifera* (grape).

Plant parts affected

Beers *et al.* (1993) recorded *T. mcdanieli* webbing leaves and fruit. This species has been intercepted live on fresh nectarines sea-freighted from California (Quancargo database, Consignment C2003/34762). *T. pacificus* feeds on both sides of the leaves and can cover the shoot terminal with webbing when population densities are high (CPCI 2008), and has been found in the stem cavity of packed nectarines in California (Curtis *et al.* 1992). Its association with fruit is demonstrated by the following interceptions: fresh plums from California (Quancargo database, Consignments C2003/40576, C2005/224025), fresh peaches/nectarines from California (Quancargo database, Consignment C2004/100980) and fresh nectarines from California (Quancargo database, Consignments C2006/173162, C2006/181827, C2006/198849). All interceptions were live (some by sea-freight) or of unknown viability, and eggs and adults of both sexes have been intercepted.

Biology

Spider mites are haplo-diploid, that is unfertilised eggs produce haploid males and fertilised eggs produce diploid females (Zhang 2003). Development from egg to adult takes from one to two weeks or more, with males developing slightly faster than females. The ovipositional period of the adult female lasts from 10 to 40 days, during which about 10 eggs a day can be produced. There are short (a few days) pre- and post-ovipositional periods (Zhang 2003). Spider mites overwinter as females, taking shelter in any protective site available; males do not live through the winter (Mellott & Krantz 2007). Overwintering females often requiring a chilling period before they reactivate and resume oviposition (Zhang 2003).
Spider mites feed on the contents of parenchyma cells in the leaves, including the green pigment chlorophyll. They often prefer to feed on the leaf undersides (Zhang 2003). Individual feeding spots have a white appearance initially, resulting in a stippled appearance. As damage progresses it takes on a brown hue, commonly called bronzing. In addition, *T. macdanieli* forms very dense webs on leaves and fruit (Beers *et al.* 1993).

5.2.1.2. Hazard identification conclusion for *Tetranychus mcdanieli* and *T. pacificus*

T. mcdanieli and *T. pacificus* are present in the Pacific Northwest, they are not known to be present in New Zealand and both species have been intercepted on fresh imported stonefruit. They are therefore both classed as potential hazards in this analysis.

5.2.2. Risk assessment

5.2.2.1. Entry assessment

T. mcdanieli and *T. pacificus* are primarily foliage feeders, but have both been recorded on fruit. Widespread outbreaks of *T. mcdanieli* occurred in central Washington during the late 1950s and early 1960s as a result of severe disturbance of biological control, but this species

later became relatively uncommon (Beers *et al*. 1993), and infestation levels on fruit are not likely to be high. Eggs and live adults of both species have been intercepted on fresh stonefruit consignments sea-freighted from California, so these species are able to survive existing harvesting, processing and transit procedures and conditions.
The likelihood of entry is estimated to be moderate.

5.2.2.2. Exposure assessment

After entry mites would need to survive, without feeding, the movement of fruit from the border to the point at which they could move onto a suitable host. This time period would be likely to be at least a week. In food deprivation studies conducted on *T. urticae*, Krainacker and Carey (1990) found that mites were capable of surviving two days without food at 24°C before fecundity and longevity decreased. *T. macdanieli* and *T. pacificus* (males and females) are both able to survive for several weeks on fruit in transit, additionally adult females survive overwinter. Infested fruit will be arriving in winter or early spring when temperatures are still low. This means the mites are more likely to be able to survive without feeding, but also that their natural movement will be slowed. Tetranychids disperse naturally by crawling from plant to plant. They may also be spread by movement in air currents (Zhang 2003), but aerial dispersal is generally initiated at high population densities and most mites fall out of the air currents after only a short distance (Kennedy & Smitley 1985). Suitable hosts would probably need to be close to infested stonefruit for colonization to occur, for example discarded fruit infesting nearby host plants in urban or suburban areas. *T. macdanieli* and *T. pacificus* have wide host ranges, with hosts available in most places. These species are polyphagous and many hosts, both evergreen and deciduous, can be found in domestic gardens, as well as in urban environments. Deciduous species may not have leaves available for colonizing when stone fruit arrives in New Zealand during the winter months, but evergreen hosts are likely to be widely available. Female *T. mcdanieli* are known to feed on weed hosts after emerging from overwintering (Jeppson *et al.* 1975). Additionally, stonefruit arriving in spring would be likely to have deciduous host plants with new leaf growth available.
The likelihood of exposure is estimated to be moderate.

5.2.2.3. Establishment assessment

Female spider mites are capable of parthenogenetic reproduction, with unfertilised eggs producing only males, which are haploid (Zhang 2003). However a mated female or mites of both sexes would be necessary to establish a reproductive population. This likelihood is considered to be higher for these species than for solitary species, due to their tendency to have an aggregated or clumped spatial distribution. Yamamura and Katsumata (1999) referred to this type of pest as gregarious, and considered them to have a higher probability of introduction into new areas via trade, due to the heightened likelihood of their locating a mate in the new environment. A single unmated female could produce one generation of male offspring, but to establish a sustainable population these males would need to mate back with their parent. This would require the female to survive the period from packing in the USA to exposure in New Zealand, the production of eggs and the development of those eggs to mature males, mating with those males and laying a second generation of eggs.
T. mcdanieli and *T. pacificus* both take only a week or two to develop from egg to adult, and can complete multiple generations per year depending on temperature (Jeppson *et al*. 1975). Female *T. pacificus* deposit 50 to 100 eggs over 2 to 4 weeks (Jeppson *et al*. 1975), so the potential for rapid population increase in suitable conditions is high. Both species are established in parts of the world with climates similar to that of New Zealand, and both are polyphagous, with host species that are widely distributed throughout New Zealand.
The likelihood of establishment is considered to be moderate to high.

5.2.2.4. Consequence assessment

Economic consequences

These spider mites can cause direct damage to host plants, and are recognised horticultural pests requiring control measures. Their management on tree crops generally follows an integrated approach (CPCI 2008). Where host crops are grown commercially in New Zealand pest management programmes will be in place for other species, and the establishment of new *Tetranychus* species could cause an increase in pest control costs and/or disruption of existing Integrated Pest Management (IPM) programmes due to increased use of acaricides or the need to use different acaricides. Additional applications of acaricides and/or increased monitoring costs may alter the economic viability of some crops.

Indirect consequences would include the potential for disrupting access to some markets, including Australia.

Environmental consequences

Environmental consequences could include damage to amenity or native plants. Beever *et al.* (2007) suggested that, in terms of risk to native flora, spider mites are a high risk group, particularly polyphagous species (based on known attacks on native plants by exotic species present in New Zealand). *T. mcdanieli* and *T. pacificus* are both pests of various species of weeds. While they may exert some control over these weeds, it is more likely that weed hosts would act as a reservoir from which mites could infest crops.

Other environmental consequences could include effects from increased use of acaricides and the effects on native mite species due to competition for resources.

Human health consequences

Mites are commonly reported to cause respiratory allergy. Astarita *et al*. (2001) reported allergies to *Tetranychus urticae* (the two-spotted spider mite), and Kronqvist *et al*. (2005) reported allergies to *Tetranychus urticae* and its associated predatory mites. *T. urticae* is widespread in New Zealand and is extremely polyphagous. The establishment of additional spider mite species would be unlikely to cause any additional impact on human health in view of the existing exposure to *T. urticae,* unless total spider mite populations were to increase very significantly.

The establishment of exotic Tetranychus mites in New Zealand is likely to cause low economic, environmental and human health consequences.

5.2.2.5. Risk estimation

Tetranychus mites have a moderate likelihood of entry, moderate likelihood of exposure and moderate to high likelihood of establishment in New Zealand. The economic, environmental and human health impacts are likely to be low. The risk associated with *Tetranychus* mites on fresh stonefruit imported from the Pacific Northwest is non negligible and phytosanitary measures can be justified.

5.2.3. Risk management

MAF Biosecurity New Zealand requires risk mitigation measures for *T. mcdanieli* and *T. pacificus* on stonefruit from California and on cherries from the Pacific Northwest. Risk mitigation measures specified in the existing IHSs are 1) visual inspection of produce and associated packaging and 2) a requirement for the consignment to be free from extraneous plant material.

5.2.3.1. Options

Pest free areas or places of production

Both spider mite species are likely to be widespread in the Pacific Northwest and pest-free areas are unlikely to be a viable option.

Orchard management, harvest and post-harvest processing

Spider mites are managed in PNW stonefruit orchards by summer sprays which include clofentezine, fenbutatin-oxide, hexythiazox, propargite and bifenazate (WSU 2007).
Post harvest washing may remove some mites from the fruit surfaces, and surfactants may assist in removing mites from under the calyx. Packhouse procedures such as post-harvest brushing and sorting of fruit may remove mites and webbing from heavily infested stonefruit, but are unlikely to remove mites that are not associated with webbing, due to their small size (less than 0.5 mm). Curtis *et al.* (1992) reported an average incidence of *T. pacificus* of 11 adults and nymphs per 100 000 fruit after packinghouse processes in California; however most of the infestations were from one lot of nectarines, suggesting that orchard management and standard packhouse procedures may be effective at reducing infestation to acceptable levels, and that monitoring orchards and applying thresholds could manage risk.

Cold treatment (pre-export or in transit)

It is not known what effect cold treatment would have these species but spider mites overwinter as adult females in the field, and are able to survive sub-zero temperatures so cold treatment is unlikely to be a useful option.

Visual inspection

Spider mites are very small and can shelter under the calyx, so may be difficult to detect by visual inspection. A hand lens may be required to see individual mites and eggs. However the presence of webbing associated with mites on the fruit and also the distinctive feeding damage they cause would aid detection, although this is unlikely to be effective at low infestation levels.

5.2.3.2. Risk management options in descending order of stringency

Option 1: orchard management
Option 2: packhouse procedures, particularly washing and brushing
Option 3: post harvest inspection

5.2.4. Assessment of uncertainty

- the distribution of *T. homorous* in the Pacific Northwest is not known
- no information on thermal thresholds for these species was found, so it is unknown what effect cold treatment would have.

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6. Analysis of potential hazards – Coleoptera (beetles)

This chapter assesses the biosecurity risks from beetles that are potentially associated with stonefruit imported from the Pacific Northwest into New Zealand

6.1. *Diabrotica undecimpunctata* (spotted cucumber beetle)

Scientific name: *Diabrotica undecimpunctata* Mannerheim, 1843 (Coleoptera: Chrysomelidae)
Common name/s: spotted cucumber beetle, southern corn rootworm, western spotted cucumber beetle
Other scientific names: *Crioceris sexpunctata*, *Diabrotica duodecimpunctata*, *Diabrotica soror*, *Chrysomela duodecimpunctata*

PNW status

D. undecimpunctata has been recorded from Washington, Oregon and Idaho (CPCI 2008)

New Zealand status

D. undecimpunctata is not known to be present in New Zealand. Genus not recorded by Leschen *et al.* (2003).

General geographical distribution

D. undecimpunctata is recorded from southern Canada, and Central America, and is widespread throughout the USA (AL, AK, AZ, CA, CO, CT, DE, FL, GA, ID, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, NE, NV, NH, NJ, NM, NY, NC, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VT, VA, WA, WV, WI, WY) (CPCI 2008).

Hosts

D. undecimpunctata has been found on more than 200 plant species. Adults most characteristically attack Cucurbitaceae, and major hosts include melon and cucumber (CPCI 2008). *D. undecimpunctata* has been recorded on apricot and peach (Mackie 1937) and nectarine (Smith & Michelbacher 1950).

Plant part(s) affected

Fruits/pods, inflorescence, leaves and roots (CPCI 2008)

Biology

(After CPCI 2008 unless otherwise stated). Two subspecies of *D. undecimpunctata* have been described, *howardi* and *undecimpunctata*. The older literature did not distinguish them (EPPO/CABI 2007a) and their biology is very similar (EPPO/CABI 2007a, CPCI 2008), so they will be assessed together here.

The species is multivoltine, with 2 to 3 generations per year in southern North America, and one generation per year in northern North America. Continuous overlapping generations are possible in subtropical and tropical regions. Adults overwinter under leaves, and become active in spring, flying when temperatures reach 21°C. They feed on the flowers and foliage of many different host plants, moving to cucurbits as soon as they become available. They have also been recorded feeding on fruit (Smith & Michelbacher 1950). Eggs are laid in soil near to host plants. Eggs hatch in 7 to 10 days, and larvae bore into the roots of their hosts. At the end of the third instar, they burrow into the soil and pupate.

First-generation adults emerge in 1 to 2 weeks, with a complete lifecycle taking 6 to 9 weeks. Adults often move from one host to another. Mating occurs before the winter. Adults are 6 to 7.5 mm long and bright yellowish-green. They are strong fliers and can spread rapidly between fields; they are also carried long distances by high-altitude air currents, for example, up to 800 km in 3 to 4 days.

Damage

D. undecimpunctata is more abundant and destructive in the southern part of its range. The beetles are polyphagous (EPPO/CABI 2007a) and adults damage various vegetable and flower crops (Hesler 1998). They also feed on fruit, particularly apricots, with cherries, nectarines and peaches also being damaged to some degree (Smith & Michelbacher 1950). Ripe fruit is preferred (Smith & Michelbacher 1950), and green fruit is rarely attacked (Michelbacher *et al.* 1941). The beetle population falls off abruptly as soon as the crop is harvested (Michelbacher *et al.* 1941, Smith & Michelbacher 1950). Larval feeding causes stunting, and *D. undecimpunctata* is also an important vector of plant pathogens (CPCI 2008).

6.1.1.2. Hazard identification conclusion

D. undecimpunctata is present in the Pacific Northwest and is not recorded from New Zealand. It has been recorded feeding on ripe fruit of various *Prunus* species including apricot, peach and nectarine, and is therefore classed as potential hazard in this analysis.

6.1.2. Risk assessment

6.1.2.1. Entry assessment

The only life stage associated with fruit is the adult. Adult beetles usually fly or drop to the ground immediately at the slightest disturbance (Meinke & Gould 1987), and harvesting fruit drives beetles from one orchard to another (Smith & Michelbacher 1950). Therefore the likelihood that beetles will remain on harvested stonefruit is negligible. Additionally, although the adult beetle is relatively small, it is brightly coloured and likely to be noticed on fruit.

The likelihood of D. undecimpunctata entering New Zealand on fresh stonefruit from the Pacific Northwest is negligible and this species is not classed as a hazard. Therefore risk management measures are not justified.

6.2. *Hippodamia convergens* (convergent lady beetle)

Scientific name: *Hippodamia convergens* Guérin-Méneville, 1842 (Coleoptera: Coccinellidae)
Common name/s: convergent lady beetle, Ladybird
Other scientific names: *Hippodamia juncta*, *Hippodamia modesta*, *Hippodamia convergens* var. *obsoleta*, *Hippodamia praticola*

PNW status

Recorded from Washington, Oregon and Idaho (CPCI 2008)

New Zealand status

Introduced twice for aphid biological control but failed to establish (Thomas 1989). Genus not recorded by Leschen *et al.* (2003).

General geographical distribution

Recorded from China, Pakistan, the Philippines, Turkey, Europe, sub-Saharan Africa, Bermuda, Canada, the USA (AL, AZ, AR, CA, FL, GA, ID, IL, IN, IA, KS, LA, MD, MS, NM, NY, ND, OK, OR, PA, RI, SC, SD, TX, VA, WA), Mexico, Central America, South America and Australia (CPCI 2008).

Hosts

H. convergens is a polyphagous predator, feeding on a wide variety of insects including aphids, beetles, chinch bugs, whiteflies and mites (CPCI 2008).

Plant parts affected

Ladybirds do not feed on plants, but rather on phytophagous arthropods. They may be present on any part of the plant that their prey is present on. They have a biological relationship with the plant and are not hitchhikers. A hitchhiker is defined here as a species that has an opportunistic association with transported commodities or other items (like sea containers) with which they have no biological relationship. *H. convergens* has been intercepted alive on shipments of nectarines sea-freighted from California (Quancargo database, Consignment C2004/101556).

Biology

(After CPCI 2008). Adults are about 5 mm in length, orange-brown in colour with black spots and white stripes on the head shield. Eggs are oval and orange and larvae are black with orange spots. Both lifestages are efficient polyphagus predators of various insects, particularly aphids. A larva will consume about 400 aphids in its larval stage and an adult will consume over 5000. Adults also require a source of nectar or pollen to mature. Eggs are laid shortly after mating in clusters on the undersides of leaves near appropriate arthropod prey species. At optimum temperatures the life cycle takes about 30 days. Adults can live for over 3 months, and are mobile insects that move freely.

6.2.1.2. Hazard identification conclusion

H. convergens is present in the Pacific Northwest and is not known to be present in New Zealand. It is associated with *Prunus* species and has been intercepted on fresh imported stonefruit. It is therefore classed as a potential hazard in this analysis.

6.2.2. Risk assessment

6.2.2.1. Entry assessment

Ladybirds are predatory and do not have a primary association with stonefruit, but are likely to be on fruit if prey is present. Although adults are strong fliers and would be likely to move off fruit if disturbed (e.g. during harvest), a live adult *H. convergens* has been intercepted on fresh nectarines sea-freighted from California (Quancargo database), so this species is able to survive existing harvesting, processing and transit procedures and conditions.
The likelihood of entry is considered to be low.

6.2.2.2. Exposure assessment

Adults are highly mobile; they can fly well and locate new infested plants easily (CPCI 2008). Larvae are assumed to be more likely to move off fruit than larval phytophages, and may do so at any time in search of prey. The likelihood of finding prey depends on how close the fruit distribution pathway takes them to a prey source. The ability of adults to move greater distances from infested fruit to sources of prey by flight significantly increases their likelihood of exposure.
H. convergens is a generalist predator, whose prey is found on a wide range of plants. Prey species such as *Aphis gossypii* and *Myzus persicae* are widely distributed, and are known to be present on native as well as introduced plant hosts in New Zealand (Spiller & Wise 1982). There should be no lack of suitable prey species for this ladybird in a wide range of habitats.
The likelihood of exposure is considered to be moderate.

6.2.2.3. Establishment assessment

A mated female or at least one individual of both sexes would be necessary to establish a reproductive population, as ladybirds reproduce sexually.
This species is distributed throughout the Pacific Northwest where climatic conditions are similar to those of New Zealand, indicating climate would not be a restricting factor for establishment. Nevertheless, two deliberate attempts have been made to introduce *H. convergens* into New Zealand from the USA. Both were apparently unsuccessful and although large numbers of ladybirds were released, the species did not establish (Thomas 1989). This indicates that some barriers to establishment may exist. Adult ladybirds can fly actively and an established population would probably have little difficulty spreading throughout New Zealand.
The likelihood of establishment is considered to be very low

6.2.2.4. Consequence assessment

Economic consequences

H. convergens is a polyphagus predator of various insects, particularly aphids. It is generally considered to be beneficial to crops by feeding on pest species. There is a possibility that the addition of generalist predators could disrupt existing IPM programmes, which could have negative economic consequences (see discussion for *Chrysopa* species). It is possible but highly unlikely that access to some markets could be disrupted.

Environmental consequences

Several arthropod generalist predators are known to have become invasive when moved by humans beyond their native range but their ecological effects are complex and unpredictable (Snyder & Evans 2006). They may include direct effects on potential prey species and indirect effects on native predators. It is likely that this ladybird could exploit native aphids as prey. If it were able to penetrate native ecosystems, *H. convergens* could be assumed to have at least a minor impact, as it would probably be feeding on native arthropods. Snyder & Evans

(2006) specifically advise against the intentional introduction of arthropod generalist predators (e.g. ladybirds for biological control or crayfish species for aquaculture) given the large potential for adverse effects.

Human health consequences

There are no known human health consequences. Ladybirds do not bite or sting humans.

The establishment of H. convergens in New Zealand is likely to cause negligible economic and very low environmental consequences.

6.2.2.5. Risk estimation

H. convergens has a low likelihood of entry, a moderate likelihood of exposure and a very low likelihood of establishment in New Zealand. The economic consequences are likely to be negligible and the environmental consequences low. The risk associated with *H. convergens* on fresh stonefruit imported from the Pacific Northwest is non negligible and phytosanitary measures can be justified.

6.2.3. Risk management

6.2.3.1. Options

Pest free areas or places of production

H. convergens is likely to be widespread in the Pacific Northwest and pest-free areas are not a viable option.

Orchard management, harvest and post-harvest processing

Because ladybirds are viewed as beneficial insects there are no management programmes in place for them, though population levels are likely to be dependent on those of their prey and these species are also likely to be controlled by management programmes for phytophages. Harvesting and packhouse procedures such as post-harvest brushing and sorting of fruit are likely to remove ladybirds.

Cold treatment (pre-export or in transit)

It is not known what effect cold treatment would have this species.

Visual inspection

H. convergens adults are moderately small (ca. 5 mm in length), but adults and larvae are brightly coloured and distinctive in appearance. Additionally they are not cryptic by nature, so thorough inspections are likely to detect them.

6.2.3.2. Risk management options in descending order of stringency

Option 1: orchard management
Option 2: packhouse procedures, particularly washing and brushing
Option 3: post harvest inspection
Option 4: no measures, taking into account the likely very low likelihood of establishment, negligible economic and low environmental impacts of this species.

6.2.4. Assessment of uncertainty

- it is assumed that predators are more likely to move off fruit than phytophages, making the likelihood of exposure higher.
- there is uncertainty and considerable debate over the ecosystem effects of generalist predators

- no information on thermal thresholds for this species was found, so it is unknown what effect cold treatment would have.

6.3. *Anthonomus quadrigibbus* (apple curculio)

Scientific name: *Anthonomus quadrigibbus* Say, 1831 (Coleoptera: Curculionidae)
Common name(s): apple curculio, larger apple curculio, western apple curculio, cherry curculio
Other scientific names: *Tachypterellus quadrigibbus*, *Tachypterellus quadrigibbus magna*, *Tachypterus quadrigibbus*

PNW status

Recorded from Washington, Oregon and Idaho (Burke & Anderson 1989, EPPO/CABI 1997h, CPCI 2008: restricted distributions in all three states)

New Zealand status

A. quadrigibbus is not known to be present in New Zealand. Not recorded in EPPO/CABI (1997h), CPCI (2008); genus not recorded by Leschen *et al.* (2003).

General geographic distribution

USA, Canada, Mexico (CPCI 2008). In the USA it is known from every mainland state except Nevada and Wyoming, where it probably also occurs (Burke & Anderson 1989).

Hosts

A. quadrigibbus is associated with a wide range of plants in the genera *Amelanchier*, *Crataegus*, *Malus*, *Prunus*, *Pyrus* and *Sorbus* (Rosaceae) and *Cornus* species (Cornaceae) (CPCI 2008). Beers *et al.* (2003) record it from cherry, peach and plum.

Plant part(s) affected

Fruit/pods, inflorescence and seeds (CPCI 2008)

Biology

A. quadrigibbus is univoltine (that is have only one generation per year) (CPCI 2008). Adults overwinter under debris on the ground, but do not enter the soil (Hammer 1936). They emerge early in spring, when ground surface temperatures exceed 16°C for about 24 hours (Hammer 1936), and disperse actively (CPCI 2008). They attack foliage or tender twigs during the blossom period and flower buds, blossoms, and fruit as soon as it begins to form (CPCI 2008). The first signs of injury are usually tiny punctures through the skin of the fruitlets. Beneath the punctures, the adults dig out cavities for feeding or oviposition (Burke & Anderson 1989). Oviposition punctures are closed with a pellet of frass (Hammer 1932, 1936) and generally occur on the lower halves of the fruit, seldom on the calyx end (CPCI 2008). As the fruit grows it becomes deformed. Larvae, pupae and adults can be found in mature apples (EPPO/CABI 1997h). Feeding on maturing fruit by adults produces collapsed brown spots that can coalesce. Larvae feed primarily on the seed(s), though they may also be found in the fruit flesh (Hammer 1932). Apparently they do not tunnel through the fruit.
Eggs are around 1 mm long, final instars are 7.5–9 mm, pupae 4.7–5.5 mm and adults 5 –11 mm, including the long "snout" (CPCI 2008). Females lay from 20 to over 100 eggs, one to six eggs per fruit (Hammer 1936). Eggs take 7 to 10 days to hatch (Lamerson 1934). There are three larval instars, taking 13 to 28 days. Pupation usually occurs in the fruit while it is still on the tree (Hammer 1932), and takes 4 to 7 days (bionomics for Kansas, Lamerson 1934). There is considerable mortality in growing fruit due to rapid growth of the fruit tissue surrounding the oviposition cavities crushing the eggs (Hammer 1936). Newly emerged adults eat their way out of the fruit still clinging to the trees (Hammer 1932).

6.3.1.2. Hazard identification conclusion

A. quadrigibbus is present in the Pacific Northwest and is not known to be present in New Zealand. It is associated with stonefruit and known to infest fruit, and is therefore treated as a potential hazard in this analysis.

6.3.2. Risk assessment

6.3.2.1. Entry assessment

Eggs are laid in developing fruit, and cause it to become deformed and unlikely to be harvested. Larvae, pupae and adults may be found in mature fruit (EPPO/CABI 1997h), but are likely to cause conspicuous damage. CPCI (2008) states there are no records of their interception, and *A. quadrigibbus* has not been identified at the New Zealand border on fresh produce (Quancargo database). Additionally most reports of damage to crops are at least 30, and most over 50 years old (EPPO/CABI 1997h), suggesting that this species is largely controlled by existing programmes and that population levels are low. Beers *et al.* (1993) state that *A. quadrigibbus* has not been seen by them in Washington. The entire life cycle from egg to newly emerged adult takes around 7 weeks in the field, so this insect would have the ability to survive air and sea freight, depending on the specific circumstances.

The likelihood of entry is considered to be very low.

6.3.2.2. Exposure assessment

All life stages may enter the country within fruit. Following post-border distribution, fruit will either be consumed (and the remains discarded) or discarded whole. Immature weevils would need to develop through to adults and emerge from the fruit while it is still in a suitable condition, but mature pupae and adults would be able to emerge soon after entry. Adults are strong fliers (CPCI 2008) and would be able to disperse and find suitable hosts if they emerge successfully from infested fruit. There should be no lack of hosts throughout most modified habitats in New Zealand.

The likelihood of exposure is considered to be moderate.

6.3.2.3. Establishment assessment

A. quadrigibbus reproduces sexually (CPCI 2008, EPPO/CABI 1997h). Adults may enter New Zealand in fruit but are very unlikely to have mated, so at least one of each sex would need to enter, locate each other and mate to establish a reproductive population. There may be more than one weevil present per fruit.

The species is distributed throughout the Pacific Northwest where climatic conditions are similar to those of New Zealand, indicating climate would not be a restricting factor for establishment. Availability of suitable hosts would not be expected to be a limiting factor for establishment of this species.

The overall likelihood of establishment is considered to be moderate.

6.3.2.4. Consequence assessment

Economic consequences

A. quadrigibbus is widespread in North America on a number of genera of Rosaceae (Burke & Anderson 1989). The literature indicates that its economic impact varies substantially with year, location and possibly host cultivar (CPCI 2008). It can cause very severe damage to apples, locally inflicting more than 50% crop losses (CPCI 2008). Overwintering beetles can cause up to 100% damage (Kelly 1922, Lamerson 1934). Primary damage is caused to fruit by feeding and oviposition. In late summer, feeding punctures may act as a means of entry for pathogens and other insects (Hammer 1936). Besides direct yield loss, the establishment of this species in New Zealand may result in increased pest control costs and may cause disruption of access to some markets.

Environmental consequences

Environmental consequences could include damage to (particularly) amenity or native plants. Beever *et al.* (2007) suggested that, in terms of risk to native flora, weevils are a high risk group, based on known attacks on native plants by exotic species present in New Zealand. However an analysis by Phillips *et al*. (2008) concluded that any impacts of existing exotic weevil species (excluding scolytines) on New Zealand natural ecosystems are likely to be restricted to the effects of just a few species, and that the evidence to date suggests these impacts are minor. Phillips *et al.* (2008) report that of 37 non-indigenous weevil species in NZ (excluding Entiminae and Scolytinae) none have been recorded feeding or breeding on native plants.

Other environmental consequences could include effects from increased use of pesticides, and effects on native weevils due to competition for resources.

Human health consequences

There are no known human health consequences.

The establishment of A. quadrigibbus in New Zealand is likely to cause low to moderate economic and low environmental consequences.

6.3.2.5. Risk estimation

A. quadrigibbus has a very low likelihood of entry, moderate likelihood of exposure and moderate likelihood of establishment in New Zealand. The potential impact within New Zealand is low to moderate. The risk associated with *A. quadrigibbus* on stonefruit from the Pacific Northwest is non negligible and phytosanitary measures can be justified.

6.3.3. Risk management

6.3.3.1. Options

Pest area or pest free place of production

The distribution of *A. quadrigibbus* in the Pacific Northwest may be restricted, in which case pest freedom would be an option.

The requirements for the establishment of a pest free area are described in the International Standards for Phytosanitary Measures (ISPM) number 4, while the requirements for the establishment of a pest free place of production are described in ISPM number 10. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained.

Normally pest free status is based on verification from specific surveys such as an official delimiting or detection survey. *A. quadrigibbus* could be detected by trapping at appropriate times of the year. Adults may be detected at or about the time of blossom, and subsequently, through the use of a beating tray or sweep net. Small punctures ringed by necrotic tissue on the external surface of immature fruit are the initial indications of feeding and possible oviposition. Developing fruit can be monitored weekly for the presence of these punctures. Immature fruit may be cut open longitudinally to inspect for the presence of eggs or larvae. Mature fruit may contain larvae, pupae or adults (CPCI 2008).

It could therefore be considered possible that a reliable determination of pest freedom of the area or place of production could be obtained once an appropriate official delimiting or detection survey had been completed.

Orchard management, harvest and post-harvest processing

Insecticide sprays applied during the adult feeding and oviposition period in the spring appear to give measurable control. Deltamethrin is registered for control of *A. quadrigibbus* on *Amelanchier alnifolia*. The second and third applications (early blossom and petal fall) give adequate control but orchard hygiene is important (CPCI 2008).

Cold treatment (pre-export or in transit)

It is not known what effect cold treatment would have on eggs or larvae. Adults are likely to be able to tolerate low temperatures, being the overwintering stage.

Visual inspection

Eggs are laid inside fruit and larvae feed internally, however the damage is likely to be conspicuous and should be detectable on inspection.

6.3.3.2. Risk management options in descending order of stringency

Option 1: pest freedom
Option 2: orchard management
Option 3: post harvest inspection

6.3.4. Assessment of uncertainty

- there is little data available regarding the distribution of *A. quadrigibbus* in the Pacific Northwest. CPCI (2008) and Beers *et al.* (1993) suggest it is restricted.
- there is very little information available regarding domestic and industry fruit disposal practices e.g. disposal of culled and unsold fruit by wholesalers and retailers, or uneaten fruit and fruit remains by consumers. A survey conducted in the UK found that 26% of fruit purchased was thrown away uneaten, and also that between 15 and 25% of households compost at home (Ventour 2008), but similar data for New Zealand does not appear to be available.
- the effect of cold treatment on immature stages of this weevil is not known.

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7. Analysis of potential hazards – Diptera (flies)

This chapter assesses the biosecurity risks from flies that are potentially associated with stonefruit imported from the Pacific Northwest into New Zealand

7.1. *Rhagoletis completa* (walnut husk fly)

Scientific name: *Rhagoletis completa* Cresson, 1929 (Diptera: Tephritidae)
Common name/s: walnut husk fly
Other scientific names: *Rhagoletis suavis* var. *complet*a, *Rhagoletis suavis completa. Rhagoletis suavis* (Loew) has been treated as a synonym of *R. completa*, but these species are now generally regarded separate (EPPO/CABI 1997d).

PNW status

R. completa has been recorded from Washington, Oregon and Idaho (EPPO/CABI 1997d, CPCI 2008)

New Zealand status

Not known to be present in New Zealand. Not recorded by: EPPO/CABI (1997d), CPCI (2008)

General geographical distribution

Native to North America (EPPO/CABI 1997d). Introduced into some parts of Europe (Germany, Italy, Slovenia and Switzerland) where it has a restricted distribution. Widely distributed in the western USA (AZ, CA, CO, ID, IA, KS, MN, MS, MO, NE, NV, NM, OK, OR, TX, UT, WA) (CPCI 2008)

Hosts

The principal hosts are *Juglans* species. CPCI (2008) lists *Juglans californica*, *J. hindsii*, *J. nigra* and *J. regia*. AliNiazee *et al*. (1996) consider this species to be a key pest of walnuts. EPPO/CABI (1997d) states that "Under certain conditions peaches … may be attacked" but "the significance of this is not clear". CPCI (2008) lists peaches as a minor host. Beers *et al.* (1993) record it as occasionally attacking peaches grown close to walnuts in Washington's Yakima Valley, and AliNiazee *et al*. (1996) record it as "an occasional pest of peaches and nectarines". Yokoyama and Miller (1993) carried out field and laboratory tests and concluded that walnuts were the natural host for *R. completa*, that nectarines and peaches were poor hosts, and that Japanese plums (*P. salicina*) were non-hosts. Field tests and laboratory choice and no-choice tests all showed that oviposition took place and that survival to the pupal stage was possible on nectarines and peaches, but the survival rate was much lower than for walnuts. Yokoyama *et al.* (1992) undertook field sampling in a peach orchard adjacent to a walnut orchard and failed to find pupae in the soil, or rear pupae from fallen fruit, even though adult *R. completa* were trapped in the orchard. Yokoyama and Miller (1999) reported that in laboratory tests plum (*P. domestica*) fruit were accepted as ovipositional hosts in no-choice tests, but that pupae did not develop from the infested fruit.

Plant parts affected

Eggs are laid below the skin of the host fruit and larvae develop within the fruit. Pupation is in the soil under the host plant (EPPO/CABI 1997d).

Biology

The general life history is similar to that of *R. pomonella* (Section 7.2): eggs are laid in groups of about 15 below the skin of the host fruit and hatch after 3-7 days; the larvae usually feed for 2-5 weeks; pupation is in the soil under the host plant and this is the normal overwintering stage; most emerge the following summer as adults, but some pupae remain in the soil for two

years or more. Adults are colourful insects about the size of houseflies and may live for up to 40 days under field conditions (CPCI 2008, Pickel *et al*. 2008j).
Like most *Rhagoletis* species (Prokopy & Papaj 2000), *R. completa* is univoltine, with adults emerging from late June to mid-August or sometimes early September and peak oviposition in late August (data for Oregon, Kasana & Aliniazee 1994). In California adults emerge from late June until early September, with peak emergence around mid-August. In coastal areas emergence can begin as early as mid-May (Pickel *et al.* 2008j). In Washington adults usually emerge from July until early September but sometimes as late as October (AliNiazee *et al*. 1996, Beers *et al.* 1993).

7.1.1.2. Hazard identification conclusion

R. completa is present in the Pacific Northwest, absent from New Zealand. It has been recorded infesting the fruit of stonefruit. It is thus considered to be a potential hazard in this analysis.

7.1.2. Risk assessment

7.1.2.1. Entry assessment

The natural host of *R. completa* is walnut; stone fruit are not preferred hosts, and infestation levels are likely to be low (see section on Hosts). In California Yokoyama and Miller (1994) found adults did not emerge from their puparia until after 1 July, and that the highest numbers of adults were collected in walnuts from 19 August through 8 October. In California, stone fruit harvested prior to July would be extremely unlikely to be contaminated with eggs of this species, but fruit harvested from July to October would be available for oviposition. These dates in could be expected to be delayed the Pacific Northwest, according to data from Kasana and Aliniazee (1994).
The life cycle from egg to pupation takes 3 to 6 weeks in the field (the pupal stage overwinters), so this insect would have the ability to survive air and sea freight (1 to 3 weeks), depending on the specific circumstances.
No interceptions of *Rhagoletis* species have been made on stonefruit from the USA (Quancargo database).
The likelihood of entry is considered to be very low, based on assumed low infestation rates.

7.1.2.2. Exposure assessment

It is unlikely that *R. completa* will enter the country as adults. The most likely life stages to enter the country are eggs or early instar larvae; late instar larvae may enter if there are few in the fruit, and the damage caused is not conspicuous. The lower development thresholds for *R. completa* were determined to be 6.6, 5.3, 2.9 and 5°C for preoviposition, egg, larval and pupal stages, respectively (laboratory data, Kasana & Aliniazee 1994). Thus, ambient temperatures on arrival in New Zealand are likely to be above the lowest necessary for larvae to continue developing (2.9°C). Infested fruit must remain in a suitable condition long enough for larvae to develop to maturity. This time depends on which instar larvae are infesting the fruit. The minimum time would be around a week for late instars. Larvae would then need to find a suitable pupation site – this is usually soil. The likelihood of finding a pupation site depends on the method of fruit disposal. If fruit/remains are disposed of as bagged waste into landfill or into sewage via domestic waste disposal, the likelihood would be negligible. If fruit/remains are disposed of into domestic compost, or randomly by the roadside, the likelihood is high.

Larvae pupate and overwinter in the soil, and most emerge the following summer as adults, but some pupae remain in the soil for two years or more (Beers *et al*. 1993, Pickel *et al*. 2008j). It is not known what conditions are necessary to break diapause. In the Pacific

Northwest, adults emerge from July onwards, which would correspond to January onwards in New Zealand. Stone fruit is likely to arrive in New Zealand from June until late October. Larvae will encounter increasing day lengths and temperatures, and it is possible they may be able to emerge in the summer immediately after they arrive, or they may need to overwinter until the following summer (15–18 months). In either case they are likely to emerge in mid summer, and must find a suitable host.

The host range of *R. completa* is apparently somewhat limited. The natural host is walnut (*Juglans* spp.). Several species are present in New Zealand, including *J. regia* (English walnut), *J. nigra* (black walnut) and *J. ailantifolia* (Japanese walnut). English walnuts are now the most abundant and successfully cultivated edible nut and in many towns and cities the majority of large older gardens have at least one tree (Webb *et al.* 1988). Peaches and nectarines are possible hosts and these are also widely distributed in modifed habitats.
The likelihood of exposure is considered to be moderate

7.1.2.3. Establishment assessment

Since it is unlikely that mated females will enter the country, for establishment to take place adults of both sexes must emerge, locate host plants and mate (in this order, mating appears to occur exclusively on host plants in *Rhagoletis* species, Prokopy & Papaj 2000). This likelihood is higher for insects such as fruit flies, where more than one individual is likely to be present in a fruit, than for solitary insects (Yamamura & Katsumata 1999).
Since flies must oviposit in fruit, not only must a suitable species of host be available, but it must also be fruiting when the flies emerge. *R. completa* prefer to oviposit in mature, slightly coloured fruits (Yokoyama & Miller 1993). *J. regia* flowers in October (Webb *et al.* 1988); and mature nuts are shed from the end of March and through April[1], so suitable fruit is likely to be available when adults emerge. Similarly peach and nectarine fruit are likely to be available when adults emerge.
The odour of ripening fruit attracts both sexes, and males also produce a pheromone which attracts females, but only over short distances (Prokopy & Papaj 2000). Opp *et al*. (2003) conducted field and laboratory trials testing the flight capacity of *R. completa* and concluded that it is “neither a weak flier nor likely to be confined to a single orchard if other hosts are available within ½ mile” (0.8km).

In summary, suitable hosts are widespread in New Zealand and fruit is likely to be available for oviposition when adults are likely to emerge. The existing distribution of this species suggests that ecoclimatically most places in New Zealand will be suitable for establishment.
The overall likelihood of establishment is estimated to be moderate.
[1]http://www.crackernut.co.nz/supplying.html

7.1.2.4. Consequence assessment

Economic consequences

R. completa was previously included in the EPPO A1 quarantine list with other *Rhagoletis* species, but because it has now been introduced into some European areas it has been removed from the A1 list. Because there are no practical measures to prevent its spread and it is not considered to be a very important pest, EPPO decided against adding it to its A2 list. In the EPPO region, the only economically significant host is probably walnuts, and it could become a problem for walnut fruit production (in 1991, 50% of harvested walnuts in some Italian orchards were infested by *R. completa*; Ciampolini & Trematerra 1992). Plant Health Australia lists this species as an Emergency Plant Pest Priority.
The walnut industry in New Zealand is currently small and primarily domestic, with imports accounting for most consumption a decade ago, but with consumption rising at about 6% per year (McNeil & Savage 2001).

Planted areas in June 2005 were 518 hectares (Aitken *et al*. 2007). Stonefruit production is a larger industry, but this pest is likely to have only limited impact on these crops. Establishment of this species in New Zealand could cause disruption of access to some markets, including Australia. Additional sprays to control *R. completa* may disrupt the IPM systems already in place in commercial orchards.

Environmental consequences

The host range of *R. completa* is comparatively limited, with all known hosts in the family Rosaceae. Environmental consequences could include damage to (particularly) amenity or possibly native plants. The only listed threatened species within Rosaeae is *Acaena rorida* (nationally critical, Plant Conservation Network). Other environmental consequences could include effects from increased use of pesticides, and effects on native tephritids due to competition for resources.

Human health consequences

There are no known human health consequences.
The establishment of R. completa in New Zealand is likely to cause low to moderate economic and low environmental consequences.

7.1.2.5. Risk estimation

R. completa has a very low likelihood of entry and a moderate likelihood of exposure and establishment in New Zealand. The economic impact is likely to be low to moderate and the environmental impact low. The risk associated with *R. completa* on fresh stonefruit imported from the Pacific Northwest is non negligible and phytosanitary measures can be justified.

7.1.3. Risk management

Rhagoletis species (*fausta*, *indifferens* and *pomonella*) have been considered in other Import Health Standards, and previously approved quarantine measures exist for these pests, although not for *R. completa*. Biosecurity New Zealand requires risk mitigation measures for these three species on cherries from the Pacific Northwest, consisting of following an agreed offshore fruit fly treatment (Appendix 7). Interception of live or dead *Rhagoletis* species would result in the shipment being rejected (reshipped or destroyed) and the packinghouse being suspended for the remainder of the season. There have been no interceptions of *Rhagoletis* species on fresh stonefruit at the New Zealand border (Quancargo database).

7.1.3.1. Risk management options

Options and consequent measures put in place to mangage *R. pomonella* are also expected to manage *R. completa* (Section 7.2.3). Only information specific to *R. completa* is discussed here.

Agreed offshore fruit fly treatment

This treatment consists of the use of a methyl bromide fumigation in conjunction with orchard pest management programmes. The programme developed for cherries from the Pacific Northwest (Appendix 7) could be used as a basis, with confirmation that preshipment activities have been undertaken by the USA NPPO providing appropriate phytosanitary certification.

Pest free area or pest free place of production

This species is likely to be widely distributed in the Pacific Northwest and pest freedom is unlikely to be an option.

Orchard management

One to three insecticide applications per season are recommended, the first within 10 days after trap catches show a sharp increase over a 3 day period. The removal of fallen infested fruit and the removal of alternate hosts (usually infested walnut trees) are also recommended. Because some pupae remain in the ground for more than one year, flies may continue to appear after the source is removed and control may be needed over several years (Beers *et al.* 1993).

Cold treatment

Yokoyama and Miller (1996) found that survival to the pupal stage for 2nd and 3rd instars of *R. completa* was significantly lower than controls after exposure to low temperature storage in green walnuts at 1.1–1.7° C for 7, 14, and 21 days. Few pupae developed from eggs and 1st, 2nd, and 3rd instars after a 21-day exposure.

7.1.3.2. Risk management options in descending order of stringency

Option 1: agreed offshore fruit fly treatment (MeBr fumigation plus orchard pest management and postharvest culling, washing, waxing and visual inspection)
Option 2: a systems approach incorporating demonstrated poor host status with other treatments *e.g.* cold treatment; or life-cycle "window"

7.1.4. Assessment of uncertainty

- levels of infestation on stonefruit in the Pacific Northwest are not know but are assumed to be very low based on the available literature
- there is very little information available regarding domestic and industry fruit disposal pathways and practices. A UK survey showed that between 15 and 25% of households compost at home (Ventour 2008), but data for New Zealand does not appear to be available. Additionally little is known about disposal of culled and unsold fruit by wholesalers and retailers.

7.2. *Rhagoletis pomonella* (apple maggot)

Scientific name: *Rhagoletis pomonella* (Walsh, 1867) (Diptera: Tephritidae)
Common name/s: apple maggot
Other scientific names: *Rhagoletis symphoricarpi, Spilographa pomonella, Trypeta pomonella, Zonosema pomonella*

PNW status

Recorded from Washington and Oregon (Brunner 1996, EPPO/CABI 1997g, CPCI 2008) and Idaho (Beers *et al*. 1993, Brunner 1996). WSDA has been operating an apple maggot control program in Washington State since 1980, and *R. pomonella* is currently present in 22 of 39 counties (WSDA 2008).

New Zealand status

Not known to be present in New Zealand. Not recorded by: EPPO/CABI (1997g), CPCI (2008)

General geographical distribution

Native to North America (Weems Jr & Fasulo 2002). Recorded from Canada, the USA (AR, CA, CO, CT, DE, FL, GA, IL, IN, IA, KS, ME, MD, MA, MI, MN, MS, MO, NE, NH, NJ, NY, NC, ND, OH, OR, PA, RI, SC, SD, TX, UT, VT, VA, WA, WV, WI) and Mexico (CPCI 2008)

Hosts

R. pomonella belongs to the "*pomonella*-group" of Bush (1966). In addition to *R. pomonella*, this group includes the blueberry maggot, *R. mendax* Curran; the dogwood maggot, *R. cornivora* Bush and the snowberry maggot, *R. zephyria* Snow. The other species in this group infest only one or two plant genera, each in different families, but *R. pomonella* seems to be the most adaptable, infesting at least 16 plant species in five genera of the family Rosaceae (Brunner 1996).
The natural host is hawthorn (*Crataegus* spp.), while the major commercial host is apple (CPCI 2008), although according to Brunner (1996), cherry is preferred as a host over apple in Utah.
In addition to apple, cherry and hawthorn, *R. pomonella* can infest crab apple, plum, apricot, pear, wild rose, *Cotoneaster* sp. and *Pyracantha* sp. (Brunner 1996). However in Washington it has only been recorded on apple, crab apple and hawthorn (Beers *et al*. 1993, Brunner 1996). According to CPCI (2008) minor hosts include apricot and peach (see "Assessment of uncertainty").
White and Elson-Harris (1992) give a list of hosts, which include apricot, peach and plum. They regard all valid records to be from the plant family Rosaceae, and records from Ericaceae and Solanaceae to be based on misidentifications.

Plant parts affected

Eggs are laid below the skin of the host fruit, larvae feed in fruit pulp and pupation is in the soil under the host plant (CPCI 2008)

Biology

(After CPCI 2008 unless otherwise stated). Like most *Rhagoletis* species, *R. pomonella* is univoltine. Females lay their eggs beneath the skin of the fruit. The larvae hatch 3 to 7 days later and tunnel into the fruit pulp in all directions, leaving brown channels. This infestation is visible to the naked eye when fruit is cut open (EPPO/CABI 1997g). When a single fruit is infested with several larvae, the pulp will be honeycombed with burrows until it breaks down.

Larvae complete their development within one fruit, taking anywhere from 2 weeks to several months to mature, depending primarily on fruit hardness (Brunner 1996). They may exit from hanging fruit on rare occasions, but usually infested fruit drops to the ground. Larvae remain inside the dropped fruit until reaching maturity, when they make an exit hole in the skin of the fruit, move to the ground and enter the soil to pupate. They burrow to a depth of 2 to 5 cm, usually beneath the host plant. Larval emergence from fruit may continue into early December. Pupae stay dormant over winter, and they may persist in the soil for several years. Adults emerge in late June or July, and may feed on honeydew and bird dung, reaching sexual maturity 7 to 10 days after emergence. As the flies mature and mate they respond more to oviposition-site stimuli, that is, fruit shape and fruit odour. After mating, a single female fly is capable of laying over 200 eggs. Adults usually die after 3 to 4 weeks, but may live up to 40 days under field conditions. Larvae are cream coloured and 6 to 9mm long (Beers *et al.* 1993, Caprile *et al.* 2006a); adults are black and smaller than the average house fly (Weems Jr & Fasulo 2002). Larvae infesting a single fruit may be from one or more females, and there is a significant positive correlation between fruit size and the number of larvae per fruit (Aluja *et al.* 2001). Injury to fruit can also leave the infested fruit prone to secondary infection by pathogens causing further fruit rotting (Caprile *et al*. 2006a).

7.2.1.2. Hazard identification conclusion

R. pomonella is present in the Pacific Northwest, absent from New Zealand. It has been recorded infesting the fruit of stonefruit and is therefore considered to be a potential hazard in this analysis.

7.2.2. Risk assessment

7.2.2.1. Entry assessment

R. pomonella is present in all three states of the Pacific Northwest, though the WSDA has been operating a control program in Washington State since 1980. Detection and containment of *R. pomonella* within its present geographical limits in Washington is a high priority and WSDA coordinates control activities in urban areas to achieve eradication of local populations, or suppression to levels where they are not a threat to commercial apple orchards. Any orchard or production site that is infested or threatened with infestation by apple maggot must be inspected by the department following accepted agency standards (WSDA 2008). *R. pomonella* has never been found in commercially packed fruit in Washington (WSDA 2008).

The major commercial host is apple, but apricot and plum are known hosts and peach is a possible host. Infestation levels of stonefruit are very unlikely to be high.

The life cycle from egg to pupation takes anywhere from 2 weeks to several months in the field (the pupal stage overwinters), so this insect would have the ability to survive air and sea freight, depending on the specific circumstances.

The likelihood of entry is low.

7.2.2.2. Exposure assessment

Factors influencing exposure are likely to be similar to those for *R. completa*. Adults emerge from the soil during early summer (Weems Jr & Fasulo 2002) and, like those of *R. completa*, will need to find a suitable host.

R. pomonella is polyphagous and there would be no shortage of hosts in modified habitats. Stone fruit and apples are common in suburban areas. The natural host is hawthorn (*Crataegus* spp.). Several species are present in New Zealand, including *C. simonsii* and *C. monogyna*. *C. monogyna* is widespread in rural and urban localities, while *C. simonsii* has a more southerly distribution (Webb *et al.* 1988).

The likelihood of exposure is considered to be moderate.

7.2.2.3. Establishment assessment

It is unlikely that mated females will enter the country, so for establishment to take place adults of both sexes must emerge, locate host plants and mate (in this order, mating appears to occur exclusively on host plants in *Rhagoletis* species: Prokopy & Papaj 2000). This likelihood is higher for insects such as fruit flies, where more than one individual is likely to be present in a fruit, than for soliatry insects (Yamamura & Katsumata 1999). *R. pomonella* is known to lay large numbers of eggs in a single fruit (Klass 2003), and several females may lay eggs in the same fruit (Aluja *et al.* 2001).

Since females must oviposit in fruit, for establishment to take place not only must a suitable species of host be available, but it must also be fruiting when adult flies emerge (early summer). The natural hosts are *Crataegus* species: *C. monogyna* fruits from December to April and *C. simonsii* has an extended fruiting period from December to July (Webb *et al.* 1988). Fruiting in apples varies with variety, but fruit are generally harvested from mid February until late April or mid May (Hawkes Bay Fruitgrowers Association). Stonefruit are available from mid-November to mid March (Summerfruit New Zealand, 2008). Adults are winged and have been recorded moving up to 100 m in the presence of hosts, and up to 1.5 km when released away from an orchard (CPCI 2008).

In summary, suitable hosts are widespread in New Zealand and fruit are likely to be available for oviposition when adults emerge. This species can apparently survive in a wide range of conditions, from the cool, coastal climate of western Oregon and Washington, to the hot, dry climate of The Dalles, Oregon, or the mountain conditions of Utah (Beers *et al*. 1993), and its existing distribution suggests that most places in New Zealand will be suitable for establishment.
The likelihood of establishment is estimated to be moderate.

7.2.2.4. Consequence assessment

Economic consequences

R. pomonella is a key pest of commercial apples throughout eastern Canada and the northeastern United States. If left unchecked it can damage almost all the fruit on infested trees, and even small numbers can heavily damage apple crops (Beers *et al.* 1993). It is on the EPPO A1 "List of pests recommended for regulation as quarantine pests" and is considered the most serious fruit fly pest in North America, except for introductions of *Ceratitis capitata* (EPPO/CABI 1997g). *R. pomonella* is the subject of quarantine regulations in many countries and establishment in New Zealand could cause wide-scale disruption of market access. Loss of export markets would mean that additional fruit would be channelled to the domestic market. Additional sprays to control *R. pomonella* may disrupt the IPM systems already in place in commercial orchards. Use of certain sprays for control or disinfestation could prevent export or be limited by ACVM (Agricultural Compounds and Veterinary Medicines, NZFSA) or ERMA (Environmental Risk Management Agency).

Should an incursion occur, attempts to eradicate *R. pomonella* would have very significant national impacts. Additionally, there are no effective and/or selective traps currently used for detection of this species, so it would be difficult to detect, eradicate and/or control if it established in New Zealand. A synthetic attractant based on butyl hexanoate is used in some areas but have had limited effectiveness and selectivity (Rull & Prokopy 2000).

Environmental consequences

Environmental consequences could include damage to (particularly) amenity or native plants. The valid host records for *R. pomonella* all appear to be from the family Rosaceae (White &

Elson-Harris 1992). The only listed threatened species within Rosaeae is *Acaena rorida* (nationally critical, Plant Conservation Network). Other environmental consequences could include effects from increased use of pesticides, and effects on native tephritids due to competition for resources.

Human health consequences

There are no known human health consequences

The establishment of Rhagoletis pomonella in New Zealand is likely to cause high to severe economic and low environmental consequences

7.2.2.5. Risk estimation

Rhagoletis pomonella has a low likelihood of entry and a moderate likelihood of exposure and establishment in New Zealand. The economic impact is likely to be high to severe and the environmental impact low. The risk associated with *R. pomonella* on fresh stonefruit imported from the Pacific Northwest is non negligible and phytosanitary measures can be justified.

7.2.3. Risk management

Rhagoletis species (*fausta*, *indifferens* and *pomonella*) have been considered in other Import Health Standards, and previously approved quarantine measures exist for these pests. Biosecurity New Zealand requires risk mitigation measures for these three species on cherries from the Pacific Northwest. They consist of following an agreed offshore fruit fly treatment (Appendix 7). Interception of live or dead *R. pomonella* would result in the shipment being rejected (reshipped or destroyed) and the packinghouse being suspended for the remainder of the season. There have been no interceptions of *R. pomonella* on fresh stonefruit at the New Zealand border (Quancargo database).

7.2.3.1. Risk management options

Agreed offshore fruit fly treatment

This treatment consists of the use of a methyl bromide fumigation in conjunction with orchard pest management programmes. The programme developed for cherries from the Pacific Northwest (Appendix 7) could be used as a basis, with confirmation that preshipment activities have been undertaken by the USA NPPO providing appropriate phytosanitary certification.

Pest free area or pest free place of production

Pest freedom may be an option. The requirements for the establishment of a pest free area are described in the International Standards for Phytosanitary Measures (ISPM) number 4, while the requirements for the establishment of a pest free place of production are described in ISPM number 10. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained. Normally pest free status is based on verification from specific surveys such as an official delimiting or detection survey. WSDA has developed an apple maggot control programme which includes a survey component (administered by WSDA). The survey programme is based on the deployment of 5,000 to 8,500 apple maggot traps placed in the field each summer. It could therefore be considered possible that a reliable determination of pest freedom of the area or place of production could be obtained.

Fruit treatments

Since the withdrawal of Ethylene Dibromide because of its carcinogenicity (EPPO/CABI 1997g), many alternative disinfestation techniques have been developed (e.g. hot air and hot water treatments, use of radiation and cold storage) (McPheron & Steck 1996).

Irradiation

The recommended irradiation treatment dose for Tephritidae is 150 Gy (non-emergence treated eggs, larvae; Corcoran & Waddell 2003). However specific research into the efficacy of irradiation against *R. pomonella* in apples and pears has been conducted (Hallman 2004). This showed that 57 Gy completely prevented pupation in 22,360 and 15,530 third instars, irradiated in ambient and hypoxic atmospheres respectively. Hypoxia is known to reduce the effects of radiation on organisms because less oxidative radicals, responsible for some of the radiation injury, are produced. Fruit is often stored under hypoxic conditions to prolong shelf life.

Cold treatment

Weems Jr and Fasulo (2002) suggested that *R. pomonella* in fruit may be killed by placing the fruit in cold storage at 0° C for a period of 40 days, and disinfestation by cold storage at 0°C for 40 days is approved by some regulatory agencies (Hallman 2004). The Canadian Food Inspection Agency requires that imported fruit has been continuously maintained at a maximum temperature of 0.6°C (33°F) for a minimum of 42 days (CFIA 2008).

Controlled atmosphere

Experiments using elevated atmospheres of carbon dioxide (CO_2) for various exposure times have shown some ability to disinfest apples. Several combinations of different CO_2 levels and periods of exposure were used: 10.6, 14.9, and 19.0% CO_2 and 7 and 14 days. Eggs subjected to the treatments always exhibited some survival, which was lower for the 14 day than the 7 day exposure periods. Newly hatched larvae were less able to survive the treatments. The 7 day exposure allowed low levels of survival of neonates, but the 14-day exposure period allowed virtually no survival at 10.6% CO_2 and no survival at 14.9, and 19.0%. A minimum of 800 larvae were tested at each combination of concentration and exposure time. No apparent browning, internal breakdown or other fruit defects were detected in any of the treatments (Agnello *et al.* 2002).

Orchard management

Preharvest sprays of acetamiprid are recommended for *R. pomonella* control (WSU 2007). Emergence and dispersal of adult flies must be carefully monitored to effectively time treatments. Sticky traps are used in the absence of specific lures. In Oregon, where some orchards are treated regularly for *R. pomonella* the first spray is applied 7 to 10 days after the first fly has emerged. Later sprays follow at 10 to 14 day intervals as long as adults are active and are being caught in traps (Weems Jr & Fasulo 2002).

Fruit fly infestation may be reduced by implementation of in-field sanitation such as removal of infested fruits, ripe or decaying fruits and use of protein bait insecticide. The systematic destruction of infested apples and the elimination of hawthorn in the vicinity of orchards are considered valid control practices (Weems Jr & Fasulo 2002).

Post harvest culling, washing, waxing and visual inspection

Post harvest washing of fruit, followed by visual inspection are supplementary measures which may reduce pest levels in export fruit. When females oviposit in fruit they make oviposition wounds or small punctures around which some discoloration usually occurs (EPPO/CABI 1997g); however these may not be visible to the naked eye, and when fruit is slightly infested there may be no external indication (Weems Jnr & Fasulo 2002). Heavily infested fruit will be conspicuously damaged and is likely to be culled during sorting and packing, but recently (within three days of harvest, G.K.Waite, personal communication 2007) or lightly infested fruit may not be detected. Fruit showing any sign of damage or infestation should be discarded. An inspection protocol for cherry fruit flies in cherries has been developed by MAF Biosecurity New Zealand.

7.2.3.2. Risk management options in descending order of stringency

Option 1: pest freedom
Option 2: agreed offshore fruit fly treatment consisting of MeBr fumigation (or alternative treatment with demonstated equivalent efficacy) plus orchard pest management and postharvest culling, washing, waxing and visual inspection)

7.2.4. Assessment of uncertainty

- the host status of some stonefruit species is uncertain. CPCI (2008) record peach as a host but this is based on references disputed by the USDA. Other recorded hosts include apricot and plum, however Beers *et al.* (1993) only record this species from apple, crab apple and hawthorn in Washington.
- it is not known what conditions are necessary for *R. pomonella* to break diapause.

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8. Analysis of potential hazards – Hemiptera (aphids, bugs, mealybugs, scale, whiteflies)

This chapter assesses the biosecurity risks from Hemiptera that are potentially associated with stonefruit imported from the Pacific Northwest into New Zealand.

8.1. *Orius* species (predatory bugs)

The species examined in this risk assessment have been grouped together because of their related biology and taxonomy. They are predicted to pose a similar risk and require similar mitigation measures. They are: *Orius insidiosus* and *Orius tristicolor* (Hemiptera: Anthocoridae).

Scientific name: *Orius insidiosus* (Say, 1832)
Common name/s: minute pirate bug, insidious flower bug
Other scientific names: *Triphleps insidiosus, Reduvius insidiosus*

Scientific name: *Orius tristicolor* (White, 1879)
Common name/s: minute pirate bug
Other scientific names: *Triphleps tristicolor*

PNW status

O. insidiosus has been recorded from Washington (Newcomer & Yothers 1929) and *O. tristicolor* from Washington (Horton 2004), Oregon (Westigard *et al*. 1986) and Idaho (Hollingsworth & Bishop 1982)

New Zealand status

Neither species is known to be present in New Zealand. Not recorded by: Larivière and Larochelle 2004, CPCI 2008, PPIN 12 March 2008.

General geographical distribution

O. insidiosus has been recorded from Canada, the USA (AL, AZ, AR, FL, GA, IL, IA, KY, LA, MD, MS, MO, NY, NC, ND, OH, OK, PA, SD, TX, VA, WA), Mexico, South America and Europe. *O. tristicolor* has been recorded from Canada, the USA (AZ, CA, ID, MN, OR, TX, UT, WA, WY), Mexico and South America (CPCI 2008, plus references above).

Hosts

Anthocorid bugs are predatory. Prey species for *O. insidiosus* include many thrip species (including *Frankliniella occidentalis* and *Thrips tabaci*) and a wide range of insects including aphids, mites and the eggs of some lepidopteran species; it can also complete development on a diet of pollen (CPCI 2008). This species has been recorded on peaches: i) as a predator of *Grapholita molesta* (Atanassov *et al.* 2003) and ii) feeding on *Rhagoletis completa*, the walnut husk fly (Beers *et al.* 1993). *O. tristicolor* has also been recorded on peaches (Tamaki & Halfhill 1968) and is a predator of *Myzus persicae* (Hollingsworth & Bishop 1982).

Plant parts affected

The association of nymphs and adults with plants is largely indirect, as they feed on other arthropods, but they also feed on pollen. *Orius* eggs are laid within the plant tissue, usually in the leaf stem or in the main vein on the underside of the leaf, but they may be laid in flowers and fruit (CPCI 2008). Live nymphs or adults of *O. insidiosus* have been intercepted on apricots and peaches/nectarines air-freighted from California (C2004/70414 and C2004/90467, Quancargo database) and *Orius* sp. has also been intercepted live twice on peaches/nectarines sea and air-freighted from California (C2003/34621 and C2004/95475, Quancargo database).

Biology

O. insidiosus survives from 40 to 77 days at 25° C (Argolo *et al.* 2002). Development ceases below 10°C (CPCI 2008). Adult longevity and female fecundity at 26°C varies with diet, being respectively 42 days and 144 eggs on *Ephestia kuehniella* eggs and 17 days and 66 eggs on *Frankliniella occidentalis* adults (CPCI 2008).

8.1.1.2. Hazard identification conclusion

O. insidiosus and *O. tristicolor* are both known to be present in the Pacific Northwest and neither species has been recorded from New Zealand. *O. insidiosus* has been intercepted on fresh imported stonefruit and *O. tristicolor* has been recorded infesting the fruit of stonefruit. Both species are classed as potential hazards in this analysis.

8.1.2. Risk assessment

8.1.2.1. Entry assessment

Although anthocorid bugs are largely predatory and do not have a primary association with stonefruit, they are likely to be present on any plant part that their prey are on. *O. insidiosus* has been intercepted live on fresh stonefruit air freighted from California on several occasions, and unidentified species of *Orius* have been intercepted on fresh stonefruit consignments sea and air-freighted from California (Quancargo database). Anthocorid bugs are reasonably long-lived, and these *Orius* species would be able to survive up to three weeks in-transit depending on the specific circumstances.
The likelihood of entry is considered to be moderate.

8.1.2.2. Exposure assessment

Live individuals arriving at the border are likely to be able to survive long enough for fruit to be distributed to a point at which they could move onto a plant infested with suitable prey. Larvae and adults are highly mobile; they move rapidly, and adults can fly reasonably well and easily locate new plants infested with prey species (CPCI 2008). Larvae are assumed to be more likely to move off fruit than larval phytophages, and may do so at any time in search of prey. The likelihood of finding it depends on how close the fruit distribution pathway takes them to a prey source. The ability of adults to move greater distances from infested fruit to sources of prey by flight significantly increases their likelihood of exposure.
Orius species are generalist predators, whose prey are found on a wide range of plants. Prey species such as *F. occidentalis* and *M. persicae* are widely distributed, and at least some prey species are found on native as well as introduced plant hosts. At least some known prey species of *O. insidiosus* and *O. tristicolor* are found on native plant hosts, for example *M. persicae* is known from *Hebe* sp. and *Pittosporum crassifolium* (Spiller & Wise 1982); *Aphis gossypii* (prey of *O. insidiosus*: Soglia *et al.* 2007) has been recorded from *Hebe salicifolia* and *H. speciosa* (Spiller & Wise 1982). *O. insidiosus* can survive on pollen (Weeden *et al.* 2007). There should be no lack of suitable prey species for either species in a wide range of habitats.
The likelihood of exposure is considered to be moderate.

8.1.2.3. Establishment assessment

A mated female or bugs of both sexes arriving together would be necessary to establish a reproductive population. *O. insidiosus* nymphs are known to have a slight tendency to aggregate in the field (CPCI 2008), which could increase the likelihood of more than one individual being on a piece of fruit.

Both species are established in parts of the world with climates similar to that of New Zealand, and both are generalist predators, with prey species that are widely distributed throughout New Zealand in natural and modified habitats. Host plants suitable for oviposition are unlikely to be a limiting factor. Both species are multivoltine (Weeden *et al.* 2007), and females lay relatively large numbers of eggs so the potential for rapid population increase in suitable conditions is high.

The likelihood of establishment is considered to be low to moderate.

8.1.2.4. Consequence assessment

Economic consequences

O. insidiosus and *O. tristicolor* are generalist predators, and although they can feed on pollen and oviposit in plant tissue, there are no reports of damage to host plants. In fact these species may be beneficial to crops by feeding on pest species such as aphids, mites and/or thrips. There is a possibility that the addition of generalist predators could disrupt existing IPM programmes, which could have negative economic consequences, and also the potential for disruption of access to some markets.

Environmental consequences

Several arthropod generalist predators are known to have become invasive when moved by humans beyond their native range but their ecological effects are complex and unpredictable (Snyder & Evans 2006). They may include direct effects on potential prey species and indirect effects on native predators. No native species of *Orius* are known in New Zealand (Larivière & Larochelle 2004), but there are other endemic anthocorids that could potentially be displaced by the establishment of related exotic species. It is likely that *Orius* species could exploit native aphids, mites or thrips as prey. If they were able to penetrate native ecosystems, *Orius* spp. could be assumed to have at least a minor impact, as they would probably be feeding on native arthropods. Snyder and Evans (2006) specifically advise against the intentional introduction of arthropod generalist predators (e.g. ladybirds for biological control or crayfish species for aquaculture) given the large potential for adverse effects.

Human health consequences

Orius species are true bugs with piecing mouthparts, and may occasionally bite humans, but the bite is only temporarily irritating (Weeden *et al.* 2007). Consequences to human health are likely to be negligible.

The establishment of Orius species in New Zealand is likely to cause low economic and environmental consequences.

8.1.2.5. Risk estimation

Orius species have a moderate likelihood of entry and exposure and low to moderate likelihood of establishment in New Zealand. The economic and environmental impacts are likely to be low. The risk associated with *Orius* species on fresh stonefruit imported from the Pacific Northwest is non negligible and phytosanitary measures can be justified.

8.1.3. Risk management

8.1.3.1. Options

Pest free area or pest free place of production

Orius spp. are likely to be widely distributed in the Pacific Northwest, and pest freedom is unlikely to be a viable management option.

Orchard management, harvest and post-harvest processing

Because *Orius* bugs are predatory there are no management programmes in place for them, though population levels are likely to be dependent on those of their prey and these species are also likely to be controlled by management programmes for phytophages. Unidentified species have been intercepted on stonefruit at the border, which indicates that orchard management and standard packhouse procedures cannot reliably disinfest stonefruit of these species.

Treatment

The USDA Treatment Manual (2008; online search) suggested the following Methyl Bromide dosage rates for the fumigation of stonefruit against external feeders such as *Orius* bugs:
• 1.5 lbs per 1,000 ft^3 at 80º F or greater, or
• 2g/m^3 lbs per 1,000 ft^3 at 70 –79º F, or
• 2.5g/m^3 lbs per 1,000 ft^3 at 60 –69º F, or
• 3g/m^3 lbs per 1,000 ft^3 at 50 –59º F, or
• 4g/m^3 lbs per 1,000 ft^3 at 40 –49º F

Cold treatment (pre-export or in transit)

Development ceases below 10°C, but LT_{90}s are not known.

Visual inspection

The small size of these insects (adults are 2–3 mm long, CPCI 2008) may make them difficult to detect, but adults are dark in colour and reasonably conspicuous.

8.1.3.2. Risk management options in descending order of stringency

Option 1: fumigation
Option 2: orchard management
Option 3: post harvest inspection
Option 4: no measures, taking into account the likely low economic and environmental impacts of establishment of these species.

8.1.4. Assessment of uncertainty

- it is assumed that predators are more likely to move off fruit than phytophages, making the likelihood of exposure higher.
- there is uncertainty and considerable debate over the ecosystem effects of generalist predators
- since they are not plant pests, there is currently very little information available about the effects of treatments (*e.g.* cold treatment) on these species.

8.2. Armoured scale insects

Scientific names: *Diaspidiotus ancylus, Diaspidiotus forbesi, Diaspidiotus juglansregiae* and *Pseudaulacaspis pentagona* (Hemiptera: Diaspididae)

The species examined in this risk assessment have been grouped because of their related biology and taxonomy. They are:

Scientific name: *Diaspidiotus ancylus* (Putnam, 1878)
Common name/s: Howard scale, Putnam scale
Other scientific names: *Abgrallaspis comstocki, Abgrallaspis howardi, Aspidiella comstocki, Aspidiella pseudospinosa, Aspidiotus aesculi, Aspidiotus ancylus, Aspidiotus comstocki, Aspidiotus convexus, Aspidiotus epigaeae, Aspidiotus howardi, Aspidiotus latilobis, Aspidiotus ohioensis, Aspidiotus oxycrataegi, Aspidiotus pseudospinosus, Aspidiotus serratus, Aspidiotus solus, Aspidiotus townsendi, Aspidiotus toxycrataei, Diaspidiotus howardi, Diaspidiotus ohioensis, Diaspidiotus solus, Diaspidiotus townsendi, Gonaspidiotus comstocki, Hemiberlesia comstocki, Hemiberlesia howardi, Quadraspidiotus epigaeae, Quadraspidiotus townsendi*

Scientific name: *Diaspidiotus forbesi* (Johnson, 1896)
Common name/s: Forbes scale
Other scientific names: *Aspidiotus forbesi*, *Aspidiotus fernaldi hesperius*, *Diaspidiotus forbesi*, *Forbesaspis forbesi*, *Quadraspidiotus forbesi*

Scientific name: *Diaspidiotus juglansregiae* (Comstock, 1881)
Common name/s: Walnut Scale
Other scientific names: *Aspidiotus albiventer, Aspidiotus albus, Aspidiotus cockerelli, Aspidiotus fernaldi, Aspidiotus glandulifer, Aspidiotus glanduliferus, Aspidiotus iuglans-regiae, Aspidiotus pruni, Diaspidiotus juglans-regiae, Furcaspis juglans-regiae, Quadraspidiotus fernaldi, Quadraspidiotus glanduliferus, Quadraspidiotus juglans-regiae*

Scientific name: *Pseudaulacaspis pentagona* (Targioni-Tozzetti, 1886)
Common name/s: White peach scale
Other scientific names: *Aspidiotus lanatus*, *Aspidiotus vitiensis*, *Aspidiotus pentagona*, *Aspidiotus pentagona rubra*, *Aspidiotus pentagona auranticolor*, *Chionaspis prunicola*, *Diaspis amygdali* var. *rubra*, *Diaspis amygdali*, *Diaspis auranticolor*, *Diaspis geranii*, *Diaspis lanata*, *Diaspis lanatus*, *Diaspis patelliformis*, *Diaspis pentagona*, *Diaspis rubra*, *Epidiaspis vitiensis*, *Howardia prunicola*, *Pseudaulacaspis amygdali*, *Pseudaulacaspis prunicola*, *Sasakiaspis pentagona*

PNW status

All three *Diaspidiotus* species have been recorded from Washington State only:
D. ancylus: recorded by Crowley (1937); LaGasa (2000); Nakahara (1982) states "general distribution in conterminous U.S."
D. forbesi: recorded by LaGasa (2000); Nakahara (1982) states "general distribution in conterminous U.S."
D. juglansregiae: recorded by LaGasa (2000); Nakahara (1982) states "general distribution in conterminous U.S."
These references are either old (Crowley 1937 for *D. ancylus*) or questionable. LaGasa (2000) records *D. ancylus*, *D. forbesi* and *D. juglansregiae* from Washington. The records of *D. forbesi* and *D. juglansregiae* were based on Covell's (1984) "Field Guide to the Moths of

Eastern North America" and are not likely to be correct since this publication does not list scale insects. Nakahara (1982) does not specifically record any of these three species from the Pacific Northwest. ScaleNet (2008) does not record any of these species from the Pacific Northwest, but of the contiguous states, all three species are recorded from California, and *D. ancylus* also from Montana and Utah.

P. pentagona has been recorded from Oregon (CPCI 2008, Nakahara 1982) and Idaho (Maskew 1915, on *Pueraria thunbergiana*).

New Zealand status

None of these species is known to be present in New Zealand. Not recorded by: Charles and Henderson (2002), ScaleNet (2008), PPIN (2008)

General geographical distribution

(summarised from ScaleNet 2008)
Diaspidiotus ancylus: South Africa, Australia (Queensland), Mexico, USA (AL, AZ, CA, CO, CT, DE, DC, FL, GA, IL, IN, IA, KS, KY, LA, MD, MS, MO, MT, NJ, NY, NC, OH, OK, PA, RI, SC, TN, TX, UT, VA, WV), South America, Japan, Mediterranean.
Diaspidiotus forbesi: South Africa, Canada, USA (AZ, CA, FL, GA, IL, KS, MS, MO, OH, TX), Puerto Rico.
Diaspidiotus juglansregiae: Canada, USA (AL, AZ, CA, DC, FL, GA, KS, MA, MS, MO, NY, OH, TX, VA).
Pseudaulacaspis pentagona: Africa, Australia, Polynesia, Micronesia, Hawaiian Islands, Canada, USA (AL, CT, DE, DC, FL, GA, IN, LA, MD, MA, MS, MO, NJ, NM, NY, NC, OH, OR, PA, RI, SC, TN, TX, VA, WV. Collected from California prior to 1920, but never collected again; Gill 1997, CPCI 2008), Mexico, South America, China, Hong Kong, India, Indonesia, Malaysia, Europe, Mongolia, Tibet, the Mediterranean, North Africa, the former USSR, the Middle East, Japan (Balachowsky 1954 states that *P. pentagona* is probably native to Japan), the United Kingdom.

Hosts

D. ancylus has a wide host range, including plants in almost 30 families. Among the Rosaceae it has been recorded from apricot and peach (ScaleNet 2008) and plum (CPCI 2008). *D. forbesi* has been recorded from hosts in over 10 plant families, including peach and plum (ScaleNet 2008). *D. juglansregiae* has been recorded from hosts in around 20 plant families including peach (ScaleNet 2008).

P. pentagona is a broadly polyphagous species. ScaleNet (2008) lists over 300 hosts in 78 plant families, including the following *Prunus* species: *P. amygdaloides*, *P. armeniaca*, *P. avium*, *P. cerasus*, *P. communis*, *P. domestica*, *P. laurocerasus*, *P. mume*, *P. persica*, *P. pognostyla*, *P. pseudocerasus serrulata*, *P. salicina*, *P. sargentii*, *P. subhirtella* and *P. yedoensis.* The host plant range could be much wider than is listed (CPCI 2008). However, *P. pentagona* cannot complete development on some of the hosts listed, which indicates that some may not be true host plants.

Plant parts affected

D. ancylus is recorded from bark, leaves and fruit (ScaleNet 2008); *D. forbesi* from bark (Gill 1997), twigs, branches and fruit (Grantham 2006) and *D. juglansregiae* from bark (ScaleNet 2008). *D. ancylus* and *D. juglansregiae* have both been detected on nectarine fruit in California after packhouse procedures (Curtis *et al.* 1992), with *D. juglansregiae* being one of the common fruit contaminants and *D. ancylus* found less often on fruit.
P. pentagona is often found as thick crusts heavily infesting tree trunks and older branches in temperate regions, and rarely on roots, while the leaves and fruit are not usually infested

(CPCI 2008). However Hill (1987) records the scale insects as encrusting twigs, with some on leaves; Hely *et al*. (1982) state that "scale attacks wood, leaves and fruit" and Watson (2007a) states that fruit infestations can occur. Additionally, it is frequently intercepted in California on shipments of papaya fruit from Hawaii (Follett 2006).

Biology of *P. pentagona*

(After Watson 2007a, unless otherwise stated). *P. pentagona* is an armoured scale insect. Members of this family produce fibrous, wax-like coverings, into which they incorporate their moult skins as they grow. Unlike soft scale insects and mealybugs, armoured scale insects do not produce honeydew (Beardsley & Gonzalez 1975), and are consequently not attended by ants. *P. pentagona* reproduces sexually, with one to four generations per year depending on the climate. The scale insects overwinter as mated females in cold climates, and eggs may also overwinter in warmer climates. Takeda (2006) found that temperature was the most important factor in diapause termination, and that even when females were collected in mid-winter, exposure to temperatures of 25˚C caused some to start egg-laying. Overwintering females continued feeding in the laboratory (Takeda 2006).

Adult females are white or yellow-white and 1.5–2.8 mm in diameter; each lay about 100 eggs, which hatch around 3 to 14 days after laying (depending on temperature). Throughout her adult life, an individual female initially produces offspring of one sex, then both sexes, and finally the other sex. At 11–15˚C a minimum of 110 days is taken to complete a generation, but at 26˚C, generation time is 40 days and females begin to oviposit around 16 days after maturing (Ball 1980). Eggs hatch into first instar nymphs called crawlers, which disperse actively or passively. Once the crawlers settle, they begin feeding by inserting their piercing-sucking mouthparts into the host plant. After female crawlers moult to second instar they cannot move from that site. After feeding, the second instar female moults to the adult stage, also sessile. The only other mobile stage apart from the crawler is the adult male, which is winged, but short-lived and non-feeding.

8.2.1.2. Hazard identification conclusion for *D. ancylus*, *D. forbesi*, *D. juglansregiae* and *P. pentagona*

There is uncertainty over the presence of any of the three *Diaspidiotus* species in the Pacific Northwest. *P. pentagona* is recorded from the Pacific Northwest (Oregon and Idaho). None of these species are known to be present in New Zealand and all are associated with the fruit of stonefruit.

Due to the lack of evidence of presence of the three *Diaspidiotus* species in the Pacific Northwest, only *Pseudaulacaspis pentagona* is classed as a potential hazard and treated in this analysis. However *Diaspidiotus* species are predicted to pose a risk similar to *P. pentagona*, and will require similar mitigation measures should reliable records of their presence in the Pacific Northwest become available.

8.2.2. Risk assessment

8.2.2.1. Entry assessment

P. pentagona is usually found on trunks and branches, and less often on fruit. Although this species is recorded from Oregon and Idaho (historical), it is not reported to be an important pest in these states. Therefore levels of contamination on fruit are likely to be low. All life stages except crawlers and adult males are anchored to their host permanently and would remain on fruit during harvest (Taverner & Bailey 1995).

According to CPCI (2008), *P. pentagona* is probably intercepted in most countries, but the interceptions go largely unreported. It is a quarantine pest for California, and is frequently intercepted there on shipments of papaya from Hawaii (Follett 2006).

In New Zealand this species is very frequently intercepted at the border on sea-freighted, cold treated kiwifruit from Italy, including live specimens (for example Consignments C2002/60377, C2005/328760), but it has not been intercepted on stonefruit shipments (Quancargo database 2008).

P. pentagona is a long-lived species (at 11–15˚C a minimum of 110 days is taken to complete a generation). It is known to survive other transit conditions including cold storage, and thus it is very likely to survive sea transit on stonefruit from the USA.

The likelihood of entry is considered low (based on assumed low population levels).

8.2.2.2. Exposure assessment

Following post-border distribution and disposal of fruit (whole or remains), scale insects need to disperse and locate suitable hosts. The potential for dispersal depends on the life stage and sex. Adult males are the only winged forms, but they are short-lived (Hanks & Denno 1994). The mobile crawler is the primary dispersal stage, but crawlers (and adult males) are unlikely to survive packing and transit conditions. Later instar nymphs and adult females are immobile and would be unable to disperse to a new host, and would die once the fruit they were attached to had decomposed to the point where it was no longer a suitable host. However a mated female (or a dead female with viable eggs), could remain at a fruit disposal location and produce mobile crawlers. Adult females and eggs are also the stages most likely to survive packing and transit. Eggs may hatch in transit or on arrival. Adult females would probably be able to continue development if ambient temperatures exceed 10.5˚C, based on temperature thresholds calculated by Takeda (2004). This condition could be met from October in the northern parts of New Zealand (NIWA 2008).

The following factors will influence the likelihood of exposure of crawlers:

(i) Longevity of the host

Evidence suggests that crawlers will be produced by a female scale insect as long as the host fruit remains in good condition. Schweig & Grunberg (1936) found that adult females of the armoured scale *Chrysomphalus aonidum* survived for 3 to 4 weeks on picked citrus fruit, and from 6 to 17 days on peel. This is time for a mated female to produce crawlers, but different hosts have different shelf-lives. A laboratory study in New Zealand (Anon 1994) showed that whole apples remained viable hosts for successive generations of mealybugs for up to 5 months, despite withering. Stonefruit is unlikely to remain viable for as long as apples or fruit such as melons, avocado or citrus. It is also relatively lower risk in that the skin is typically consumed along with the fruit (but this would not apply to fruit culled by wholesalers or retailers, nor to whole fruit discarded domestically). Survey information from the UK indicates that a significant proportion (26%) of fruit purchased was thrown away uneaten (Ventour 2008).

(ii) Different fruit disposal methods

Crawlers from infested fruit/remains disposed of as bagged waste into landfill or into sewage via domestic waste disposal would have a negligible likelihood of exposure. Those from infested fruit/remains disposed of into domestic compost or randomly by the roadside would have a higher likelihood of exposure. Indeed, many armoured scale insects grow well on the tubers and particularly on the sprouts of potatoes (Berry 1983), and would be capable of establishing on such hosts in domestic compost. However there is very little information available regarding domestic and industry pathways and practices. A UK survey of more than 20,000 households showed that between 15 and 25% of households compost at home (Ventour 2008, breakdown by ethnic groups), but similar data for New Zealand does not appear to be available, and little is known about disposal of culled and unsold fruit by wholesalers and retailers. In California, this was identified as a possible pathway for infestation of avocado trees by armoured scale insects on imported avocados (APHIS 2007).

(iii) Dispersal ability of crawlers

Crawlers are mobile, and recent experiments with mealybugs (three species of *Pseudococcus*) in vineyards showed that large numbers of crawlers do exhibit vertical movement; and that vine trunks, strainer wires and posts are likely pathways for dispersal (Lo *et al.* 2006). It is assumed that behaviour of mealybug crawlers is similar to that of armoured scale insect crawlers, but this may not be correct. Sex differences have been noted in armoured scale insects – female *P. pentagona* crawlers will move about on a plant for up to 12 hours before settling to feed, but males remain near their mother (Branscome 2007). Armoured scale insect crawlers are known to be wind and vector-distributed; they can be moved over several kilometres by wind, flying insects, birds and other animals including humans (Brown 1958, Beardsley & Gonzalez 1975, Greathead 1990). Lo *et al*. (2006) found that once airborne, there is a strong potential for mealybug crawlers to be carried at least 5m and up to 100m (the maximum trap distance) from source vines (V. Bell, pers. comm. 2008) (data for three species of *Pseudococcus*).
Information from situations where the source of the crawlers is small, is not a whole plant, where the crawler density is low and the source of the crawlers is low to or is on the ground (that is, comparable to a piece of discarded fruit) is scarce and somewhat contradictory. Schweig and Grunberg (1936) heaped fruit infested with the armoured scale insect *Chrysomphalus aonidum* on the ground under clean trees and left it for several months. They found that the only infestation that took place was onto branches that were in direct contact with the fruit, but no details were given of the numbers of fruit used or the number of replicates performed. In a similar experiment Melis (1943, reported in APHIS 2007) found that infested fruit placed on the ground were not important in spreading the armoured scale *Diaspidiotus perniciosus* unless a piece of fruit was placed in direct contact with a susceptible host. However a study using mealybugs (*P. longispinus*; Anon 1994) showed that when apples infested with crawlers and adults were caged outdoors in small enclosures with a suitable host tree, 83% of the trees used (n = 12) had been infested with crawlers within 30 days. No adults moved successfully from the fruit to the tree. Fruit was close to but not touching host trees.

(iv) Mortality at the crawler stage

Mortality in *P. pentagona* crawlers in the field was assessed at around 90%, compared to that of 30% for subsequent life stages (Oda 1963). Crawlers are susceptible to extremes of temperature, desiccation, rain, predation and a lack of suitable settling sites. However Barrass et al. (1994) found that 75% of mealybug crawlers (three species of *Pseudococcus*) survived low humidity (32% RH) for 48 hours. Although this work was laboratory-based, it suggests that mealybug crawlers are more likely to survive wind-dispersal in the field than previous literature has suggested.

A recent analysis has examined the phytosanitary risk associated with armoured scale insects on fresh produce for consumption in the USA (APHIS 2007). It argued that the fresh produce (for consumption) pathway is a relatively unimportant one in the introduction of scale insect species and that the risk of exposure is extremely low.

Analysis of armoured scale insect establishment patterns in New Zealand adds weight to the suggestion that the fresh produce pathway is not a high risk one for these insects: 28 exotic armoured scale insect species are known to be established here (Charles & Henderson 2002, PPIN 2008). Of these, three species are known to have established in the last 30 years: *Hemiberlesia lataniae*, first record in 1979; *Lepidosaphes pallida*, first record in 2001 (Charles & Henderson 2002) and *Furchadaspis zamiae*, first record in 2004 (R. Henderson, pers. comm.). *F. zamiae* is a pest of cycads affecting leaves and stems (Watson 2007b), and is not likely to be present on imported fruit. *L. pallida* feeds on conifers, sometimes damaging them (Watson 2007c), and is also unlikely to be present on imported fruit. *H. lataniae* is a cosmopolitan polyphagous species, found on leaves, stems and fruit, and is reasonably likely to be present on imported fruit. Thus of the three species known to have established in New Zealand in the last three decades only one, *H. lataniae*, is even likely to be present on the fresh produce pathway. Nursery stock is more likely to be the main pathway for entry of armoured scale insects into new areas (APHIS 2007).

However *P. pentagona* is an extremely polyphagous species and there would be no shortage of suitable host species throughout New Zealand. Additionally, this scale insect is able to exploit most plant parts including bark, leaves and fruit (hence the reference to a "triple threat", Branscome 2007) so it is not dependent on coming into contact with a specific part of a host plant. The available evidence does however suggest that the source of infestation must be more or less contiguous with, or very close to, the new host. Situations of exposure that might fit into this scenario could include infestation of sprouting potatoes in domestic compost, or infestation of hosts contiguous to infested fruit disposed of by wholesalers or retailers.
The likelihood of exposure is considered to be low.

8.2.2.3. Establishment assessment

A mated female or immatures of both sexes would be necessary to establish a reproductive population, as there are no reports of parthenogenesis in this species. Since exposure probably depends on successful crawler dispersal, for establishment to take place crawlers of both sexes need to find a suitable host, develop to adult stage, successfully locate each other, mate and produce viable offspring. This likelihood is considered to be higher for scale insects than for solitary insects, due to their tendency to have an aggregated or clumped spatial distribution. Yamamura and Katsumata (1999) referred to this type of pest as gregarious, and considered them to have a higher probability of introduction into new areas via trade, due to the heightened likelihood of their locating a mate in the new environment.
Generation time is relatively long at low temperatures, but the species is multivoltine at higher temperatures and females each lay around 100 eggs, so the potential for rapid population increase in suitable conditions is high. *P. pentagona* is established in parts of the world with climates similar to that of New Zealand, but may be limited to glasshouses in colder parts of the country.
The likelihood of establishment is considered to be moderate.

8.2.2.4. Consequence assessment

Economic consequences

P. pentagona was described as a very destructive pest by Kosztarab (1996), especially on flowering cherry, mulberry, peach and other deciduous fruit trees. Williams and Watson (1988) and Danzig and Pellizzari (1998) also describe it as a destructive species, and it is also known to attack currant, grape, kiwifruit and walnut, as well as some woody ornamental plants (Watson 2007a). It is unclear whether commercial pipfruit crops are reproductive hosts of this species, although CSL (2007) lists ornamental apple species as major hosts. If so the potential economic consequences of its establishment are greatly increased because *P. pentagona* is absent from key apple export markets such as Taiwan and Japan. Severe infestations can form heavy crusts, causing branches or trees to die (CPCI 2008), and feeding activities can result in early leaf drop. As with all armoured scale insects, management is difficult because they are protected by their waxy caps.

This species is the subject of quarantine regulations in many countries, and establishment in New Zealand could cause disruption of access to some markets, including Western Australia.

Environmental consequences

P. pentagona is a polyphagous species, with over 300 recorded hosts in 78 plant species (ScaleNet 2008). Damage to amenity plants and the increased use of pesticides for control in modified habitats are possible consequences of establishment of this species. Although *P. pentagona* is more likely to attack exotic hosts, damage to native plants is possible. Beever *et al.* (2007) suggested that, in terms of risk to native flora, sap-sucking hemipterans such as armoured scale insects are a high risk group (particularly polyphagous species), and Charles and Henderson (2002) recorded a number of exotic armoured scale insect species on native plant hosts. Competitive displacement of native armoured scale insect species is also a possibility.

Human health consequences

There are no known human health consequences.

The establishment of P. pentagona in New Zealand is likely to cause moderate economic and low environmental consequences.

8.2.2.5. Risk estimation

P. pentagona has a low likelihood of entry and exposure, and a moderate likelihood of establishment in New Zealand. The economic impact is likely to be moderate and the environmental impact low. The risk associated with *P. pentagona* on fresh stonefruit imported from the Pacific Northwest is non negligible and phytosanitary measures can be justified.

8.2.3. Risk management

MAF Biosecurity New Zealand requires risk mitigation measures for *P. pentagona* on kiwifruit from Italy, stonefruit from California and cherries from the Pacific Northwest.

8.2.3.1. Options

Pest free area or pest free place of production

Pest freedom might be applied to manage the risk posed this species, since it has only been recorded from Oregon in recent times. One historical record from Idaho was found. The requirements for the establishment of a pest free area are described in the International Standards for Phytosanitary Measures (ISPM) number 4, while the requirements for the establishment of a pest free place of production are described in ISPM number 10. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained. Normally pest free status is based on verification from specific surveys such as an official delimiting or detection survey. The structure and composition of the *P. pentagona* pheromone is known and pheromone traps are widely used for detection in newly infested regions, especially in Europe (Kozar *et al*. 1997). It could therefore be considered possible that a reliable determination of pest freedom of the area or place of production could be obtained once an appropriate official delimiting or detection survey had been completed.

Orchard management, harvest and post-harvest processing

Mineral oil applied during dormancy or delayed dormancy is an effective way to reduce populations of this pest (CPCI 2008). Insecticides (organophosphates, carbamates and pyrethroids) are very efficient against crawlers and effective IPM programmes have been developed (CPCI 2008).

All life stages except crawlers and adult males are anchored to their host permanently, and may not be removed by standard packing procedures (Taverner & Bailey 1995).

Cold treatment (pre-export or in transit)

The interception rate at the New Zealand border for *P. pentagona* on sea-freighted, cold-treated kiwifruit from Italy is high, including live specimens. The cold treatment specified is one of the following temperature/time combinations:

Temperature	Time
0.00ºC or below	10 days
0.55ºC or below	11 days
1.11ºC or below	12 days
1.66ºC or below	14 days
2.22ºC or below	16 days

Since *P. pentagona* is able to survive these schedules, this treatment cannot be relied on exclusively to disinfest stonefruit.
Adult females and eggs (which are laid under the protective scale cover) are particularly likely to survive cold treatment, as these are the overwintering stages. This stage was (adult females with eggs) was also found to be the most tolerant stage to irradiation (Follett 2006).

Visual inspection

Armoured scale insects are small and inconspicuous and may be difficult to detect during fruit processing, especially at low population levels. However inspections may be effective in detecting later stages, which also pose the most risk (these include mature mated females, which are white or yellow-white and can be up to 2.8mm in diameter with or without eggs).

Irradiation

Hemiptera including bugs, scales and mealybugs are irradiated to the point of sterility between 150 and 250Gy (Hara *et al.* 2002; Follett 2006). Follett (2006) showed that irradiation treatment with a minimum absorbed dose of 150 Gy provides quarantine security to control *P. pentagona* on exported papaya, as well as other commodities.). Stonefruit can tolerate much higher doses (Drake & Neven 1998).

8.2.3.2. Risk management options in descending order of stringency

Option 1: pest freedom
Option 2: orchard management
Option 3: packhouse procedures *e.g.* washing and brushing to remove crawlers
Option 4: post harvest inspection.

8.2.4. Assessment of uncertainty

- evidence regarding the presence of *D. ancylus*, *D. forbesi* and *D. juglansregiae* in the Pacific Northwest is dated and/or contradictory
- no records have been found of *P. pentagona* from Washington. It is not known if the species is not present, or whether it is present at low population levels and has not been detected.
- there is considerable debate over the level of risk posed by scale insects via the fresh produce pathway.
- in this analysis some information on crawler behaviour is extrapolated from research on mealybug crawlers. It is assumed that physiology and dispersal behaviour of mealybug crawlers is similar to that of armoured scale insect crawlers but this may not be correct.

- there have been numerous interceptions of *P. pentagona* at the border on kiwifruit consignments sea-freighted from Italy and at least some specimens have been intercepted alive. However in the majority of cases viability data is lacking. This is because viability (and hence efficacy of treatments) is extremely hard to determine for insects such as armoured scale insects, which are not only sessile, but covered with an opaque cap

8.3. *Lygus* species (plant bugs)

The species examined in this risk assessment have been grouped together because of their related biology. They are: *Lygus elisus, L. hesperus and L. lineolaris* (Hemiptera: Miridae).
Scientific name: *Lygus elisus* Van Duzee, 1914
Common name/s: pale legume bug, lucerne plant bug
Other scientific names: *Lygus desertinus*, *Lygus desertus, Lygus elysus, Lygus nigrosignatus*

Scientific name: *Lygus hesperus* Knight, 1917
Common name/s: western plant bug, western tarnished plant bug

Scientific name: *Lygus lineolaris* (Palisot de Beauvois, 1818)
Common name/s: tarnished plant bug
Other scientific names: *Capsus flavonotatus, Capsus lineolaris, Capsus oblineatus, Capsus strigulatus, Lygus pratensis* var. *rubidus*

PNW status

All three *Lygus* species have been recorded from Washington. *L. hesperus* and *L. lineolaris* have also been recorded from Oregon and Idaho (CPCI 2008).

New Zealand status

Lygus elisus, L. hesperus and *L. lineolaris* are not known to be present in New Zealand. Not recorded by: Larivière and Larochelle (2004), CPCI (2008), PPIN (2008).

General geographical distribution

L. elisus is recorded from Canada and the USA (AZ, SD, CO, WA). *L. hesperus* is only recorded from the USA (AZ, CA, GA, ID, MT, NV, OR, UT, WA). *L. lineolaris* is recorded from Bermuda, Canada, the USA (widely distributed, including all states bordering the PNW), Mexico and Central America (CPCI 2008). Demirel and Cranshaw (2006) also record *L. elisus* from CO. There is one unreferenced record from the Republic of Georgia (Asia) in CPCI (2008) but otherwise all records are from the American continent.

Hosts

For *L. elisus* the major host is carrot (CPCI 2008). CPCI (2008) lists the following hosts whose status is unknown: Indian mustard, shepherd's purse, white lupine, lucerne, peppermint. *L. elisus* has been recorded from peach (Pickel *et al.* 2006b) and nectarine (Bentley & Day 2006c).
L. hesperus is reported to feed on 117 non-crop and over 25 cultivated plants (Schwartz & Foottit 1998). Major hosts are carrot, Bourbon cotton and tomato (CPCI 2008). This species has been recorded from peach (Pickel *et al.* 2006b) and nectarine (Bentley & Day 2006c).
L. lineolaris has been suggested to have the broadest documented feeding niche of any arthropod. It is most attracted to flowering plants in the families Asteraceae and Brassicaceae. Food plants affected by *L. lineolaris* in North America include 328 species in 55 families, of which 130 are economically important. It also has a number of important weed hosts and causes significant yield losses in cotton, canola/oilseed rape, mustard, seed lucerne, vegetable crops such as *Phaseolus vulgaris* and *P. lunatus*, fruit crops such as strawberry, apple and nursery stock. Peach is also a major host of *L. lineolaris* (CPCI 2008).

Biology

Lygus species are, like other mirids, generalised plant feeding insects. Nymphs and adults pierce and suck the juices of plant tissues, including fruit and other reproductive tissues, such as flowers and buds (CPCI 2008). Buds, flowers and fruit are especially favoured by *L. lineolaris*, which also sometimes feeds on other insects, for example eggs and larvae of *Heliothis* (CPCI 2008). Feeding by *Lygus* bugs can result in embryoless seeds while the exterior appears well-filled and normal (Flemion & Olson 1950). *L. lineolaris* does not commonly transmit plant diseases, but it is capable of transmitting *Erwinia amylovora* (CPCI 2008).

Eggs of *Lygus* species are laid singly into plant tissue, including stems, leaf parts, flowers (Mueller & Stern 1973b) and fruit (Udayagiri & Welter 2000). On strawberry, *L. hesperus* was shown to lay over 46% of all eggs on fruit and 23% on petioles (Udayagiri and Welter, 2000). Numbers of eggs laid ranges from 38 to 48 for *L. elisus* to 117 to 161 for *L. hesperus* (Mueller & Stern 1973a).

L. lineolaris is multivoltine, with two to five generations per year, depending on location and latitude (CPCI 2008). In California, there may be 6 to 10 overlapping generations per year for some *Lygus* species (Pickel *et al.* 2006b). *Lygus* species overwinter as adults in for instance dead weeds, leaf litter. Fye (1982) studied the overwintering behaviour of *L. elisus* and *L. hesperidum* in Washington, and concluded they were well adapted to extreme temperatures. Previous studies cited in this report found that these species were active throughout winter when temperatures exceed 9.4°C.

Plant parts affected

Eggs are laid in plant tissues, preferentially fruit in some hosts. Nymphs and adults feed on plant tissue, particularly reproductive tissue, and may be facultative predators (CPCI 2008).

8.3.1.2. Hazard identification conclusion

L. elisus, L. hesperus and L. lineolaris are widespread throughout the PNW and are not known to be present in New Zealand. All three species are associated with the fruit of *Prunus* species and are therefore classed as potential hazards in this analysis.

8.3.2. Risk assessment

8.3.2.1. Entry assessment

Adult *Lygus* species are approximately 6 mm long, and are very active insects, flying readily when disturbed (CPCI 2008). It is unlikely that they would remain on fruit throughout harvesting and processing. Nymphs are also mobile, although they do not fly, and it is possible that they may remain on fruit. Feeding by *L. lineolaris* is known to cause abscission of immature fruit (CPCI 2008), further reducing the likelihood that feeding stages will be present on mature fruit. The greatest risk is that eggs laid in fruit will enter New Zealand undetected, as infested fruit is unlikely to be culled. No interceptions of *Lygus* species have been made on stonefruit from the USA (Quancargo database), however eggs within fruit would be unlikely to be detected.

The likelihood of entry is considered to be moderate for eggs and very low for nymphs.

8.3.2.2. Exposure assessment

The most likely life stages to enter the country are eggs, and possibly nymphs. Fruit is likely to be distributed throughout urban, suburban and provincial regions and will either be consumed (and the remains discarded) or discarded whole. Eggs would need to hatch while fruit is in a suitable condition, which is before it decomposes or is disposed of as bagged waste into landfill, or into sewage via domestic waste disposal. From the fruit disposal location, larvae must disperse from the discarded fruit and locate suitable hosts. Larvae are mobile and likely to move off fruit/remains at any time, particularly as fruit quality degrades. All three *Lygus* species are polyphagous and there would be no shortage of suitable hosts throughout New Zealand, including many weed hosts.

The likelihood of exposure is considered to be moderate.

8.3.2.3. Establishment assessment

A mated female or immatures of both sexes would be necessary to establish a reproductive population, as *Lygus* species reproduce sexually (Graham *et al.* 1987). Eggs are the most likely stages to enter New Zealand, so at least one of each sex would need to enter, hatch and develop to adulthood successfully, locate each other and mate. Female *Lygus* bugs attract males with pheromones (Wardle & Borden 2003), increasing the probability that the sexes would locate each other and mate.

These species are distributed throughout the Pacific Northwest where climatic conditions are similar to those of New Zealand, indicating climate would not be a restricting factor for establishment. The overall probability of establishment is estimated to be low, based on the low probability of two larvae or pupae successfully developing, emerging and locating each other to mate. Should this happen, however, many different plants are suitable hosts for feeding and reproduction. Additionally, the high reproductive rates and dispersal abilities of these species indicate that there would be few barriers to their spread throughout modified habitats in New Zealand.

The overall likelihood of establishment is estimated to be low.

8.3.2.4. Consequence assessment

Economic consequences

Lygus species are highly polyphagous, resulting in significant direct losses in many economically important crops. *L. lineolaris* is the principal mirid pest of strawberry, apple and peach in the eastern and southern USA (CPCI 2008) and causes abscission of immature fruit. Damaged fruit may have shrivelled seeds or seeds without embryos. Apples, peaches, and other fruits can develop dimpling (catfacing) around the feeding sites (CPCI 2008). One single *Lygus* bug is considered capable of producing “a tremendous amount of destruction in a very short time” in relation to seed production (Flemion and Olson, 1950).

Indirect consequences of the establishment of these species could include an increase in pest control costs and/or the need to use different pesticides, which may disrupt IPM programmes. This may alter the economic viability of some crops. Establishment of this species in New Zealand could also cause disruption of access to some markets, including Australia.

Environmental consequences

Lygus species infest a large variety of plants, potentially affecting many amenity species in urban, suburban and rural areas. Hosts also include conifer species, broadly distributed throughout New Zealand, and a large number of weed species. Beever *et al.* (2007) suggested that, in terms of risk to native flora, sap-sucking hemipterans such as mirids are a high risk group, particularly polyphagous species (based on known attacks on native plants by exotic species present in New Zealand). The same study identified *L. elisus* and *L. hesperus* as specific potential threats to native *Lepidium* species (Brassicaceae), based on attacks on related plant taxa overseas.

Other environmental consequences could include effects from increased use of pesticides, and effects on native mirids due to competition for resources.

Human health consequences

There are no known human health consequences

The establishment of Lygus species in New Zealand is likely to cause moderate economic and low environmental consequences.

8.3.2.5. Risk estimation

L. elisus, L. hesperus and *L. lineolaris* eggs and nymphs have a moderate and very low likelihood of entry respectively, moderate likelihood of exposure and low likelihood of establishment in New Zealand. The economic impact is likely to be moderate and the environmental impact low. The risk associated with *Lygus species* on fresh stonefruit imported from the Pacific Northwest is non negligible and phytosanitary measures can be justified.

8.3.3. Risk management

Biosecurity New Zealand requires risk mitigation measures for *L. lineolaris* on stonefruit from California and cherries from the Pacific Northwest.

8.3.3.1. Risk management options

Pest free area or pest free place of production

Lygus species are likely to be widely distributed in the Pacific Northwest and pest freedom is unlikely to be a viable management option.

Orchard management, harvest and post-harvest processing

Lygus bugs are managed in Pacific Northwest stonefruit orchards by pre-bloom and petal fall sprays of endosulfan, formetanate hydrochloride and lambda-cyhalothrin (WSU 2007). Adult *Lygus* species are unlikely to remain on fruit throughout harvesting and processing; nymphs are slightly more likely to. These species have not been identified in packhouse surveys, but eggs within fruit would be unlikely to be detected.

Cold treatment (pre-export or in transit)

Research indicates that 10°C is below the developmental threshold for eggs of *L. hesperus* (Champlain & Butler 1967), but it is not known what effect cold treatment would have on the viability of eggs or larvae

Visual inspection

Eggs within fruit would be unlikely to be detected. Nymphs are not internal feeders but may be difficult to detect due to their small size (1–5 mm in length), cryptic coloration and tendency to hide within preferred feeding spots (Flemion & Olson 1950).

Treatment

The USDA Treatment Manual (2008; online search) suggested the following dosage rates for the fumigation of stonefruit against external feeders such as *Lygus* bugs:
• 1.5 lbs per 1,000 ft^3 at 80º F or greater, or
• 2g/m^3 lbs per 1,000 ft^3 at 70 –79º F, or
• 2.5g/m^3 lbs per 1,000 ft^3 at 60 –69º F, or
• 3g/m^3 lbs per 1,000 ft^3 at 50 –59º F, or
• 4g/m^3 lbs per 1,000 ft^3 at 40 –49º F

8.3.3.2. Risk management options in descending order of stringency

Option 1: orchard management
Option 2: packhouse procedures *e.g.* washing and brushing (nymphs and adults)
Option 3: methyl bromide fumigation
Option 4: post harvest inspection

8.3.4. Assessment of uncertainty

- little information is available on infestation rates in fruit of *Prunus* species

- very little information on thermal thresholds for these species was found, so it is unknown what effect cold treatment would have.

8.4. *Pseudococcus maritimus* (grape mealybug)

Scientific name: *Pseudococcus maritimus* (Ehrhorn, 1900) (Hemiptera: Pseudococcidae)
Common name/s: grape mealybug
Other scientific names: *Dactylopius maritimus***,** *Pseudococcus bakeri***,** *Pseudococcus omniverae*

PNW status

Recorded from Washington and Oregon (ScaleNet 2008)

New Zealand status

Not known to be present in New Zealand. Not recorded by: CPCI (2008), ScaleNet (2008), PPIN (2008). Cox (1977) noted that previous records of this species from New Zealand were based on misidentifcations.

General geographical distribution

Canada, the USA (CA, CT, DC, FL, GA, IL, IN, IA, MD, MA, MI, MO, NH, NJ, NY, OH, OR, PA, RI, TN, TX, VT, VA, WA, WV), Mexico, South America, Indonesia, Armenia, Poland (ScaleNet 2008). Recently recorded from China (Abudujapa & Sun 2007).

Hosts

P. maritimus is polyphagous and hosts include all tree fruits grown in the Northwest, as well as other rosaceous plants, grapes, ornamental trees and shrubs (Beers *et al*. 1993). Grapes and pears are considered to be the primary hosts but this mealybug is recognised as being associated with apricots and plums (WSU 2007); CPCI (2008) lists peach and plum as "hosts where status is unknown"; Beers *et al*. (1993) record it as a particularly severe pest of grapes, pears and apple; ScaleNet (2008) records it as a pest of apricots in California.

Plant parts affected

P. maritimus is found mainly on leaves and under rough bark on trunks (ScaleNet 2008), but it has been recorded on fruit in grape clusters (Grimes & Cone 1985). Live adult *P. maritimus* have been intercepted at the border on apricots from the USA (12/05/1997; Lynfield PPC, Lab Accession 11394) and sea-freighted pears from California (Consignment C2005/289367, Quancargo database).

Biology

(after Beers *et al.* 1993 for Washington, unless otherwise stated). *P. maritimus* overwinters as eggs or crawlers within the loose cottony egg sac under bark scales on scaffold limbs, in other sheltered places on trees, or at the bases of trees. In spring, crawlers emerge, and mature during late June and July. Adult males appear first, mate with last instar nymphs or adult females and die. Some females will oviposit on fruit but most return to the old wood to lay the overwintering eggs (Bentley *et al.* 2006). A partial second generation matures in late August and September. Nymphs of this generation sometimes settle in or around the fruit calyx. In addition to having a wide known host range, *P. maritimus* is able to develop new host strains allowing it to adapt to more hosts. Adaptations may include different development rates and numbers of generations per year.

8.4.1.2. Hazard identification conclusion

P. maritimus is present in the Pacific Northwest and is not known to be present in New Zealand. It is associated with stonefruit and known to infest fruit, and is therefore classed as a potential hazard in this analysis.

8.4.2. Risk assessment

8.4.2.1. Entry assessment

P. maritimus is generally associated with leaves and bark rather than fruit, and *Prunus* species are not the primary hosts. However this species is a known pest of stonefruit (WSU 2007). Harvest in the Pacific Northwest states spans June to September. During June and July the first generation of mealybugs would become adults. These adult females may be present on fruit at harvest, or they may lay eggs on fruit (though most do not). Due to the overlap of generations in the field, any stage of the mealybug lifecycle is likely to be present on fruit from June to September, with adult populations peaking in July and again in September (data for Washington State from Beers *et al.* 1993).

Live adult *P. maritimus* have been intercepted at the border on apricots from the USA and sea-freighted pears from California, so adults are able to survive existing harvesting, processing and transit procedures and conditions.

The likelihood of entry is considered to be moderate.

8.4.2.2. Exposure assessment

At least some life stages (eggs and crawlers, or adult females) are likely to survive transit conditions and to hatch/become active on arrival. Following post-border distribution and disposal of fruit (either whole or remains), mealybugs need to disperse and locate suitable hosts. The potential for dispersal depends on the life stage and sex: adult males are the only winged forms, but they are short-lived and some data suggests they are not important in dispersal (Lo *et al.* 2006). The mobile crawler is the primary dispersal stage, and can move short distances actively or long distances passively. In general, factors influencing crawler dispersal and mortality are assumed to be similar to those of the armoured scale insect *Pseudaulacaspis pentagona* (*q.v.).*

However, two aspects of mealybug biology suggest that their likelihood of exposure is higher than that for armoured scale insects:

- unlike armoured scale insects, female mealybug nymphs and adults are able to move limited distances at least. Bartlett (1978) recorded female *P. longispinus* moving to branches and tree trunks before oviposition, and James (1937) reported females moved intermittently during the oviposition period, sometimes ceasing to feed and leaving the host plant altogether. However, despite their relative mobility, one study using mealybugs (*P. longispinus*; Anon 1994) showed that when infested apples were caged outdoors in small enclosures with a suitable host tree, no adults moved successfully from the fruit to the tree (although crawlers did). Fruit was close to but not touching host trees.
- some mealybugs may be carried to new host plants by ants (Beardsley *et al.* 1982). Two ant species known to farm mealybugs are the bigheaded ant, *Pheidole megacephala*, and the Argentine ant, *Linepithema humile*, both present in New Zealand (Berry 2007).

P. maritimus is polyphagous, and suitable host species are widely distributed throughout New Zealand.

The likelihood of exposure is considered to be low. It is estimated to be higher than that of armoured scale insects because of the greater mobility of the non-crawler stages and the potential for mealybugs to be moved by vectors such as ants.

8.4.2.3. Establishment assessment

P. maritimus reproduces sexually, so a mated female or immatures of both sexes need to be present to establish a reproductive population. For permanent establishment male mealybugs must be able to locate females and conditions must be suitable for mating and egg laying to occur. *P. maritimus* females release a pheromone during the day when males are active (Beers *et al*. 1993), which attracts nearby males over distances of over 1m. Males are non-feeding and live short periods of time, from one to several days. The short life span of males combined with their limited dispersal ability means that potential mates must be located nearby for males to find them and mate successfully. This likelihood is considered to be higher for mealybugs than for solitary insects, due to their tendency to have an aggregated or clumped spatial distribution. Yamamura and Katsumata (1999) referred to this type of pest as gregarious, and considered them to have a higher probability of introduction into new areas via trade, due to the heightened likelihood of their locating a mate.

Despite their limited dispersal ability, the high reproductive capacity of mealybugs (Williams & Watson 1988) means that a founding population could quickly increase in number and disperse to other nearby hosts. *P. maritimus* is established in parts of the world with climates similar to that in many parts of New Zealand.

The likelihood of establishment is considered to be moderate.

8.4.2.4. Consequence assessment

Economic consequences

P. maritimus is an increasingly severe pest of pears and apples in the Pacific Northwest. The most obvious damage it causes is due to secreted honeydew, which serves as a substrate for the development of sooty mould, preventing photosynthesis, but this is likely to be a problem only at high population densities.

Direct damage is caused by the mealybug entering the calyx ends of fruit (Beers *et al.* 1993), but the most significant problem is caused by the ability of *P. maritimus* and other mealybug species to transmit plant viruses (Spence 2001). In New Zealand, grapevine leafroll viruses, vectored by *P. longispinus, P. calceolariae* and *P. viburni*, are having a major impact in reducing vine productivity and wine quality from in vineyards (P. Lo, pers. comm. 2008). Indirect consequences of establishment could include an increase in pest control costs and/or disruption of existing control programmes, particularly those based on IPM. Establishment of this species in New Zealand could cause disruption of access to some markets, including Australia.

Environmental consequences

P. maritimus is polyphagous, and Beever *et al.* (2007) suggested that, in terms of risk to native flora, sap-sucking hemipterans such as mealybugs are a high risk group, particularly polyphagous species (based on known attacks on native plants by exotic species present in New Zealand). *P. longispinus*, a related species established in New Zealand, is known to attack native plant species (Spiller & Wise 1982). The increased use of pesticides for control in modified habitats is another possible consequence of establishment, as is the displacement of native mealybug species.

Human health consequences

There are no known human health consequences.

The establishment of P. maritimus in New Zealand is likely to cause moderate economic and low environmental consequences.

8.4.2.5. Risk estimation

P. maritimus has a moderate likelihood of entry, low likelihood of exposure and moderate likelihood of establishment in New Zealand. The economic impact is likely to be moderate and the environmental impact low. The risk associated with *P. maritimus* on fresh stonefruit imported from the Pacific Northwest is non negligible and phytosanitary measures can be justified.

8.4.3. Risk management

Biosecurity New Zealand requires risk mitigation measures for *P. maritimus* on stonefruit from California and cherries from the Pacific Northwest.

8.4.3.1. Options

Pest free areas or places of production

P. maritimus is recorded from Washington and Oregon. No records have been found from Idaho, so pest freedom could be an option. The requirements for the establishment of a pest free area are described in the International Standards for Phytosanitary Measures (ISPM) number 4, while the requirements for the establishment of a pest free place of production are described in ISPM number 10. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the area or place of production.

Orchard management, harvest and post-harvest processing

P. maritimus is managed in Pacific Northwest orchards by pre-bloom, petal fall and late spring and summer sprays which include endosulfan, diazinon, imidacloprid, phosmet (WSU 2007). All stages (except adult males and crawlers) are firmly attached to their host by their piercing mouthparts, and may not be dislodged by washing or brushing fruit. Live adults have been intercepted on apricots from California. This indicates that orchard management and standard packhouse procedures cannot be relied on exclusively to disinfest stonefruit.

Cold treatment (pre-export or in transit)

Eggs and crawlers may be able to survive cold treatment, since these are the overwintering stages (Beers *et al*. 1993, Bentley *et al.* 2006).

Visual inspection

Mealybugs are small but can be conspicuous due to their bright white colour and powdery appearance. The white cottony mass makes egg sacs easy to see (Beers *et al*. 1993), but early instars may be inconspicuous. Additionally they tend to be present in cryptic areas such as the stem end of the fruit, and may go unnoticed in inspections.

8.4.3.2. Risk management options in descending order of stringency

Option 1: pest freedom
Option 2: orchard management
Option 3: packhouse procedures, for example washing and brushing to remove crawlers
Option 4: post harvest inspection (eggs and adults).

8.4.4. Assessment of uncertainty

- viability, and hence efficacy of treatments, is difficult to determine for sessile insects such as mealybugs (though not as difficult as for armoured scale insects)
- no information on thermal thresholds for this species was found, so it is unknown what effect cold treatment would have.

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9. Analysis of potential hazards – Lepidoptera (butterflies and moths)

This chapter assesses the biosecurity risks from butterflies and moths that are potentially associated with stonefruit imported from the Pacific Northwest into New Zealand.

9.1. *Pyrrharctia isabella* (Isabella tiger moth)

Scientific name: *Pyrrharctia isabella* (Smith, 1797) (Lepidoptera: Arctiidae)
Common name/s: Isabella tiger moth, banded woollybear
Other scientific names: *Diacrisia isabella, Isia isabella*

PNW status

P. isabella has been recorded from Washington, Oregon and Idaho (Opler *et al.* 2006)

New Zealand status

Not known to be present in New Zealand. Not recorded by: Dugdale 1988, Hoare 2001, PPIN 2008.

General geographical distribution

P. isabella ranges throughout the entire North American continent.

Hosts

P. isabella has a wide host range and has been reported feeding on cuttings of 95 plant species representing 57 families in laboratory feeding trials (Shapiro 1968). Natural hosts include cotton seedlings, maize and melon crops, the fruit of tomato and the flowers and pods of beans (Fenton 1937); plantain leaves (Stamp & Bowers 2000) and maple leaves (Fincher 1987).

Plant parts affected

P. isabella is usually a foliage feeder (Fincher 1987, Stamp & Bowers 2000), but Fenton (1937) record it feeding on ripening peach and tomato fruit.

Biology

Eggs hatch in autumn and overwinter as larvae, surviving winter freezes by producing a cryoprotectant (Layne *et al.* 1999). Larvae feed mainly on grass and weeds. This species usually goes through at least two generations a year in North America.

9.1.1.2. Hazard identification conclusion

P. isabella is known to occur over most of the Pacific Northwest, is not known from New Zealand and has been recorded from the fruit of peaches. It is therefore classed as a potential hazard in this analysis.

9.1.2. Risk assessment

9.1.2.1. Entry assessment

Prunus species are not preferred hosts for *P. isabella*, and feeding is usually on foliage. Only one record of association of this species with *Prunus* fruit has been found, and that is with “ripening fruit”, not with mature fruit at harvest.
This species has been intercepted on a number of occasions:

- A dead caterpillar was intercepted in a sea container from the USA on the 25/11/2003 in Tauranga (NPPRL Accession number 320033088)

- Two live caterpillars were found in a in air-freighted crate from Copake, New York on the 08/11/2007 in the Waikato (NPPRL Accession number 920073637)
- A live caterpillar was found inside a house in Otaki in late January 1997, in a room where a visitor from the USA had recently unpacked a suitcase (Sirvid & Palma 1997)
- post-border: a moribund caterpillar was reported on imported *Cercis canadensis* 'Hearts of Gold' (Fabaceae) in a greenhouse in late February 2006, after the plants had been treated at the border (K. Paice, IDC, pers. comm., 2008). This was probably a commodity association.

None of the interceptions are on *Prunus,* or any fresh fruit. All interceptions fulfil the definition used here of a hitchhiker (that is it has an opportunistic association with a commodity or item with which it has no biological host relationship), except the post-border record from *Cercis canadensis* 'Hearts of Gold', an ornamental tree imported from the USA. This was probably a biological relationship.

The likelihood of P. isabella entering New Zealand on fresh stonefruit from the USA is considered to be negligible, and this species is not classified as a hazard. Therefore risk management measures are not justified.

9.2. *Anarsia lineatella* (peach twig borer)

Scientific name: *Anarsia lineatella* Zeller, 1839 (Lepidoptera: Gelechiidae)
Common name/s: peach twig borer
Other scientific names: *Anarsia pruniella*

PNW status

Recorded from WA, OR and ID (CPCI 2008)

New Zealand status

Not known to be present in New Zealand. Not recorded by: Dugdale (1988), Hoare (2001), PPIN (2008), CPCI (2008)

General geographical distribution

China, India, Central Asia, the Middle East, former USSR, central and Eastern Europe, the Mediterranean, the UK, Northern Africa, Canada, USA (AZ, CA, CO, DE, GA, ID, IL, IN, KS, KY, MD, MA, MI, MS, MO, NE, NV, NM, NY, NC, OH, OK, OR, PA, SC, TX, UT, WA)(CPCI 2008)

Hosts

Major hosts are almond, apricot, peach, plum and Japanese plum. European pear is a minor host (CPCI 2008). Nearly all records are from fruit trees in the family Rosaceae, with a couple of unreferenced records from the Aceraceae and Anacardiaceae (Robinson *et al.* 2008).

Plant parts affected

A. lineatella is found on fruits/pods, flowers, leaves and stems and is liable to be carried on fruit, plants for planting or in packing materials (CPCI 2008). It causes damage by feeding in shoots and causing undesirable lateral branching, or by feeding directly on the fruit. As fruit matures it becomes highly susceptible to attack and damage is most likely to occur from colour break to harvest. Peach twig borer larvae generally enter fruit at the stem end or along the suture and usually feed just under the skin (Pickel *et al*. 2006h). This species has been has been intercepted live on fresh apricots, cherries, peaches/nectarines and plums from California (Quancargo database, Consignments C2000/23784, C2004/84381 (peach/nectarine), C2004/84381 (apricot), C2004/85122 (cherry), C2004/91135 (peach/nectarine) and C2004/142850 (plum).

Biology

(timing for Washington State, after Beers *et al.* 1993 unless otherwise stated) *A. lineatella* usually has three complete generations. Larvae overwinter as first or second instars in hibernacula under bark. During bloom and petal fall, overwintered larvae emerge and begin to feed on buds and young leaves. As terminal growth develops, a larva will enter a single shoot, boring down the center, causing the terminal to wilt. When mature, the larva leaves the mined shoot to pupate beneath bark scales or cracks in the bark. Pupation can also occur in the stem cavity on fruit (Curtis *et al.* 1992, Pickel *et al.* 2006h).
Adults from overwintering larvae usually begin to emerge mid- to late May. Females lay 80 to 90 eggs on fruit, shoots or the undersides of leaves. Eggs are laid singly and hatch in 5 to 18 days, depending on temperature. Larvae can develop equally well in shoots or immature fruit. The first summer generation larvae develop during late May and June. The next adult flight is in early July. During this flight and the following one in late August, moths lay eggs on maturing fruit. Some larvae that develop from the eggs laid in August go into cells to overwinter. Others continue to develop on fruit and shoots and produce a partial third summer

flight of moths in October. These moths lay eggs that produce larvae that overwinter and emerge as moths the following spring.

9.2.1.2. Hazard identification conclusion

A. lineatella is present in the Pacific Northwest and is not known to be present in New Zealand. It is associated with *Prunus* species and has been intercepted on fresh imported stonefruit. It is therefore classed as a potential hazard in this analysis.

9.2.2. Risk assessment

9.2.2.1. Entry assessment

A. lineatella is one of the most important peach pests in the Pacific Northwest. It is a common pest of peaches and other tree fruits in eastern Washington (Beers *et al*. 1993). Larvae feed internally in fruit; additionally eggs are known to be laid on the fruit surface of peaches and plums (CPCI 2008). Live larvae have been intercepted at the New Zealand border on fresh stonefruit sea freighted from California, so are able to survive existing harvesting, processing and transit procedures and conditions.
The likelihood of entry is considered moderate to high.

9.2.2.2. Exposure assessment

A. lineatella is most likely to enter the country as larvae within fruit, or as eggs or possibly pupae in the stem cavity (Curtis *et al.* 1992, Pickel *et al*. 2006h).
The lower developmental threshold of *A. lineatella* is 10°C (Pickel *et al.* 2006h). Eggs and pupae may hatch/emerge if they arrive in New Zealand in spring (NIWA 2008). Fruit is likely to be distributed throughout urban, suburban and provincial regions. Individuals need to disperse from the fruit and locate suitable hosts. The potential for dispersal depends on the life stage imported.

- eggs and larvae: these stages are largely or wholly dependent on the movement of fruit as they have limited mobility. Infested fruit will either be consumed (and the remains discarded) or discarded whole. From the fruit disposal location, larvae must disperse from the discarded fruit and locate suitable hosts. Larvae are able to move short distances themselves (or may possibly be moved by animal vectors). They are likely to move off fruit/remains as it becomes unsuitable as a feeding site, but would need to find a suitable host nearby. The likelihood of this depends on the method of fruit disposal. Infested fruit/remains disposed of as bagged waste into landfill or into sewage via domestic waste disposal would have a negligible likelihood of exposure. Infested fruit/remains disposed of into domestic compost, or randomly by the roadside would have a higher likelihood of exposure to a suitable host
- adults: although entry of adults is unlikely, pupae may be associated with fruit and may emerge shortly after arrival (depending on the time of year). Adults are able to fly to hosts. The ability to move greater distances from infested fruit to potential hosts significantly increases the likelihood of exposure of adults over larval stages.

Hosts of *A. lineatella* are almost exclusively fruit trees (*Malus*, *Prunus* and *Pyrus*). These genera are common in urban and suburban areas throughout New Zealand, and are also grown in commercial production areas, so there would be no lack of suitable hosts for this species.
The likelihood of exposure is considered to be moderate

9.2.2.3. Establishment assessment

A mated female or immatures of both sexes would be necessary to establish a reproductive population, as this species reproduces sexually. Larvae or pupae are the most likely stages to enter New Zealand, so at least one of each sex would need to enter, develop successfully and emerge as adults, locate each other and mate. Females are able to attract males by producing pheromones.

A. lineatella is distributed through Washington, Oregon and Idaho where climatic conditions are similar to those of New Zealand, indicating climate would not be a restricting factor for establishment.

The likelihood of establishment is considered to be low, based on the low probability of at least one immature insect of each sex successfully developing, emerging and locating each other to mate.

9.2.2.4. Consequence assessment

Economic consequences

A. lineatella is considered a major pest of stone fruit across North America, Europe, Asia and North Africa (EPPO/CABI 1997i). Fruit damage may be less in some peach varieties (Gencsoylu *et al.* 2006), but further damage can be caused by secondary rots which often follow the initial tunnels (Curtis *et al.* 1992).Where stonefruit is grown commercially in New Zealand, pest management programmes will be in place and the establishment of new leafroller species could cause an increase in pest control costs and/or disruption of existing programmes due to increased use of pesticides or the need to use different pesticides. Additional applications of pesticides and/or increased monitoring costs may alter the economic viability of some crops.

Establishment of this species in New Zealand could also cause disruption of access to some markets, including Australia.

Environmental consequences

The recorded hosts of *A. lineatella* are almost all from the family Rosaceae, with a couple of records from the familes Aceraceae and Anacardiaceae. Rosaceae contains some native species which may be threatened by *A. lineatella*. Other environmental consequences could include effects from increased use of pesticides, and effects on native lepidopterans due to competition for resources.

Human health consequences

There are no known human health consequences

The establishment of A. lineatella in New Zealand is likely to cause moderate economic and low environmental consequences.

9.2.2.5. Risk estimation

A. lineatella has a moderate to high likelihood of entry, moderate likelihood of exposure and low likelihood of establishment in New Zealand. The economic impact is likely to be moderate and the environmental impact low. The risk associated with *A. lineatella* on fresh stonefruit imported from the Pacific Northwest is non negligible and phytosanitary measures are justified.

9.2.3. Risk management

Biosecurity New Zealand requires risk mitigation measures for *A. lineatella* on stonefruit from California and cherries from the Pacific Northwest.

9.2.3.1. Options

Systems approach

USDA has proposed a systems approach for *A. lineatella* (peach twig borer, PTwB) for stonefruit exported to Australia, consisting of orchard monitoring and treatment; inspection by fruit cutting in the orchard; inspection by fruit cutting in the packing facility; and the regulatory inspection. This is outlined in Appendix 8.

It should be noted that in the systems approach proposed by USDA, leaf and stem tolerances of an average of two whole leaves per box are proposed as the maximum allowable leaf tolerance. For apricots, it is proposed that packed fruit have no more than an average of 3 stems per box smaller than ½ inch in length and 2 stems larger than ½ inch in length. The Import Health Standard for Pacific Northwest cherries allows the small panicle (stem) that is typically attached to the fruit, but no leaf material. This risk analysis has not assessed the risk for leaf and stem material and it is recommended that there should be no tolerance allowed.

Pest free areas or places of production

A. lineatella is widespread in the Pacific Northwest and pest-free areas are not a viable option.

Orchard management, harvest and post-harvest processing

A. lineatella is managed in PNW orchards by pre-bloom, petal fall, summer and preharvest and harvest sprays which include endosulfan, *Bacillus thuringiensis*, esfenvalerate, spinosad, spinetoram, phosmet and carbaryl. Damage to the fruit is usually severe, with clearly visible symptoms, and Yokoyama and Miller (1999) assumed that all infested fruit would be culled during the harvest and packing processes. However Curtis *et al.* (1992) recorded this species on nectarine fruit in California after packhouse procedures at a mean incidence of 4.0 per 100,000 fruit. Most (92%) were larvae within the fruit, with the remainder as pupae located within the frass in the area damaged by larval feeding. This indicates that orchard management and standard packhouse procedures cannot be relied on exclusively to disinfest stonefruit. Eggs on the fruit surface are likely to be removed by post harvest washing and brushing.

Cold treatment (pre-export or in transit)

The lower developmental threshold of *A. lineatella* is 10°C. Larval stages overwinter and may be able to withstand cold-treatment.

Visual inspection

A. lineatella larvae feed internally. Visual inspection would be expected to detect late infestations, where damage to the fruit is usually severe and there are clearly visible symptoms. However eggs or early infestations may escape detection and additionally, infested fruit have been found following standard packhouse procedures. USDA has proposed an inspection protocol which involves cutting and inspecting fruit in the orchard and in the packinghouse (see Appendix 8).

9.2.3.2. Risk management options in descending order of stringency

Option 1: systems approach, as per Australian agreement with no tolerance for leaf material
Option 2: orchard management
Option 3: packhouse procedures *e.g.* washing and brushing to remove eggs
Option 4: post harvest inspection.

9.2.4. Assessment of uncertainty

- there is very little information available regarding domestic and industry fruit disposal practices, for example disposal of culled and unsold fruit by wholesalers and retailers, or uneaten fruit and fruit remains by consumers. A survey conducted in the UK found that 26% of fruit purchased was thrown away uneaten, and also that between 15 and 25% of households compost at home (Ventour 2008), but similar data for New Zealand does not appear to be available.

- no information on thermal thresholds for this species was found, so it is unknown what effect cold treatment would have.

9.3. Pyralid moths

The species examined in this risk assessment have been grouped together because of their related biology and taxonomy. They are *Acrobasis tricolorella* and *Amyelois transitella* (Lepidoptera: Pyralidae).

Scientific name: *Acrobasis tricolorella* Grote, 1878
Common name/s: destructive pruneworm, Mineola moth

Scientific name: *Amyelois transitella* (Walker, 1863)
Common name/s: navel orange worm
Other scientific names: *Myelois duplipunctella*, *Myelois notabilis*, *Myelois venipars*, *Paramyelois transitella*

PNW status

A. tricolorella has been recorded from Oregon (Shull & Wakeland 1941) and Idaho (Pack & Dowdle 1930). *A. transitella* has been recorded from Washington and Oregon (Riedl *et al.* 1979).

New Zealand status

These species are not known to be present in New Zealand. Not recorded by: Dugdale (1988), Hoare (2001), CPCI (2008), PPIN (2008)

General geographical distribution

A. tricolorella has been recorded from southern Canada and the USA (Agnello *et al.* 2006). *A. transitella* has been recorded from Mexico, the USA (CA, OR, TX, WA), Central America, South America and Europe (CPCI 2008, AQIS 1999 and selected references above).

Hosts

A. tricolorella has been recorded from apple (Agnello *et al.* 2006), apricot (Pack & Dowdle 1930), cherry (Oatman 1964) and plum (Essig & Keifer 1933).
Major hosts for *A. transitella* are citrus and walnut (CPCI 2008). This species has also been recorded from almonds, pistachios and figs (Burks & Brandl 2004, Siegel *et al.* (2006) and nectarines (Curtis *et al*. 1992). Yokoyama and Miller (1999) found that plums were a suitable ovipositional substrate for *A. transitella*, which laid an average 10 eggs per fruit (in laboratory no-choice tests). This study also found that *A. transitella* was able to develop to adulthood on plums.
A. transitella hosts (CPCI 2008)**:** *Acacia farnesiana* (mimosa bush), *Brachychiton* sp. (bottle tree), *Carya illinoensis* (pecan), *Ceratonia siliqua* (locust), *Citrus* sp., *Citrus limon* (lemon), *Citrus x paradisi* (grapefruit), *Citrus sinensis* (orange), *Coffea* sp. (coffee), *Cydonia oblonga* (quince), *Eriobotrya japonica* (loquat), *Ficus* sp. (fig), *Forchhammeria* sp., *Genipa americana* (marmelade-box), *Gleditsia triacanthos* (honey locust), *Heteromeles arbutifolia* (toyan berry), *Juglans regia* (walnut), *Malus pumila* (apple), *Phoenix dactylifera* (date), *Pistacia vera* (pistachio), *Pithecellobium flexicaule* (Texas ebony), *Prunus armeniaca* (apricot), *Prunus domestica* (plum), *Prunus dulcis* (almond), *Prunus persicae* (peach), *Punica granatum* (pomegranate), *Pyrus communis* (pear), *Vitis vinifera* (grape vine), *Yucca* sp. (beargrass), *Ziziphus* sp. (jujube).

Plant parts affected

Both species feed internally in fruit to a greater or lesser extent. *A. tricolorella* has been recorded causing considerable injury to apricot and prune fruits in southern Idaho (Pack & Dowdle 1930); also feeding within cherry fruit (Oatman 1964) and Sierra plum fruit (Essig & Keifer 1933). *Amyelois transitella* has been recorded excavating feeding chambers beneath the surface of nectarine fruit skin, and pupae have been found webbed with the frass of the larval feeding area (Curtis *et al*. 1992). Live larval *A. transitella* have been intercepted on fresh apricots from the USA (5/06/2000, Agriquality Ids, Lab Accession 19701, as *P. transitella*).

Biology

Acrobasis tricolorella is multivoltine. Overwintered larvae feed on and consume "fruit buds and developing flower parts", later forming nests in leaf terminals from which they continue to feed. Early summer larvae attack the fruits and feed around the pits as they near harvest (Agnello *et al.* 2006).

Amyelois transitella is a multivoltine scavenger on fallen or damaged fruits and nuts and can also attack undamaged nuts. Larvae do not diapause and are active throughout the year if conditions are favorable, but all larval and pupal stages are known to overwinter (Shelton 1989). Overwintering takes place in the previous season's unharvested crop (mummies) and development occurs sporadically through the winter and spring when temperatures exceed the lower threshold of 12.7° C. Adults emerge from the mummies on the ground and in the trees (first flight) and these females lay their eggs on other mummies to continue the life cycle. Eggs are laid singly with an average of 85 eggs laid per female (Shelton 1989). When this second wave emerges (second flight), females oviposit on mummies or the new crop nuts as they become available. Life cycle data is from studies on walnuts (California, Siegel *et al.* 2006, unless otherwise stated), but is presumed to be similar on stonefruit.

9.3.1.2. Hazard identification conclusion

Both pyralid species are present in the Pacific Northwest and absent from New Zealand. They are recorded feeding internally on the fruit of *Prunus* species. Accordingly these species are classed as potential hazards in this analysis.

9.3.2. Risk assessment

9.3.2.1. Entry assessment

A. tricolorella appears to be rare in the Pacific Northwest; the most recent records found were from 1941 (Shull & Wakeland 1941). In the eastern USA, where population levels of this moth are higher, it is very rarely considered a pest (Agnello *et al.* 2006). The likelihood of *A. tricolorella* entering New Zealand on fresh stonefruit is therefore considered to be negligible, and this species is not classified as a hazard. Therefore risk management measures are not justified.

Major hosts for *A. transitella* are citrus and walnut. While various stonefruit have been shown to be acceptable hosts both in the field and the laboratory, they are not preferred hosts of this species and infestation levels are likely to be low.

Live larval *A. transitella* have been intercepted at the New Zealand border on fresh apricots from the USA but the method of freight is unknown.

The likelihood of entry of A. transitella is considered to be low to moderate.

9.3.2.2. Exposure assessment

A. transitella is most likely to enter the country as larvae or pupae in or on fruit. Entry of adults is unlikely, but oviposition on the surface of walnut fruit is known, so contamination of fruit by eggs is also possible. Infested fruit is likely to be distributed throughout urban, suburban and provincial regions where it will be consumed (and the remains discarded) or it will be discarded whole. Individuals must disperse from the fruit and locate suitable hosts. The potential for dispersal depends on the life stage imported:

- eggs and larvae: these stages are largely or wholly dependent on the movement of fruit as they have limited mobility. They are internal feeders and often complete their feeding stage within one fruit. The fruit would need to remain a suitable substrate until the larvae are ready to pupate. The likelihood of larvae pupating and emerging successfully is dependent on the method of fruit disposal. Larvae in infested fruit/remains disposed of as bagged waste into landfill or into sewage via domestic waste disposal would have a negligible likelihood of exposure. Larvae in infested fruit/remains disposed of into domestic compost, or randomly by the roadside would have a higher likelihood of exposure to a suitable host. Little information is available regarding domestic and industry fruit disposal practices
- pupae may emerge when temperatures exceed the lower developmental threshold of 12.8°C (Siegel *et al.* 2006). Adults can fly to hosts and although flight appears to be limited to distances of 0.5 km (Shelton 1989), the ability to move greater distances from infested fruit to potential hosts significantly increases the likelihood of exposure of adults over larval stages.

The host range of *A. transitella* includes species such as stonefruit, citrus and walnut, which are common in urban and suburban areas throughout New Zealand and are also grown in commercial production areas.
The likelihood of exposure is considered to be moderate.

9.3.2.3. Establishment assessment

A mated female or immatures of both sexes would be necessary to establish a reproductive population, as *A. transitella* reproduces sexually. Larvae or pupae are the most likely stages to enter New Zealand, so at least one of each sex would need to enter, develop successfully and emerge as adults, locate each other and mate. Females are able to attract males by producing pheromones. *A. transitella* is distributed through California, Washington and Oregon where climatic conditions are similar to those of New Zealand, indicating climate would not be a restricting factor for establishment.
The overall likelihood of establishment is estimated to be low, based on the low probability of at least one immature of each sex successfully developing, emerging and locating the other to mate.

9.3.2.4. Consequence assessment

Economic consequences

A. transitella is a primary pest of almonds and pistachios (Siegel 2006), a serious pest of walnuts and figs and a sporadic pest in navel oranges in California (California Ag Supply 2007). If it established, *A. transitella* could become a problem for walnut production. The walnut industry in New Zealand is currently small and primarily domestic, with imports accounting for most consumption a decade ago, but with consumption rising at about 6% per year (McNeil & Savage 2001). Planted areas in June 2005 were 518 hectares (Aitken *et al.* 2007).
Other crops that may be affected are *Citrus* and figs. In 2005 there were 1,702 hectares in commercial *Citrus* production. The estimated value of the domestic crop was NZ$16 million (June 2004) and the export crop was $5 million (March 2006) (MAF 2006). In December 2006 the US market opened to New Zealand *Citrus* exports with an estimated worth then of NZ$2 million per annum, predicted to expand rapidly (New Zealand Government 2006).

Stonefruit production is a larger industry than *Citrus*, walnuts or figs, but this pest is likely to have only limited impact on stonefruit crops.
Where fruit is grown commercially in New Zealand, pest management programmes will be in place and the establishment of new pest species could cause an increase in pest control costs and/or disruption of existing programmes due to increased use of pesticides or the need to use different pesticides. Additional applications of pesticides and/or increased monitoring costs may alter the economic viability of some crops. Establishment of this species in New Zealand would also cause disruption of access to some markets, including Australia.

Environmental consequences

Environmental consequences could include damage to particularly amenity or native plants. Other environmental consequences could include effects from increased use of pesticides, and effects on native lepidopterans due to competition for resources.

Human health consequences

There are no known human health consequences.

The establishment of A. transitella in New Zealand is likely to cause low to moderate economic and low environmental consequences.

9.3.2.5. Risk estimation

A. tricolorella has a negligible likelihood of entry into New Zealand on fresh stonefruit imported from the Pacific Northwest.
A. transitella has a low to moderate likelihood of entry, moderate likelihood of exposure and low likelihood of establishment in New Zealand. The economic impact is likely to be low to moderate and the environmental impact low. The risk associated with *A. transitella* on fresh stonefruit imported from the Pacific Northwest is non negligible and phytosanitary measures can be justified.

9.3.3. Risk management

Biosecurity New Zealand requires risk mitigation measures for *A. transitella* on stonefruit from California and cherries from the Pacific Northwest.

9.3.3.1. Options

Pest free areas or places of production

A. transitella has been recorded from Washington and Oregon in the Pacific Northwest. It is unlikely that pest freedom would be a viable management option.

Orchard management, harvest and post-harvest processing

Control of *A. transitella* relies mainly on good orchard sanitation, for example eliminating overwintering and feeding sites and harvesting the new crop before larvae can enter the nuts. Insecticides currently registered for the control of this species are not very effective, so management is focused on preventing infestations (Pickel *et al*. 2008).
Live *A. transitella* larvae (94%) and pupae (6%) have been found on nectarine fruit after packhouse procedures in California at a mean incidence of 4.9 per 100,000 fruit (Curtis *et al.* 1992). Damage to the fruit caused by this species is usually severe, with clearly visible symptoms, and Yokoyama and Miller (1999) assumed that all infested fruit would be culled during the harvest and packing processes, but the findings of Curtis *et al*. (1992) indicate that standard packhouse procedures cannot be relied on exclusively to disinfest stonefruit to an acceptable level of risk.

Cold treatment (pre-export or in transit)

The upper 95% confidence limit of the LT_{95} (lethal time) for the most cold tolerant stage of *A. transitella* was found to be 21 days at 5°C (pupae) and 10 days at O°C (larvae), indicating that cold treatment for sea-freighted produce has the potential to be an effective disinfestation treatment. Eggs were less cold tolerant than either larvae or pupae (Johnson 2007).

Visual inspection

Eggs are laid inside fruit and larvae feed internally and, although it is said to be conspicuous, damage may be difficult to detect by visual inspection.

Fumigation

Methyl bromide treatment schedules for internally feeding insects are provided in the USDA Treatment Manual (2004), and some evidence is available on the effectiveness of methyl bromide specifically on pests of stonefruit.

9.3.3.2. Risk management options in descending order of stringency

Option 1: Methyl bromide fumigation
Option 2: orchard management
Option 3: cold treatment
Option 4: post harvest inspection.

9.3.4. Assessment of uncertainty

- there is very little information available regarding domestic and industry fruit disposal practices e.g. disposal of culled and unsold fruit by wholesalers and retailers, or uneaten fruit and fruit remains by consumers. A survey conducted in the UK found that 26% of fruit purchased was thrown away uneaten, and also that between 15 and 25% of households compost at home (Ventour 2008), but similar data for New Zealand does not appear to be available.
- little information on thermal thresholds for this species was found, so it is unknown what effect cold treatment would have.

9.4. *Archips* species (leafroller moths)

The species examined in this risk assessment have been grouped together because of their related biology and taxonomy. They are: *Archips argyrospilus*, *Archips fuscocupreanus*, *Archips podana* and *Archips rosana* (Lepidoptera: Tortricidae)
Scientific name: *Archips argyrospilus* (Walker, 1863)
Common name/s: fruit-tree leafroller, apple leafroller, pear borer
Other scientific names: *Archips argyrospila*, *Archips mortuanus*, *Cacoecia argyrospila*, *Retinia argyrospila*, *Tortrix argyrospila*

Scientific name: *Archips fuscocupreanus* Walsingham, 1900
Common name/s: apple tortrix, Asiatic leafroller, apple leafroller
Other scientific names: *Archips ishidai*, *Archips punicae*, *Cacoecia fuscocupreana*, *Ptycholoma fuscocupreanum*

Scientific name: *Archips podana* (Scopoli, 1763)
Common name/s: great brown twist moth, fruit tree tortrix moth
Other scientific names: *Archips oporana*, *Archips podanus*, *Archippus podanus*, *Cacoecia oporana*, *Cacoecia podana*, *Phalaena podana*, *Tortrix podana*

Scientific name: *Archips rosana* (Linnaeus, 1758)
Common name/s: european leafroller, filbert leafroller, rose twist moth
Other scientific names: *Archips rosanus*, *Cacoecia hewittana*, *Cacoecia rosana*, *Tortrix hewittana*, *Tortrix laevigana*, *Tortrix rosana*

PNW status

A. argyrospilus has been recorded from Washington (Anthon 1951; Melander 1924; Wolfe & Anthon 1953; Beers *et al*. 1993), Oregon (Fulton 1921a, Zhang 1994) and Idaho (Anonymous 1926, 1928; Edmundson 1916; Smith 1922). *A. fuscocupreanus* has been recorded from Washington (CPCI 2008, ODA 2004, Maier 2006). *A. podana* has been recorded from Washington (LaGasa *et al.* 2003). *A. rosana* has been recorded from Washington (Beers *et al.* 1993) and Oregon (AliNiazee 1976, Beers *et al.* 1993, CPCI 2008).

New Zealand status

These species are not known to be present in New Zealand. Not recorded by: Dugdale (1988), Hoare (2001), CPCI (2008), PPIN (2008).

General geographical distribution

A. argyrospilus is widely distributed throughout central and eastern Europe and has also been recorded from the Mediterranean, the U.K, Canada and the United States. *A. fuscocupreanus* has been recorded from Japan, Korea, Russia and the United States. *A. podana* is widely distributed throughout central Europe and has also been recorded from eastern Europe, the U.K, Canada and the United States. *A. rosana* is widely distributed throughout central and eastern Europe and has also been recorded from the Mediterranean, the U.K, Canada and the United States (CPCI 2008).

Hosts

A. fuscocupreanus, A. podana and *A. rosana* are polyphagous species, feeding on a range of fruit trees and deciduous trees and shrubs. *A. fuscocupreanus*, for example, is recorded from 87 plants in 15 families, and is most abundant on *Malus*, *Pyrus* and *Morus*. *A. argyrospilus* has been recorded from fewer hosts than the other species but is probably similarly polyphagous (CPCI 2008). All four species have been recorded from plum (Beers *et al*. 1993, Maier 2006, LaGasa *et al*. 2003, Zhang 1994); *A. argyrospilus* has additionally been recorded from apricot (Beers *et al*. 1993) and *A. rosana* from apricot and peach (CPCI 2008).

Plant parts affected (from CPCI 2008)

Eggs of the four *Archips* species are laid in masses on leaves or trunks and branches. No records were found of any of these species ovipositing on fruit. Larvae feed on leaves and flowers, and also fruit. However, most records for these four species feeding on fruit refer to immature, developing or young fruit or “fruitlets”. Only one reference was found to any of these species feeding internally on fruit: CPCI (2008, *in* ‘Means of movement and dispersal”) states that *A. podana* may feed internally on fruit. This statement is unreferenced. Pupation occurs towards the bottom of the host plants or in the soil close to hosts (*A. fuscocupreanus*), or in rolled leaf shelters (*A. podana, A. rosana*). There are no records of interceptions of this genus in MAF’s Quancargo database; however unidentified live tortricids are intercepted reasonably frequently in stonefruit consignments from the USA, and *A. argyrospilus* has been intercepted on citrus from the USA (Townsend 1984).

Biology

The genus *Archips* is classified in the tortricid tribe Archipini, in which all species lay their eggs in groups or masses (Chapman 1973). This habit is important for the dispersal pressure it creates at the hatching site. *A. argyrospilus*, *A. fuscocupreanus* and *A. rosana* are univoltine (Beers *et al.* 1993, CPCI 2008). *A. podana* is generally univoltine but may initiate a second generation in Europe where conditions are favourable (CPCI 2008). *A. argyrospilus, A. fuscocupreanus* and *A. rosana* overwinter as eggs, while *A. podana* overwinters as immature larvae (Chapman 1973). The stonefruit harvest in the Pacific Northwest spans June to September, with approximately 70 per cent of the harvest occurring in July and August. At this time, when mature fruit are available, the univoltine populations of *A. argyrospilus, A. fuscocupreanus* and *A. rosana* are likely to be present in orchards as predominantly late instar larvae or pupae and adults (Beers *et al.* 1993). Populations of *A. podana* however are likely to be present as early instar (small) larvae at harvest time as they overwinter as immature larvae and have matured, mated, laid eggs and the next generation have hatched by harvest.

9.4.1.2. Hazard identification conclusion

These four tortricid species are present in the Pacific Northwest and absent from New Zealand. They are all known to feed externally on the fruit of *Prunus* species. *A. argyrospilus* has been intercepted on fresh citrus and *A. podana* has been recorded as feeding internally in stonefruit (but this record is probably erroneous). Accordingly these species are treated as potential hazards in this analysis.

9.4.2. Risk assessment

9.4.2.1. Entry assessment

Most records of these species on fruit refer to external feeding on immature, developing or young fruit or “fruitlets”. At harvest time *A. argyrospilus, A. fuscocupreanus* and *A. rosana* are likely to be present in orchards predominantly as late instar larvae or pupae and adults. In the unlikely event they would be associated with mature fruit, packhouse procedures such as post-harvest brushing and sorting of fruit would be likely to remove them due to their reasonably large size. Fully grown larvae are around 2cm long; pupae are dark brown and about 1 cm long; adults have a wingspan of 2 to 3 cm.

Only one species, *A. podana*, is likely to be present as early instar (small, and hard to detect) larvae at harvest time, though records of fruit-feeding refer to immature fruit. *A. podana* is a relatively recent invader in the USA, having been first recorded from Washington State in 2000. LaGasa *et al*. (2003) carried out a survey in 2001, and reported that where it was found, this species was less common than any other leafroller species, and caused little damage. While this may be due to the species being a relatively recent invader, it also appears that *Prunus* is not a favoured host. The only *Prunus* host recorded by LaGasa *et al*. (2003) was plum, and this accounted for only 2.3% of all host records (not fruit records), with the majority of hosts being apple and mountain ash. Thus levels of contamination on fruit are likely to be extremely low.

The likelihood of A. argyrospilus, A. fuscocupreanus, A. podana or A. rosana entering New Zealand on fresh stonefruit from the USA is considered to be negligible and they are not classified as hazards. Therefore risk management measures are not justified.

9.5. Archipine leafrollers

The species examined in this risk assessment have been grouped together because of their related biology. They are: *Argyrotaenia citrana*, *Choristoneura rosaceana* and *Pandemis pyrusana* (Lepidoptera: Tortricidae: Archipini)

Scientific name: *Argyrotaenia citrana* (Fernald, 1889)
Common name/s: apple skinworm, orange tortrix
Other scientific names: *Argyrotaenia franciscana*, *Argyrotaenia purata*, *Cacoecia franciscana, Eulia citrana*, *Eulia franciscana*, *Tortrix citrana, Tortrix franciscana, Tortrix purata.*

Scientific name: *Choristoneura rosaceana* (Harris, 1841)
Common name/s: Obliquebanded leafroller, rosaceous leaf roller
Other scientific names: *Archips rosaceana, Cacoecia rosaceana, Loxotaenia rosaceana, Teras vicariana, Tortrix gossypiana, Tortrix rosaceana*

Scientific name: *Pandemis pyrusana* Kearfott, 1907
Common name/s: apple pandemis
Other scientific names: *Tortrix pyrusana*

PNW status

A. citrana has been recorded from Washington (Breakey & Batchelor 1948, Coop *et al.* 1989) and Oregon (Coop *et al.* 1989). *C. rosaceana* has been recorded from Washington (CPCI 2008, Zhang 1994) and Oregon (CPCI 2008, Grimble & Beckwith 1992, Zhang 1994). *P. pyrusana* has been recorded from Washington (CPCI 2008, Pfannenstiel *et al*. 2004, Zhang 1994).

New Zealand status

None of these species are known to be present in New Zealand. Not recorded by: Dugdale (1988), Hoare (2001), CPCI (2008), PPIN (2008).

General geographical distribution

A. citrana has been recorded from Canada, the USA (CA, OR, WA) and Mexico. *C. rosaceana* has been recorded from Canada and much of the USA (AZ, AR, CA, CO, FL, GA, IA, LA, ME, MA, MI, MN, MS, NY, ND, OR, PA, TX, UT, VA, WA, WI, WY). *P. pyrusana* has only been recorded from the USA (CA, WA) (CPCI 2008).

Host range

All three species are more or less polyphagous.
A. citrana has a very broad crop and non-crop host range. Apple, *Rubus* spp. and grape are primary hosts, but over 80 host species have been reported in the following families: Anacardiaceae, Asparagaceae, Asteraceae[1], Aquifoliaceae, Begoniaceae, Berberidaceae, Buddlejaceae, Caryophyllaceae[1], Commelinaceae, Cupressaceae[1], Dryopteridaceae[1], Ericaceae[1], Fabaceae[1], Fagaceae, Geraniaceae[1], Hydrophyllaceae, Juglandaceae, Lauraceae[1], Myrtaceae[1], Onagraceae[1], Pinaceae, Poaceae[1], Polygonaceae[1], Ranunculaceae[1], Rhamnaceae[1], Rosaceae[1], Rutaceae[1], Salicaceae, Scrophulariaceae[1], Solanaceae[1], Urticaceae[1], Verbenaceae[1] and Vitaceae (Robinson *et al.* 2008). Hosts include citrus, various greenhouse plants, *Pinus radiata*, avocado and apricot (CPCI 2008). Peach and plum were reported as hosts by Breakey and Batchelor (1948).

C. rosaceana is broadly polyphagous, feeding on the foliage or fruit of a wide variety of plants. Hosts have been recorded from the following families: Aceraceae, Anacardiaceae, Apiaceae[1], Aquifoliaceae, Asteraceae[1], Betulaceae, Caprifoliaceae, Caryophyllaceae[1], Cornaceae, Corylaceae, Elaeagnaceae, Ericaceae[1], Fabaceae[1], Fagaceae (including *Quercus*), Geraniaceae[1], Grossulariaceae, Hippocastanaceae, Oleaceae[1], Pinaceae, Rhamnaceae[1], Rosaceae[1], Salicaceae, Tiliaceae, Typhaceae[1], Ulmaceae and Verbenaceae[1] (Robinson *et al.* 2008). Primary hosts are woody plants (that is deciduous trees) including a number of fruit trees, shrubs and conifers, with notable preference for species in the Rosaceae, including apple and pear (CPCI 2008), peach and plum (Fulton 1921a) and cherry (Beers *et al.* 1993).

P. pyrusana has been recorded from the following host families: Cornaceae, Caprifoliaceae, Rhamnaceae[1], Rosaceae[1] and Salicaceae (Robinson *et al.* 2008). Hosts in the Rosaceae include apple and pear (CPCI 2008), cherry (Beers *et al.* 1993), apricot (Newcomer & Carlson 1952, Carlson & Newcomer 1950, Beers *et al.* 1993) and peach (Brunner & Beers 1990). *Pandemis* larvae have also been found on wild plants such as cottonwood, rose, willow, dogwood, hawthorn, antelope brush, big-leaf maple, chokecherry, lupine and alder, generally in low numbers (Beers *et al.* 1993).

[1] family contains native species, according to New Zealand Plant Conservation Network database

Plant parts affected

A. citrana attacks fruits/pods, growing points, inflorescence, leaves and stems (CPCI 2008); feeding mainly on the foliage, but also attacking the flowers and ripening fruit of raspberries, and contaminating fruit in processing plants (Breakey & Batchelor 1948).

C. rosaceana larvae feed on foliage, buds and blossoms, bore into growing shoots and feed on immature and mature fruit (Beers *et al.* 1993). EPPO/CABI (1997j) and Pickel *et al.* (2006g) reported larvae feeding on the fruit surface rather than foliage of peaches and nectarines. Kaethler *et al.* (1982) also recorded larvae feeding on the surface of fruit, especially on peaches with opened split pits, where they feed around the opened stem end and down into the fleshy areas around the pit.

P. pyrusana feeds primarily on foliage but can damage fruit, particularly fruit near leaves, or in clusters (Beers *et al*. 1993, Walker & Welter 2001).

There are no records of interceptions of these species on fresh produce in MAF's Quancargo database; however unidentified *Argyrotaenia* species have been intercepted on oranges from the USA, and unidentified live tortricids are intercepted reasonably frequently on stonefruit consignments from the USA.

Biology

A. citrana (after Grafton-Cardwell *et al.* 2004 and CPCI 2008): *A. citrana* is adapted to cool maritime climates. In coastal areas it may have more than three generations a year, whereas in intermediate districts it has two or three and up to five generations. Larvae overwinter as small or large larvae or pupae in grape clusters, on weeds or in dead leaves remaining on branches and buds. Pupation generally occurs at the larval feeding site. Up to five egg masses (more than 200 eggs) are laid in clusters on smooth surfaces, such as stems, the upper side of leaves or fruit. Moths are negatively phototropic and remain in vegetation during the day.

C. rosaceana and *P. pyrusana* (timing for Washington State, after Beers *et al.* 1993): both species have two generations a year and overwinter as second or third instar larvae within a hibernaculum in crevices in bark. The overwintering larval generation becomes active in spring, and larvae are fully grown by mid-to late May, when they pupate. Adult activity peaks about mid-June and summer egg hatch is generally from mid- to late June. These larvae mature by late July or early August, and summer generation adult activity peaks in mid- to late August. Eggs of the overwintering generation hatch in late August to early October some years. Newly hatched larvae feed for a short time before moving to scaffold limbs and building hibernacula in October. Mature fruit are present from June to September, with the main harvest being in July and August. Early instar summer generation larvae are present at early harvest, and mature over the harvest period. Winter generation eggs and early instar larvae are present towards the end of harvest. Damage to plum and apricot fruit caused by surface feeding can be severe if populations are not managed.

9.5.1.2. Hazard identification conclusion

All species are present in the Pacific Northwest and absent from New Zealand. They are known to feed externally on the fruit of *Prunus* species and are therefore classed as potential hazards in this analysis.

9.5.2. Risk assessment

9.5.2.1. Entry assessment

Chapman (1973) classed these three species as "external fruit feeders". *A. citrana* is known to feed in fruit clusters, but generally produces webbing which increases the chance of detection. Data on field bionomics indicates that all developmental stages are present throughout the year. The main risk is likely to be eggs laid on the fruit surface. Adults and pupae are not likely to be associated with fruit.

C. rosaceana and *P. pyrusana* have both been reported to feed preferentially on fruit rather than foliage of stonefruit (EPPO/CABI 1997j, Pickel *et al.* 2006g), and both are associated with feeding on mature fruit (Brunner & Beers 1990, Beers *et al*. 1993). Data on field bionomics in Washington State indicates that all larval instars of both species are potentially present during harvest. According to EPPO/CABI (1997j) it is unlikely that commercially traded fruits would carry these two species because the larvae feed externally on the fruits. However, both are common in Washington State and *C. rosaceana* is the dominant leafroller pest in parts of Oregon (Beers *et al.* 1993), so levels of contamination on fruit are likely to be relatively high. Larval stages of *C. rosaceana* and *P. pyrusana*, in particular those of the winter generation are likely to be able to survive cold treatment.
The likelihood of entry is considered to be low to moderate for all three species.

9.5.2.2. Exposure assessment

A. citrana is most likely to enter New Zealand as eggs on the fruit surface. They would be unable to develop while in cold storage but may hatch on arrival if temperatures exceed 5°C. *C. rosaceana* and *P. pyrusana* are most likely to enter the country as early instar larvae on the fruit surface, or within the stem cavity. Entry of eggs, pupae and adults of these two species is unlikely, as these stages are not associated with fruit.
Fruit is likely to be distributed throughout urban, suburban and provincial regions, where it will either be consumed (and the remains discarded) or discarded whole. From the fruit disposal location, larvae need to disperse from the discarded fruit and locate suitable hosts. Larvae are able to move short distances themselves (or may possibly be moved by animal vectors). They are likely to move off fruit/remains as it becomes unsuitable as a feeding site, but would need to find a suitable host nearby. The likelihood of this depends on the method of fruit disposal. Infested fruit/remains disposed of as bagged waste into landfill or into sewage via domestic waste disposal would have a negligible likelihood of exposure. Infested fruit/remains disposed of into domestic compost, or randomly by the roadside would have a higher likelihood of exposure to a suitable host.
Upper and lower developmental thresholds for *P. pyrusana* are 5°C and 30°C (Beers *et al*. 1993). *C. rosaceana* larvae have higher developmental thresholds, and they also vary depending on the instar. The 4th larval instars have the lowest developmental threshold of

7.1°C (Gangavalli & Aliniazee 1985). Even in winter months, *P. pyrusana* larvae arriving in the northern parts of New Zealand are likely to continue developing, based on minimum temperatures given by NIWA (2008).

All three species have wide host ranges, including fruit trees and woody plants common in urban and suburban areas throughout New Zealand, and also grown in commercial production areas, so finding suitable host plants is unlikely to be a limiting factor.

The likelihood of exposure is considered to be moderate.

9.5.2.3. Establishment assessment

A mated female or immatures of both sexes would be necessary to establish reproductive populations, as tortricids reproduce sexually. Larvae are the most likely stages to enter New Zealand, so at least one of each sex would need to enter, develop successfully and emerge as adults, locate each other, mate and oviposit on a suitable host. As with all tortricids, females are able to attract males by producing pheromones.

These three species are classified in the tortricid tribe Archipini, in which all species lay their eggs in groups or masses (Chapman 1973). If eggs enter the country, it is highly likely that a mass will enter and that if any hatch, more than one will do so.

However multiple larvae are unlikely to be present on fruit. This is because archipine species are under strong pressure to disperse from the hatching site, making spread more likely than in species where eggs are laid singly and there is lower dispersal pressure on first instars (Chapman 1973).

All three species are established in areas of the Pacific Northwest where climatic conditions are similar to those of New Zealand, indicating climate would not be a restricting factor for establishment.

The overall likelihood of establishment is considered to be low to moderate depending on the lifestage that enters.

9.5.2.4. Consequence assessment

Economic consequences

These species are pests of important fruit crops including stone fruit, apple, pear and grape. *C. rosaceana* was not considered a serious problem until resistance problems developed in the USA and Canada (CPCI 2008), and it has recently been added to the EPPO A1 quarantine pest list. *C. rosaceana* and *P. pyrusana* have developed resistance to organophosphates such as azinphosmethyl and cross-resistance to insect growth regulators in Washington State, and some populations also display cross resistance to spinosad and indoxacarb (Dunley *et al.* 2006). It would be more difficult to eradicate or control these pests if resistant populations became established in New Zealand.

Establishment of these species in New Zealand could also cause disruption of access to some markets, including Europe and Australia.

Environmental consequences

A. citrana has been recorded from hosts in over 30 families, 20 of which contain native species, *C. rosaceana* from hosts in 26 plant families, 11 of which contain native species and *P. pyrusana* from hosts in five families, 2 of which contain native species. Since these moths, particularly *A. citrana* and *C. rosaceana,* are broadly polyphagous it is likely that they will be able to feed on some of the native species in these plant families. However some recent literature suggests that polyphagous species are less likely to have significant impacts on native species than oligophages. Beever *et al*. (2007) state “highly damaging polyphagous species appear exceptional and it has been postulated that the impact of relatively specialised organisms is likely to be greater than highly polyphagous species”.

Environmental consequences could also include damage to amenity plants such as oaks (*Quercus* is a host of *C. rosaceana*).Other environmental consequences could include effects from increased use of pesticides, particularly if resistant populations were introduced, and effects on native lepidopterans due to competition for resources.

Human health consequences

There are no known human health consequences

The establishment of any of these leafroller species in New Zealand is likely to cause moderate economic and low environmental consequences

9.5.2.5. Risk estimation

A. citrana, C. rosaceana and *P. pyrusana* are considered to have a low to moderate likelihood of entry, a moderate likelihood of exposure and a low to moderate likelihood of establishment in New Zealand. The economic impact is likely to be moderate and the environmental impact low. The risk associated with these leafroller species on fresh stonefruit imported from the Pacific Northwest is non negligible and phytosanitary measures can be justified..

9.5.3. Risk management

Biosecurity New Zealand requires risk mitigation measures for *C. rosaceana* and *P. pyrusana* on cherries from the Pacific Northwest.

9.5.3.1. Options

Pest free area or pest free place of production

The distribution of these species in the Pacific Northwest may be restricted, in which case pest freedom would be an option. The requirements for the establishment of a pest free area are described in the International Standards for Phytosanitary Measures (ISPM) number 4, while the requirements for the establishment of a pest free place of production are described in ISPM number 10. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the area or place of production.

Orchard management, harvest and post-harvest processing

Leafrollers are managed in PNW stonefruit orchards by blossom, petal fall, shuck fall, late spring and summer sprays which include *Bacillus thuringiensis*, methoxyfenozide and spinosad (WSU 2007).
Data on field bionomics in Washington State indicates that all larval instars of *C. rosaceana* and *P. pyrusana* are potentially present during harvest, including early instars which are small, hard to detect (and identify), and may not be removed by packhouse procedures such as post-harvest brushing and sorting of fruit.

Cold treatment (pre-export or in transit)

The effect of cold treatment on these species is not known
In *A. citrana,* larvae are the main overwintering stage and winters with extended periods with temperatures <-10°C truncate the age distribution primarily to the third instar, which is presumably the most cold tolerant (CPCI 2008). Its lower developmental threshold is 5°C (CPCI 2008). It is likely that late instar larvae at least would survive cold treatment of several days to three weeks at around 1°C.

Visual inspection

These species are external feeders and thorough post harvest inspection should detect most stages and also damage and frass on fruit.

9.5.3.2. Risk management options in descending order of stringency

Option 1: pest freedom
Option 2: orchard management
Option 3: packhouse procedures *e.g.* washing and brushing
Option 4: post harvest inspection.

9.5.4. Assessment of uncertainty

- there is very little information available regarding domestic and industry fruit disposal practices e.g. disposal of culled and unsold fruit by wholesalers and retailers, or uneaten fruit and fruit remains by consumers. A survey conducted in the UK found that 26% of fruit purchased was thrown away uneaten, and also that between 15 and 25% of households compost at home (Ventour 2008), but similar data for New Zealand does not appear to be available
- there is uncertainty concerning the impact of broadly polyphagous phytophages on native species.

9.6. *Cydia latiferreana* (filbertworm)

Scientific name: *Cydia latiferreana* (Walsingham, 1879) (Lepidoptera: Tortricidae)
Common name/s: filbertworm
Other scientific names: *Carpocapsa inquilina*, *Carpocapsa latiferreana*, *Melissopus auricalceana*, *Melissopus latiferreanus*, *Cydia inquilina*, *Cydia latiferreanus*

PNW status

Recorded from WA and OR (CPCI 2008)

New Zealand status

Not known to be present in New Zealand. Not recorded by: Dugdale (1988), Hoare (2001), CPCI (2008), PPIN (2008)

General geographical distribution

Canada, USA (AL, AR, CA, CT, FL, IL, MS, MO, NM, NY, NC, OH, OR, PA, TX, UT, VA, WA, WV), Mexico (CPCI 2008)

Hosts

Reported hosts include chestnuts (*Castanea*, Fagaceae), many oak species (*Quercus*, Fagaceae), beeches (*Fagus*, Fagaceae), walnut (Juglandaceae) and *Prunus* (Rosaceae) species (CPCI 2008), filberts or hazelnuts (*Corylus* spp., Betulaceae) and citrus (Rutaceae, Dohanian 1940). CPCI (2008) reports stone fruit and apricot as minor hosts of *C. latiferreana*, and Dohanian (1940) reported apricot and peach as minor hosts.

Plant parts affected

Fruits/pods (CPCI 2008). Dohanian (1940) recorded larvae feeding internally in hazelnuts (*Corylus* spp.), and Branigan (1916) recorded larvae feeding on the fruit of *Prunus integrifolia* (Catalina cherry) and within the seed itself. Larval and pupal stages of *Cydia latiferreana* have been detected on nectarine fruit in California after packhouse procedures (Curtis *et al.* 1992).
In New Zealand there have been two post border reports involving this species:

- a live larva found tunnelling in a nectarine in Tauranga was reported to MAF's Investigation and Diagnostic Centre (IDC) and subsequently identified as *C. latiferreana* (Validated Post Border Report, Accession Number 03/2007/2272). The nectarine (imported from the USA) had been purchased approximately one week before the larva was detected in the partially decomposed fruit (around 12 October 2007).
- four live larva found in hazelnuts in Opotiki were reported to IDC and subsequently identified as *C. latiferreana* (Validated Post Border Report, Accession Number 03/2008/1599). The hazelnuts had been imported from Oregon, and the larvae were only detected after cracking the shells.

C. latiferreana has not been recorded on fresh produce in MAF's Quancargo interceptions database.

Biology

C. latiferreana is a tortricid or leafroller. It is closely related to the codling moth (*C. pomonella*, present in New Zealand), which causes similar damage primarily to apples and pears. *C. latiferreana* is an important pest of hazelnuts and can also infest stone fruit (AliNiazee 1983a, Dohanian 1940). Eggs are laid singly on or near hazelnuts, and hatch in 8-11 days. Larvae enter the nuts to feed and mature in 3 weeks, overwintering as diapausing larvae in cocoons in the nuts, on the ground (Dohanian 1940) or in cracks and crevices of other shelters including gunnysacks and packing house sheds. Some larvae hibernate 2 to 5 cm below the soil surface (CPCI 2008). Mature larvae are whitish and 12 to 15 mm long (CPCI 2008). In Washington and Oregon, pupation takes place between early May and late August, and the adults emerge 2-5 weeks later. Mating takes place soon after emergence and egg laying begins the next day (CPCI 2008). *C. latiferreana* is generally a univoltine species, however, in southern California partial and full second generations occur (Dohanian 1940, CPCI 2008). Larvae feed internally in the fruit, boring large tunnels which are commonly filled with frass. This damage also provides an opportunity for secondary infection by a range of bacteria and fungi. An average of "more than 20%" hazelnut damage was recorded by AliNiazee (1983a) in unsprayed blocks.

9.6.1.2. Hazard identification conclusion

C. latiferreana is present in the Pacific Northwest and is not known to be present in New Zealand. It is associated with *Prunus* species and is present on the fresh produce pathway as demonstrated by live post border interceptions in imported fresh produce. It is therefore classed as a potential hazard in this analysis.

9.6.2. Risk assessment

9.6.2.1. Entry assessment

C. latiferreana larvae feed internally in fruit; additionally eggs (Dohanian 1940) and pupae (Curtis *et al.* 1992) are likely to be associated with the stem cavity and fruit surface respectively. This species is recorded from Washington and Oregon but it is not reported to be an important pest of stonefruit, so levels of contamination on fruit are not likely to be high; however there is little information available.

No interceptions of this species have been reported (Quancargo database), however unidentified tortricids are relatively often intercepted on stonefruit consignments. Additionally, live larvae have been detected post-border in New Zealand twice in produce imported from the USA. Since the detections were post-border, the pathway is not known and may have been air freight; it is only possible to say that the species is apparently capable of survivng transit conditions for a week.

The likelihood of entry is considered to be moderate.

9.6.2.2. Exposure assessment

C. latiferreana is most likely to enter the country as larvae within fruit, or as pupae or possibly eggs in the stem cavity of the fruit. Entry of adults is unlikely. Eggs and pupae may hatch/emerge in transit or on arrival if they arrive in New Zealand in spring (NIWA 2008). Fruit is likely to be distributed throughout urban, suburban and provincial regions. Individuals must disperse from the fruit and locate suitable hosts. The potential for dispersal depends on the life stage imported.

- eggs and larvae: these stages are largely or wholly dependent on the movement of fruit as they have limited mobility. Larvae are able to move from one host to another (CPCI 2008). Infested fruit will either be consumed (and the remains discarded) or will be discarded whole. From the fruit disposal location, larvae must disperse from the discarded fruit and locate suitable hosts or pupation sites. Larvae are able to move short distances themselves and are likely to move off fruit/remains as it becomes unsuitable as a feeding site, but would need to find a suitable host/pupation site very nearby. Pupation takes place inside the fruit, on trees or in the soil (Dohanian 1940). The likelihood of finding a suitable host or pupation site is dependent on the method of fruit disposal. Larvae in infested fruit/remains disposed of as bagged waste into landfill or into sewage via domestic waste disposal would have a negligible likelihood of exposure. Larvae in infested fruit/remains disposed of into domestic compost, or randomly by the roadside would have a higher likelihood of exposure to a suitable host.

- adults: entry of adults is unlikely. However pupae may be associated with fruit and may emerge either in transit or on arrival (depending on the specific conditions). Adults are not strong fliers but can fly short distances to hosts (Dohanian 1940). The ability to move greater distances from infested fruit to potential hosts significantly increases the likelihood of exposure of adults over larval stages.

The host range of *C. latiferreana* includes species such as stonefruit, citrus and oaks which are common in urban and suburban areas throughout New Zealand, and are also grown in commercial production areas. The primary host, hazelnut, is grown commercially in New Zealand as a relatively new industry with limited plantings to date.

The likelihood of exposure is considered to be moderate.

9.6.2.3. Establishment assessment

A mated female or immatures of both sexes would be necessary to establish a reproductive population, as *C. latiferreana* reproduces sexually. Larvae or pupae are the most likely stages to enter New Zealand, so at least one of each sex would need to enter, develop successfully and emerge as adults, locate each other and mate.

Eggs are laid singly on fruit, so the likelihood of an adult male and adult female surviving and finding each other is considered to be lower than that for gregarious insects such as mealybugs or fruit flies (Yamamura & Katsumata 1999). However hosts such as hazelnuts are likely to be purchased in large numbers, increasing the likelihood that adults may emerge in close proximity (four live larve were found after clearance at the border by a commercial importer of hazelnut germplasm; Post Border Report 03/2008/1599). Additionally, female moths are able to attract males by producing pheromones. Pheromone traps are used to estimate population thresholds in the USA in order to maximise control impact (AliNiazee 1983b).

C. latiferreana is distributed through California, Washington and Oregon where climatic conditions are similar to those of New Zealand, indicating climate would not be a restricting factor for establishment.

The overall likelihood of establishment is estimated to be moderate.

9.6.2.4. Consequence assessment

Economic consequences

In the USA *C. latiferreana* is considered a major pest of hazelnuts, capable of causing over 50% damage to hazelnut plantations if left untreated, and it is an occasional stone fruit pest (Curtis *et al.* 1992, AliNiazee *et al.* 1996). Hazelnut production is a relatively new industry in New Zealand, with most orchards having been planted within the last fifteen years. In 2001, plantings were estimated at over 350, 000 trees on blocks which average in size from around 300-3000 trees, primarily in the South Island (Hazelnut Nurseries Limited, 2001).

A truffle industry dependent on oaks and hazelnut trees is emerging in New Zealand. Current truffle production is small (in the order of 20 kilos per year), but it is expected to grow rapidly over the next five years as plantations mature, and growers refine their management techniques (New Zealand Truffle Association 2008). This could also be negatively impacted by damage to these tree species.

Stone fruit is a minor host for *C. latiferreana* (Dohanian 1940, CPCI 2008), but its commercial value is much greater than hazelnuts. Where stonefruit is grown commercially in New Zealand, pest management programmes will be in place and the establishment of new leafroller species could cause an increase in pest control costs and/or disruption of existing programmes due to increased use of pesticides or the need to use different pesticides.

Additional applications of pesticides and/or increased monitoring costs may alter the economic viability of some crops.
Establishment of this species in New Zealand could also cause disruption of access to some markets, including Australia.

Environmental consequences

The recorded hosts of *C. latiferreana* are from the families Betulaceae, Fagaceae, Juglandaceae, Rosaceae, and Rutaceae. Environmental consequences could include damage to (particularly) amenity or native plants. Of the plant families with known hosts of *C. latiferreana*, only Rosaceae and Rutaceae contain native species. The only listed threatened species in either of these families is *A. rorida* (nationally critical, Plant Conservation Network). Other environmental consequences could include effects from increased use of pesticides, and effects on native lepidopterans due to competition for resources.

Human health consequences

There are no known human health consequences

The establishment of C. latiferreana in New Zealand is likely to cause moderate economic and low environmental consequences.

9.6.2.5. Risk estimation

C. latiferreana has a moderate likelihood of entry, moderate likelihood of exposure and establishment in New Zealand. The economic impact is likely to be low to moderate and the environmental impact low. The risk associated with *C. latiferreana* on fresh stonefruit imported from the Pacific Northwest is non negligible and phytosanitary measures can be justified.

9.6.3. Risk management

9.6.3.1. Options

Pest free area or pest free place of production

C. latiferreana has been recorded from Washington and Oregon in the Pacific Northwest. It is unlikely that pest freedom would be a viable management option.

Orchard management, harvest and post-harvest processing

Chemical control of *C. latiferreana* is with Carbaryl, and commercial pheromone lures are available. Populations are monitored in Washington and Oregon throughout the growing season, and flight information is used for insecticide application timing.
C. latiferreana has been recorded on nectarine fruit in California after packhouse procedures at a mean incidence of 1.8 per 100,000 fruit, both as larvae within the fruit (83%) and as pupae in the stem cavity of the fruit (17%) (Curtis *et al.* 1992). Standard packhouse procedures would not have any effect on larvae within fruit, and are evidently not sufficient to remove all pupae contaminating the external fruit surface so cannot be relied on exclusively to disinfest stonefruit to an acceptable level of risk.

Cold treatment (pre-export or in transit)

Cold treatments against related species have been developed, for example *Cydia molesta* and *Cydia pomonella* (Yokoyama & Miller 1989, Hansen 2002), but the effects of cold treatment on *C. latiferrana* are not known. Yokoyama and Miller (1989) found that low-temperature storage (at 0°C for 14 days) prevented *C. pomonella* eggs from developing to the adult stage, and complete mortality of eggs occurred in the embryonic stage after 21 days. *C. pomonella* females that survived a 7-day low-temperature storage in the egg stage laid fewer eggs and fewer viable eggs than control females. They concluded that low-temperature storage may be used as a quarantine treatment for this species if combined with other treatments.

Fumigation

Biosecurity Australia (2006) suggested the following schedule for the fumigation of stonefruit imported from New Zealand (either pre-shipment on on-arrival) against *G. molesta*:

Controlled Atmosphere Temperature Treatment

The USDA-APHIS Treatment Manual list two CATTS treatment schedules for *Cydia pomonella* on peaches and nectarines (USDA Treatment Manual 2008). These treatments are approved for commodities exported from the U.S. into certain countries, but have not (as of January 2008) been approved for imported commodities or domestic movement of these commodities. Regulatory approval is pending.

Visual inspection

Eggs are laid singly in the fruit stem cavity and larvae feed internally, with entry holes which may be difficult to detect by visual inspection alone. International literature also states the difficulty in detecting this species by visual examination (DeFrancesco 2006).

9.6.3.2. Risk management options in descending order of stringency

Option 1: fumigation with methyl bromide or CATTS treatment
Option 2: cold treatment
Option 3: orchard management
Option 4: packhouse procedures *e.g.* washing and brushing to remove pupae

9.6.4. Assessment of uncertainty

- there is very little information available regarding domestic and industry fruit disposal practices, for instance disposal of culled and unsold fruit by wholesalers and retailers, or uneaten fruit and fruit remains by consumers. A survey conducted in the UK found that 26% of fruit purchased was thrown away uneaten, and also that between 15 and 25% of households compost at home (Ventour 2008), but similar data for New Zealand does not appear to be available.
- there is little information available on infestation levels by *C. latiferreana* of stonefruit in the USA.
- information regarding cold treatment has been extrapolated form closely related species and it is assumed that this species will have similar tolerances.

9.7. *Grapholita* species

The species examined in this risk assessment have been grouped together because of their related biology and taxonomy. They are: *Grapholita packardi* and *Grapholita prunivora* (Lepidoptera: Tortricidae).

Scientific name: *Grapholita packardi* Zeller, 1875
Common name/s: cherry fruitworm
Other scientific names: *Cydia packardi, Enarmonia packardi, Enarmonia pyricolana, Grapholitha packardi, Laspeyresia packardi, Laspeyresia pyricolana, Steganoptycha pyricolana*

Scientific name: *Grapholita prunivora* (Walsh, 1868)
Common name/s: plum moth, lesser appleworm
Other scientific names: *Cydia prunivora, Enarmonia prunivora, Grapholitha prunivora, Laspeyresia prunivora, Semasia prunivora*

PNW status

G. packardi has been recorded from Washington (CPCI 2008, Zhang 1994) and Oregon (CPCI 2008). *G. prunivora* has been recorded from all three states (CPCI 2008).

New Zealand status

These species are not known to be present in New Zealand. Not recorded by: Dugdale (1988), Hoare (2001), CPCI (2008), PPIN (2008).

General geographical distribution

G. packardi has been recorded from Canada and the USA (CA, CO, DE, MD, MI, NJ, NY, NC, OR, TX, WA, WI) (CPCI 2008). *G. prunivora* is native to northeastern North America (Beers *et al.* 1993). It has been recorded from Canada and is widespread in the USA (AR, CA, CO, GA, ID, IL, IN, IA, ME, MD, MA, MI, MO, NY, OH, OR, PA, VA, WA, WV, WI) (Mantey *et al.* 2000, CPCI 2008).

Hosts

G. packardi: major hosts are sweet and sour cherry (*Prunus avium* and *P. cerasus*). Minor hosts include quince, apple, plum, peach, Japanese plum, firethorn, European pear, *Rosa* spp. and blueberry. Except for blueberry (Ericaceae), all hosts are members of the Rosaceae (EPPO/CABI 1997k, CPCI 2008). Chapman and Lienk (1971) record *G. packardi* from shoots and fruit of apple, and fruit of cherry, hawthorn and blueberry.
G. prunivora: the main natural host is *Crataegus,* but *G. prunivora* readily attacks apples, plums and cherries (EPPO/CABI 1997l). It has been recorded on peaches, roses and *Photinia* spp. Larvae may also develop in galls of *Quercus* and *Ulmus* (EPPO/CABI 1997l). CPCI (2008) states the main hosts as apple and *Prunus* species, and minor hosts as serviceberries, apricot, sweet cherry, peach, Japanese plum, *Pyrus* spp. and *Rosa* spp.

Plant parts affected

G. packardi and *G. prunivora* are classified as internal fruit and shoot feeders by Chapman (1973). Individual larvae usually complete their feeding within one fruit (Rothschild & Vickers 1991). *G. prunivora* has been reared from the woody tissue of the galls produced by the black knot disease of plum (*Apiosporina morbosa*), and from some insect galls on the leaves of elm and oak. The habit of feeding on woody growth, however, appears to be much less common than in *G. packardi* (CPCI 2008). Live *G. packardi* larvae have been intercepted on fresh stonefruit consignments from the USA on two occasions (Table 10).

Table 10: Interceptions of *G. packardi* on fresh produce from the USA (data from Agriquality)

Lab accession Nº	Date	Host commodity	Life stage	Viability
18201	24/08/1999	Peaches	Larva	alive
18215	26/08/1999	Nectarines	Larva	alive

Biology

Both species overwinter as mature larvae and lay eggs singly (Chapman 1973).

G. packardi eggs are laid on terminal leaves of apple shoots or on fruits of other hosts, usually on sutures or rough areas, but sometimes on fruit stems. Eggs hatch in 7-10 days, and larvae bore into fruits or terminal shoots (apples). Larvae emerge when fully grown and construct overwintering quarters boring into broken or pruned branches, or spinning cocoons in crevices of bark or in the soil. The number of generations per year varies with host and location (CPCI 2008).

G. prunivora overwinters in debris on the ground under the host plant or under bark. In the Pacific Northwest, the pupa develops over a 2- to 3-week period in early spring. Adult emergence begins in early April, depending on weather conditions, and adults that develop from overwintering larvae may be active until early June. Soon after emerging, adults mate and females lay eggs on leaf surfaces or fruit. Eggs hatch in 7 to 10 days. Larvae feed on the fruit immediately after hatching and continue to feed for 18 to 24 days. When mature, they spin tightly woven cocoons in debris or fruit on the ground or under bark scales on the tree. Second generation adults are active from mid-June through early August. Moths from this generation tend to deposit more of their eggs on fruit than on leaves. After maturing, the larvae spin cocoons and most overwinter (after Beers *et al.* 1993). In some parts of Oregon, where *G. prunivora* became a major pest of plums and cherries, the species may produce a partial third generation (CPCI 2008). The stonefruit harvest in the Pacific Northwest spans June to September, with approximately 70 per cent occurring in July and August. At this time, when mature fruit are available, populations of *G. prunivora* are likely to be present in orchards as predominantly eggs and early instar larvae (Beers *et al.* 1993, data for Oregon).

9.7.1.2. Hazard identification conclusion

Both *Grapholita* species are present in the Pacific Northwest and absent from New Zealand. They feed internally on the fruit of *Prunus* species and accordingly these species are classed as potential hazards in this analysis.

9.7.2. Risk assessment

9.7.2.1. Entry assessment

Larvae of both *Grapholita* species feed internally in fruit; additionally eggs are likely to be associated with the fruit surface.

G. packardi is primarily a pest of cherry and an infrequent pest of other stonefruit (EPPO/CABI 1997k, CPCI 2008). *G. prunivora* is ‘a relatively obscure pest of several deciduous trees in the United States and Canada and is not commonly found in commercial orchards. It became a concern in the Pacific Northwest in the early 1990s as a quarantine issue on apples for export, particularly to Japan, but has not been a production problem for the grower’ (Beers *et al.* 1993). However Mantey *et al.* (2000) recognised *G. prunivora* as a recognised pest of stonefruit in the Pacific Northwest and CPCI (2008) states it is a particular problem on plums, apricots and peaches. EPPO/CABI (1997l) considers it to have considerable pest potential, particularly if chemical control practices were to be substantially eased.

Live larvae have been intercepted at the New Zealand border on fresh stonefruit from the USA (Table 6.1). The interception data available does not specify if the consignments were air- or sea freighted, so it is only possible to say that larvae are capable of surviving transit for the minimum amount of time, which is several days.

The likelihood of entry is considered to be moderate.

9.7.2.2. Exposure assessment

Grapholita species are most likely to enter the country as eggs on or larvae within fruit. Entry of pupae and adults is unlikely. Eggs may hatch in transit or after arrival. Infested fruit is likely to be distributed throughout urban, suburban and provincial regions where it will be consumed (and the remains discarded) or it will be discarded whole. From the fruit disposal location, larvae need to disperse from the discarded fruit and locate suitable hosts. These species are internal feeders and often complete their feeding stage within one fruit. The fruit would need to remain a suitable substrate until the larvae reach maturity, at which point these species usually move off the fruit to pupate within wood, in bark or in crevices in the soil (although *G. packardi* can also pupate inside host fruit; Hoerner & List 1952, Brown 1953).

The likelihood of larvae successfully moving off the fruit to pupate is dependent on the method of fruit disposal. Larvae in infested fruit/remains disposed of as bagged waste into landfill or into sewage via domestic waste disposal would have a negligible likelihood of exposure. Larvae in infested fruit/remains disposed of into domestic compost, or randomly by the roadside would have a higher likelihood of exposure to a suitable pupation site or host.

The host range of these two *Grapholita* moths includes species which are common in urban and suburban areas throughout New Zealand, and are also grown in commercial production areas.

The likelihood of exposure is considered to be moderate.

9.7.2.3. Establishment assessment

Immatures of both sexes would be necessary to establish a reproductive population, as *Grapholita* species reproduce sexually. Larvae or eggs are the most likely stages to enter New Zealand, so at least one of each sex would need to enter, develop successfully and emerge as adults, locate each other and mate. Females are able to attract males by producing pheromones. The pheromone produced by *G. prunivora* is very similar in composition to that produced by Oriental fruit moth (*G. molesta*) and extracts can be used to attract males of both species (Gentry *et al.* 1974).

G. packardi and *prunivora* are distributed through the Pacific Northwest where climatic conditions are similar to those of New Zealand, indicating climate would not be a restricting factor for establishment.

The overall likelihood of establishment is estimated to be low, based on the low probability of at least one larva of each sex successfully developing, emerging and locating the other to mate.

9.7.2.4. Consequence assessment

Economic consequences

G. packardi and *prunivora* are both on the EPPO A1 quarantine pest list, and both are capable of causing direct damage to host plants. *G. packardi* was considered a major pest of cherries in the USA until the 1960s, although it was primarily a problem in poorly sprayed orchards (Hoerner & List 1952). Cherries are an important domestic and export crop in New Zealand with 1,341,214 kg being produced in the 2006-07 season, about half for the export market (Summerfruit New Zealand 2008).

Reports of the pest status of *G. prunivora* for stonefruit appear to be slightly contradictory. However both species are likely to cause greater impacts in new environments where established natural enemies are not present. Where stonefruit is grown commercially in New Zealand, pest management programmes will be in place and the establishment of new pest species could cause an increase in pest control costs and/or ii) disruption of existing programmes due to increased use of pesticides or the need to use different pesticides. Additional applications of pesticides and/or increased monitoring costs may alter the economic viability of some crops.

Establishment of these species in New Zealand could also cause disruption of access to many markets since they are both only known from North America.

Environmental consequences

G. prunivora has a wider recorded host range than *G. packardi*. The environmental consequences of establishment of either species could include damage to (particularly) amenity or native plants. Other environmental consequences could include effects from increased use of pesticides, and effects on native lepidopterans due to competition for resources.

Human health consequences

There are no known human health consequences

The establishment of exotic Grapholita species in New Zealand is likely to cause high economic and low environmental consequences.

9.7.2.5. Risk estimation

Grapholita species have a moderate likelihood of entry, moderate likelihood of exposure and low likelihood of establishment in New Zealand. The economic impact is likely to be high and the environmental impact low. The risk associated with *Grapholita* species on fresh stonefruit imported from the Pacific Northwest is non negligible and phytosanitary measures can be justified.

9.7.3. Risk management

Biosecurity New Zealand requires risk mitigation measures for both species on cherries from the Pacific Northwest and stonefruit from California.

9.7.3.1. Options

Pest free areas or places of production

G. packardi has been recorded from Washington and Oregon and *G. prunivora* has been recorded from all three states. It is unlikely that pest freedom would be a viable management option for these species.

Orchard management, harvest and post-harvest processing

Chemical control of *G. prunivora* is accomplished using alpha-cypermethrin, with phosmet and azinphos-methyl used as part of IPM practices. Pheromones are available for monitoring, but there are some problems with specificity (CPCI 2008). Insecticide treatments for control of *Cydia pomonella*, *Rhagoletis cingulata* and *R. pomonella* provide incidental control of these species in some crops.

Most fruit with internally feeding larvae would show external damage or the presence of frass, and would be likely to be rejected during harvesting and processing. Live *G. packardi* larvae have been intercepted at the border, which indicates that orchard management and standard packhouse procedures cannot be relied on exclusively to disinfest stonefruit.

Cold treatment (pre-export or in transit)

Some temperature data are available (Neven 2004):

- at 2°C, 99% mortality of late stage *G. prunivora* eggs was achieved after 52 days
- larvae are more cold tolerant, with 99% per cent mortality of fourth instar larvae, the most tolerant stage, taking 236 days at 2°C
- 99% mortality of the least cold tolerant larval stage, first instars, took 46 days.

The time for 100% mortality (LT_{100}) of the most tolerant egg stage of *G. prunivora* at 2.0°C was 56 days. Larvae appeared to be more cold-tolerant than eggs, with the LT_{90} of the most tolerant stage (fourth instar) at 2.0°C being 71.5 days.
Hansen (2002) evaluated two cold storage treatments against eggs and larvae of *Grapholita molesta* on apples. At 3.3°C, complete mortality was obtained for eggs and early instars by the eighth week, and for late instars by the tenth week. At 0.7+or-0.4°C, eggs and early instars died by the fourth week, and late instars by the sixth week.
These results indicate that treatment at lower temperatures may have the potential to be useful for disinfestation of *Grapholita* species.

Visual inspection

Grapholita larvae feed internally. Eggs and early instar larvae are unlikely to be detected due to their small size (eggs are around 1 mm long), and the comparatively inconspicuous amount of damage they will have produced.

Fumigation

Biosecurity Australia (2006) suggested the following schedule for the fumigation of stonefruit imported from New Zealand (either pre-shipment on on-arrival) against *G. molesta*:
• 32g/m³ at a fruit pulp temperature of 21ºC or greater, or
• 40g/m³ at a fruit pulp temperature of 16ºC or greater, or
• 48g/m³ at a fruit pulp temperature of 10ºC or greater.

The proposed fumigation time is 2 hours and that fruit should not be fumigated if the pulp temperature is below 10ºC. All pre-shipment (offshore) 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/m³)
• 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/m³).

Controlled Atmosphere Temperature Treatment

The USDA-APHIS Treatment Manual list two CATTS treatment schedules for *Grapholita molesta* on peaches and nectarines (USDA Treatment Manual 2008). These treatments are approved for commodities exported from the U.S. into certain countries, but have not (as of January 2008) been approved for imported commodities or domestic movement of these commodities. Regulatory approval is pending.

9.7.3.2. Risk management options in descending order of stringency

Option 1: fumigation with methyl bromide or CATTS treatment
Option 2: orchard management
Option 3: cold treatment

9.7.4. Assessment of uncertainty

- There is very little information available regarding domestic and industry fruit disposal practices, for example disposal of culled and unsold fruit by wholesalers and retailers, or uneaten fruit and fruit remains by consumers. A survey conducted in the UK found that 26% of fruit purchased was thrown away uneaten, and also that between 15 and 25% of households compost at home (Ventour 2008), but similar data for New Zealand does not appear to be available.
- It is assumed that treatemts for the related species *Grapholita molesta* will have similar efficacy on *G. packardi* and *G. prunivora*.

9.8. *Spilonota ocellana* (eyespotted bud moth)

Scientific name: *Spilonota ocellana* (Denis & Schiffermüller, 1775) (Lepidoptera: Tortricidae)
Common name/s: Eyespotted bud moth, apple bud moth
Other scientific names: *Eucosma ocellana*, *Grapholitha ocellana*, *Hedya ocellana*, *Olethreutes ocellana*, *Tmetocera ocellana*, *Tortrix ocellana*

PNW status

S. ocellana has been recorded from Washington (LaGasa & Welch 2005) and Oregon (Oregon Department of Fish & Wildlife 2005)

New Zealand status

This species is not known to be present in New Zealand. Not recorded by: Dugdale (1988), Hoare (2001), CPCI (2008), PPIN (2008)

General geographical distribution

S. ocellana is recorded from central and Eastern Europe, the Mediterranean, UK, Canada and the USA (OR, MI, WA, NY) (CPCI 2008 and selected references above)

Hosts

S. ocellana has a wide host range, feeding on various wild hosts and many fruit crops including apple (its most consistent food source), pear, cherry, blackberry and raspberry (CPCI 2008) and all stonefruit (Beers *et al.* 1993). Zhang (1994) recorded it from plum. Other hosts include *Rosa canina*, *Rubus fruticosus*, *R. idaeus* and *Vaccinium myrtillus* (CPCI 2008).

Plant parts affected

Larvae feed on buds and blossoms, bore into growing shoots and feed on immature and mature fruit (Beers *et al.* 1993). There are no records of interceptions of this species on fresh produce in MAF's Quancargo database; however unidentified live tortricids are intercepted reasonably frequently in stonefruit consignments from the USA.

Biology

(after Beers *et al.* 1993): Populations of *S. ocellana* are univoltine in Washington State, but in California two generations per year have been observed (Caprile *et al.* 2006b). This species overwinters as partially grown larvae within hibernaculums in bark. In Washington larvae become active in spring, burrowing into buds and feeding on the leaf and flower parts, then form feeding nests by webbing leaves and flowers together. The first larvae are full grown by late May or early June and pupate within the feeding nest. The pupal stage lasts 10 to 15 days. Adults begin to emerge in mid- to late June, with flight continuing into July. Eggs are laid singly, usually on the lower surfaces of leaves, and hatch from mid July. Ovsyannikova (2008) noted that eggs are laid "one by one or in groups of 3-5 on the upper side, less often on the lower side of leaves, occasionally on fruits". First instar larvae begin feeding on lower leaf surfaces, constructing feeding sites near the midribs. Leaves touching one another or a leaf touching an apple are also desirable feeding sites. Development continues until larvae are half grown, usually by late July or early August, when they leave feeding sites and construct hibernacula.

The stonefruit harvest in the Pacific Northwest spans June to September, with approximately 70 per cent of the harvest occurring in July and August. At this time, when mature fruit are available, the univoltine populations of *S. ocellana* are likely to be present in orchards predominantly as adults, eggs and early instar larvae.

9.8.1.2. Hazard identification conclusion

S. ocellana is present in the Pacific Northwest and absent from New Zealand. It feeds externally on the fruit of *Prunus* species. Accordingly this species is treated as a potential hazard in this analysis.

9.8.2. Risk assessment

9.8.2.1. Entry assessment

Chapman (1973) classed this species as an "external fruit feeder", feeding on buds and young fruit. There are no reports of pupae or adults associated with fruit, but Ovsyannikova (2008) noted that eggs are laid on fruit occasionally. Field bionomics in Washington indicates that at harvest time eggs and early instar larvae are likely to be present in the orchards (Beers *et al.* 1993). Beers *et al.* (1993) reported that early instar larvae tend to feed on leaves and buds rather than fruit, and Chapman (1973) reports feeding on young fruit, so the main entry risk is likely to be eggs laid on fruit. This species can reach high populations (Chapman 1973), but is easily controlled by conventional neurotoxic insecticides and is seldom reported as a significant pest in Washington (Beers *et al.* 1993). Since populations of *S. ocellana* are well controlled in commercial orchards and egg-laying on fruit is apparently a very rare event, levels of egg contamination on fruit are likely to be very low. Little is known about the cold tolerance of the egg stage and whether it would survive cold treatment. This species overwinters as larvae, so this stage is likely to have the highest cold tolerance.

The likelihood of S. ocellana entering New Zealand on fresh stonefruit from the Pacific Northwest is negligible and this species is not classed as a hazard. Therefore risk management measures are not justified.

9.9. References for chapter 9

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10. Analysis of potential hazards – Neuroptera (lacewings)

This chapter assesses the biosecurity risks from lacewings that are potentially associated with stonefruit imported from the Pacific Northwest into New Zealand

10.1. Green lacewings

***Chrysopa* and *Chrysoperla* species (Neuroptera: Chrysopidae)**
The species examined in this risk assessment have been grouped together because of their related biology and taxonomy. They are predicted to pose a similar risk and require similar mitigation measures.
Scientific names: *Chrysopa nigricornis* Burmeister, 1839; *Chrysopa oculata* Say, 1839 and *Chrysoperla plorabunda* (Fitch, 1855)

PNW status

C. nigricornis has been recorded from Washington (CPCI 2008, Horton 2004). *C. oculata* has been recorded from Washington (James 2006, Grimes & Cone 1985). *C. plorabunda* has been recorded from Washington (Johansen & Eves 1972), and from Oregon (as *C. californica*, Morrison 1940). Unidentified *Chrysopa* species have been recorded from Idaho (Henry & Busher 1987). *C. nigricornis* is the most common lacewing species in the U.S. Pacific Northwest (Zhang *et al*. 2006).

New Zealand status

The genera *Chrysopa* and *Chrysoperla* are not known to be present in New Zealand. Not recorded by: Wise (1992), Macfarlane (in press). *Mallada* (=*Chrysopa*) *basalis* has been recorded from Whale Island in the Bay of Plenty but has not been recorded from mainland New Zealand (Wise 1983, Wise 1992). Deliberate introductions of green lacewing (chrysopid) species have been made on a number of occasions between 1890 and 1972 (Wise 1995).

Hosts

Lacewing larvae are considered generalists, but are best known as aphid predators. *C. nigricornis* is a predator of the aphids *Aphis pomi*, *Monellia caryella*, *Monelliopsis pecanis*, *Myzus persicae* (CPCI 2008) and *Panonychus ulmi* (Holdsworth 1972), among other species.

Plant parts affected

Lacewing larvae and adults do not feed on plants, but rather on phytophagous arthropods. They may be present on any part of the plant that their prey is present on. They have a biological relationship with the plant and are not hitchhikers. A hitchhiker is defined here as a species that has an opportunistic association with transported commodities or other items (like sea containers) with which they have no biological relationship. *Chrysopa* is one of the most common interceptions on stonefruit from the USA. Over 150 interceptions of lacewings identified as this genus were made, live and dead, on fresh stonefruit air and sea-freighted from the USA between 1/02/2003 and 1/10/2006. All stages (eggs, larvae, pupae and adults) were present on fruit, but the most common stage identified was the pupal stage.

Biology

(after Hagley 1998, data for Ontario): Lacewings are generalist predators. Female green lacewings (family Chrysopidae) lay their stalked eggs on plants at night, singly or in groups of 20 to 30. One female lays several hundred eggs, which hatch in 4-12 days. There are three larval instars during the developmental period of about 11-12 days. Larvae are voracious predators, attacking most insects of suitable size, especially soft-bodied ones (aphids, caterpillars and other insect larvae, insect eggs, and at high population densities also each other). Species from temperate regions usually overwinter as prepupae. Adults are crepuscular or nocturnal. *Chrysopa* species are mainly predatory as adults, but other green lacewing adults feed on pollen, nectar and honeydew supplemented with small arthropods.

10.1.1.2. Hazard identification conclusion

Several species of *Chrysopa*/*Chrysoperla* are known to be present in the Pacific Northwest. These genera have not been recorded from New Zealand. They have been intercepted on fresh imported stonefruit many times, and are therefore classed as potential hazards in this analysis.

10.1.2. Risk assessment

10.1.2.1. Entry assessment

Lacewing larvae and adults are generalist predators. They do not feed on plants, but do have a biological relationship with them, that is they are not hitchhikers. *Chrysopa* and *Chrysoperla* species have been intercepted repeatedly on fresh stonefruit imported from the USA. All life stages have been intercepted, and live lacewings have been intercepted on both air and sea cargo (for example Consignment C2003/42357). *Chrysopa* species were recorded on nectarine fruit in California after packhouse procedures at a mean incidence of 60.3 ± 35.7 per 100,000 fruit, the highest level of contamination for any taxonomic group. Cocooned larvae (50%) and pupae (50%) (all alive) were found in the stem cavity of nectarines (Curtis *et al.* 1992).
The likelihood of entry is considered to be high.

10.1.2.2. Exposure assessment

All *Chrysopa/Chrysoperla* life stages are likely to enter the country from the PNW on stonefruit, and all stages may enter by air or sea. Eggs and pupae may hatch/emerge in transit or after arrival. Fruit is likely to be distributed throughout urban, suburban and provincial regions. Individuals must disperse from fruit and locate suitable hosts. The potential for dispersal depends on the life stage imported.

- larvae are mobile but cannot fly. They are assumed to be more likely to move off fruit than larval phytophages, and may do so at any time in search of prey. The likelihood of finding it depends on how close the fruit distribution pathway takes them to a prey source
- adults are able to fly. Green lacewings are not capable of sustained flight, but usually disperse downwind after sunset (Hagley 1998) The ability to move greater distances from infested fruit to sources of prey significantly increases the likelihood of exposure of adults over larval stages.

Although they are generalist predators, some some feed primarily on certain prey species *e.g. C. nigricornis* adults feed primarily on *Cacopsylla pyricola*, the pear psylla; *C. oculata* and *C. carnea* on the green apple aphid, *Aphis pomi* (Hagley 1998). None of these prey species are present in New Zealand, and it is not known whether this host preference would significantly affect the likelihood of exposure or establishment of these predators.
The likelihood of exposure is considered to be moderate.

10.1.2.3. Establishment assessment

A mated female or at least one individual of both sexes would be necessary to establish a reproductive population, as lacewings reproduce sexually.
These species are distributed throughout the Pacific Northwest where climatic conditions are similar to those of New Zealand, indicating climate would not be a restricting factor for establishment. Many purposeful introductions of neuropteran predators have been made into New Zealand from the USA, Canada, Europe, Australia and Pakistan between 1890 and 1972 (Wise 1995). Species that have been introduced from the USA include *C. nigricornis* (against

aphids in 1972); *C. oculata* (against aphids in 1925 and 1926) and *Chrysoperla plorabunda* (against aphids in 1922, 1925, 1926, 1968 and 1970). All importations were unsuccessful, that is none of the introduced species established (Wise 1995). Although this appears to indicate some barriers to establishment exist, Thomas (1989) pointed out that most of the introductions of *Chrysopa* species resulted in the release of very few individuals, which probably limited their prospects for establishment. *C. plorabunda*, however, has been released on a number of occasions, suggesting that this species may have difficulty establishing in New Zealand. Three exotic lacewing species have self-introduced, two from Australia and one from Europe (Wise 1992), though none of these self-introductions are chrysopids.

Green lacewings can fly actively and are also known to be distributed passively by wind currents (McEwen *et al.* 2001). An established population would probably have little difficulty spreading throughout New Zealand.

The likelihood of establishment is considered to be low to moderate, depending on the species.

10.1.2.4. Consequence assessment

Economic consequences

Green lacewings are generalist predators of arthropods, although some feed primarily on certain prey species. They are generally considered to be beneficial (Holdsworth 1972, Grimes & Cone 1985, Hagley 1998). Their establishment in New Zealand is unlikely to cause negative economic consequences, unless it resulted in the disruption of existing IPM programmes for prey species. The introduction of new natural enemies can disrupt control of pests by existing biological control agents, for example the accidentally introduced parasitoid *Meteorus pulchricornis* is known to outcompete the intentionally introduced tomato fruitworm parasitoid *Cotesia kazak* in some situations (Berry & Walker 2004). This can have a negative effect because the introduced generalist, *M. pulchricornis*, allows host larvae to develop to a later stage before killing them, resulting in economic damage to tomatoes; whereas the intentionally introduced agent *C. kazak* kills host larvae at an earlier stage, before they damage crops (Walker *et al.* 2005).

It is possible but very unlikely that the establishment of these species might cause disruption of access to some markets. “Beneficial” species have not been widely considered in risk analyses. Biosecurity Australia (2006) made a detailed consideration of biological control agents (predatory beetles, bugs, mites and thrips and parasitoids) associated with apple pests but only four were considered likely to enter Australia on mature apple fruit. In all four cases, the potential for consequences was considered to be “not significant”, and the species concerned was considered likely to have either a positive impact as a biological control agent, or no negative impact.

Environmental consequences

Several arthropod generalist predators are known to have become invasive when moved by humans beyond their native range, but their ecological effects are complex and unpredictable (Snyder & Evans 2006). They may include direct effects on potential prey species and indirect effects on native predators. Wise (1995) recorded several occurrences of introduced lacewings feeding on native insects, and suggested that introduced predatory lacewings should be considered not as beneficial insects but as pests, due to their possible impact on the endemic insect fauna. No native species of these genera are recorded from New Zealand, but there are 7 endemic and several native neuropteran species (Macfarlane, in press) that could potentially be displaced by the establishment of related exotic species.

Human health consequences

There are no known human health consequences. Lacewings do not bite or sting humans.

The establishment of exotic Chrysopa/Chrysoperla species in New Zealand is likely to cause very low economic and environmental consequences.

10.1.2.5. Risk estimation

Chrysopa/Chrysoperla species have a high likelihood of entry, moderate likelihood of exposure and low to moderate likelihood of establishment in New Zealand. The economic and environmental impacts are likely to be very low. The risk associated with *Chrysopa* species on fresh stonefruit imported from the Pacific Northwest is non negligible and phytosanitary measures can be justified.

10.1.3. Risk management

10.1.3.1. Options

Pest free areas or places of production

C. nigricornis is common and widespread in the Pacific Northwest and pest-free areas are not a viable option.

Orchard management, harvest and post-harvest processing

Because lacewings are viewed as beneficial insects there are no management programmes in place for them, though population levels are likely to be dependent on those of their prey and these species are also likely to be controlled by management programmes for phytophages. Lacewings were the most common contaminant in packed nectarines in California and a very common interception at the border, which indicates that orchard management and standard packhouse procedures cannot be relied on to disinfest stonefruit to an acceptable level of risk.

Cold treatment (pre-export or in transit)

Little is known about the effects of cold treatment on these species. Temperate region chrysopids usually overwinter as prepupae, which would presumably be the most cold tolerant stage.

Visual inspection

Lacewings are distinctive in appearance, even at the egg stage (this is attached to its substrate by a conspicuous stalk). This may in part account for the large numbers of identifications at the border. Thorough inspections should detect most stages.

10.1.3.2. Risk management options in descending order of stringency

Option 1: orchard management
Option 2: packhouse procedures *e.g.* washing and brushing
Option 3: post harvest inspection
Option 4: no measures, taking into account the likely very low economic and environmental impacts of establishment of these species.

10.1.4. Assessment of uncertainty

- there is uncertainty over which green lacewing species (singular or plural) are being intercepted repeatedly at the New Zealand border. A number of species in these genera are known from the Pacific Northwest and the likelihood of establishment may vary considerably depending on which species is entering the country.

- it is assumed, but not known, that predators are more likely to move off fruit than phytophages, making the likelihood of exposure higher
- it is not known whether species with host preferences would be less likely to establish than true generalists
- there is uncertainty and considerable debate over the ecosystem effects of generalist predators
- no information on thermal thresholds for these species was found, so it is unknown what effect cold treatment would have.

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11. Analysis of potential hazards – Thysanoptera (thrips)

This chapter assesses the biosecurity risks from thrips that are potentially associated with stonefruit imported from the Pacific Northwest into New Zealand**.**

11.1. Thrips (Thysanoptera: Thripidae)

The species examined in this risk assessment have been grouped together because of their related biology and taxonomy. They are predicted to pose a similar risk and require similar mitigation measures. They are: *Frankliniella tritici* and *Taeniothrips inconsequens.*

Scientific name: *Frankliniella tritici* (Fitch, 1855)
Common name/s: eastern flower thrips, peach flower thrips, wheat thrips
Other scientific names: *Euthrips tritici, Frankliniella californica, Thrips tritici*

Scientific name: *Taeniothrips inconsequens* (Uzel, 1895)
Common name/s: pear thrips, fruit tree thrips
Other scientific names: *Euthrips inconsequens, Euthrips pyri, Physopus inconsequens, Physothrips calcaratus, Physothrips inconsequens, Physothrips pyri, Taeniothrips adustus, Taeniothrips pyri*

PNW status

F. tritici has been recorded from Washington (LaGasa 2000), Oregon (Phillips & Poos 1940) and Idaho (CPCI 2008). *T. inconsequens* has been recorded from Washington and Oregon (CPCI 2008).

New Zealand status

Neither species has been recorded from New Zealand. Not recorded by Mound and Walker (1982), CPCI (2008).

General geographical distribution

F. tritici has been recorded from the former USSR, Eastern Europe and Spain, Canada, USA (AR, FL,GA, ID, IL, KY, LA, MD, MS, MT, NJ, NY, NC, ND, OK, OR, PA, WA) and Puerto Rico. *T. inconsequens* has been recorded from the former USSR, the Middle East, Korea, Japan, Central and Eastern Europe, the Mediterranean, Scandinavia, the UK, North Africa, Canada, the USA (CA, CO, IA, KS, ME, MD, MA, MI, MN, NH, NJ, NY, NC, OH, OR, PA, RI, UT, VT, VA, WA, WV, WI) and South America (CPCI 2008 and selected references above).

Hosts

Thrips are commonly polyphagous. The major hosts of *F. tritici* are strawberry and roses; minor hosts include horseradish, asparagus, oats, safflower, sennas, daisy, soyabean, cotton, tomato, lucerne, sweet cherry, plum, wild radish, *Rubus* spp., rye, wild mustard, clovers, wheat and cowpea (CPCI 2008). *T. inconsequens* is a tree-living species that has been considered a major pest of pome fruit trees in California, and of sugar maple trees in Vermont and adjoining eastern States in the USA, primarily through feeding damage to leaves (Mound 2007). Additional hosts are basswood, birch, beech, ash, and black cherry. In Europe, this thrips is associated with woodland vegetation (Palm 2002). Both species have been recorded from nectarines and peaches (Yonce *et al.* 1990, Lewis 1997).

Plant parts affected

Thrips generally have a preference for immature, succulent plant tissue. They feed by puncturing host tissue and sucking out the cell contents, and are generally found within buds and furled leaves or in other enclosed parts of the plant (Dreistadt *et al.* 2008). Both *F. tritici* and *T. inconsequens* have been recorded on the fruit of nectarines and peaches (Payne *et al.* 1991, Lewis 1997) and *T. inconsequens* eggs have been recorded contaminating nectarine and peach fruit (Lewis 1997).

Biology

Thrips are haplodiploid (males = n, females = 2n). Males develop from unfertilized eggs and are usually smaller and shorter-lived than females (Funderburk & Stavisky 2004). Many thrips reproduce sexually, but some species are parthenogenic.

F. tritici is multivoltine. In warmer areas the species reproduces throughout the year, with up to 15 generations mainly in the warmer months. Newly emerged females begin to lay eggs within 1 to 4 days in summer and within 10 to 35 days in winter. In summer, it takes about 11 days to reach the adult stage. Eggs are inserted into flower or leaf tissue, and the pupal stages are spent in the soil. During summer, *F. tritici* adults may live several weeks in summer, and overwintering thrips may live all winter (from Baker & Bambara 1997, data for North Carolina). In Eastern Europe, adults were reported overwintering in plant remains and in the soil. In spring, they emerged, fed, mated and laid eggs singly or in small batches (Kirkov 1965).

Eggs of *T. inconsequens* are laid mainly in the petioles of blossoms and leaves as soon as buds open. Larvae feed on foliage, and after 2 to 3 weeks fall to the ground, enter the soil to depths of up to 40 cm and form pupal cells. In autumn they pupate within the cells and remain in the soil until the following spring. Adults emerge when soil temperature has risen to between 7 to 12° C. After emergence, adults migrate to the expanding buds and begin to feed. There is apparently one generation per year in cooler areas, adults appearing in late April to early May, and larval feeding finished by early June (Palm 2002, data for New York; Teulon *et al.* 1998, data for Pennsylvania). Only female *T. inconsequens* are know to occur in North America, so this species probably reproduces exclusively by parthenogenesis. Both sexes are found in Europe (Stannard 1968).

11.1.1.2. Hazard identification conclusion

Both thrips species are present in the Pacific Northwest and are not known to be present in New Zealand. They are associated with stonefruit and known to infest fruit, and are therefore classed as potential hazards in this analysis.

11.1.2. Risk assessment

11.1.2.1. Entry assessment

All life stages of these two thrips species have been recorded infesting fruit, excepting the pupal stages which overwinter in the soil. *F. tritici* is multivoltine and eggs, larvae or adults may be present at harvest time. Data on the bionomics of *T. inconsequens* (Palm 2002, New York; Teulon *et al.* 1998, Pennsylvania) indicate that adults fly from late March to mid May. Larvae have mostly finished feeding and dropped to the soil by June, thus are only likely to contaminate fruit which is harvested early in the season.

Neither species has been identified at the New Zealand border on stonefruit imported from the USA, although *Frankliniella occidentalis* and unidentified *Frankliniella* species are frequently detected (Quancargo database).

The likelihood that of entry is considered to be low to moderate.

11.1.2.2. Exposure assessment

Exposure to a suitable host requires that nymphs and/or adults survive transport from the border and then the sale and consumption and/or disposal of fruit. From the fruit disposal location, thrips need to disperse from discarded fruit (and/or remains) and locate suitable hosts. The potential for dispersal depends on the life stage

- immatures lack wings and have limited mobility. They are likely to move off fruit/remains as it becomes unsuitable as a feeding site, but would need to find a suitable host very nearby. The likelihood of this depends on the method of fruit disposal
- adults are winged, and the ability to move greater distances from infested fruit to potential hosts significantly increases their likelihood of exposure over that of larval stages. Although most are poor fliers, some species are known to be better dispersers than others – for example *Frankliniella tritici* is highly dispersing, and is known to move rapidly between flowers (Funderburk & Stavisky 2004). The bionomics of the species suggests that adult *F. tritici* are also likely to be contaminating fruit.

Both thrips species are polyphagous and suitable host species are widely distributed throughout New Zealand.

The likelihood of exposure is moderate.

11.1.2.3. Establishment assessment

In general, thrips' high fecundity, short generation time, and capacity to reproduce by parthenogenesis suggest that minimal numbers are required for establishment of founding populations. For example, 33% and 100% of founding populations of 10 and 810 individual *Sericothrips staphylinus*, respectively, established on the weed gorse in New Zealand (cited in Morse & Hoddle 2006). Leaves and fruit from plants infested with adult thrips can easily harbour sufficient eggs to give rise to larval populations exceeding the minimum viable population sizes needed for establishment. Indeed, under optimal conditions populations can potentially establish from a single female (Morse & Hoddle 2006). Yamamura and Katsumata (1999) considered that parthenogenetic, gregarious pests (such as thrips) had the highest probability of introduction into new areas via trade.

Parthenogenesis is likely to facilitate the development of high population densities and also host switching (Schultz 1991). Although most species are poor fliers, they can readily spread long distances by floating (Dreistadt *et al.* 2008). *F. tritici* has been trapped at altitudes of 3,000 meters and is carried over large areas by frontal wind systems (Baker & Bambara 1997). Both species are established throughout the world in places with widely differing climates, including those with climates similar to that of New Zealand.

The likelihood of establishment is estimated to be high.

11.1.2.4. Consequence assessment

Economic consequences

Direct economic consequences include the possibility of extensive crop damage. *F. tritici* is one of the main thrips pests of peaches in southeastern USA (Payne *et al.* 1991) and *T. inconsequens* is economically important to growers of plum, cherry, apple and pear on the West and East Coasts (Palm 2002) and has also been involved in outbreaks on sugar maples.

Thrips are important vectors of viral diseases. *F. tritici* is a known vector of the tomato spotted wilt virus (Chaisuekul *et al.* 2003). This virus is present in New Zealand and has a wide host range. There are numerous mild and severe strains, but it is not known which strains are present or absent from New Zealand. No records have been found of *T. inconsequens* vectoring viral diseases (Brunt et *al.* 1996).

Indirect consequences of the establishment of either of these species include the possibility of permanent destabilisation of IPM systems owing to irruptive outbreaks that require remediation with insecticides, leading to the development of insecticide resistance (Morse & Hoddle 2006), and disruption of access to some markets, particularly Australia.

Environmental consequences

One possible consequence of either thrips species establishing in New Zealand is attack on native plants. Although a large proportion of the New Zealand terebrantian thrips fauna is exotic, few of the exotic species appear to attack native or endemic plants. Reported proportions of exotic terebrantian species vary but are around 50% (24 exotic of 51 according to Morse & Hoddle 2006; 32 of 51 according to Beever *et al.* 2007). Of these exotic species only two (Beever *et al.* 2007), three (Plant-SyNZ 2008) or four (Fagan *et al.* 2008) have been recorded attacking native plants; and there do not appear to be any reports of significant impacts. Beever *et al.* (2007) state "Although some …. introduced thrips are pest species overseas, they are rarely pests in New Zealand because the prolonged dry weather they require to produce large populations occurs infrequently (Mound & Walker 1982)". Other possible consequences of the establishment of these species are increased use of pesticides for control in modified habitats, and the displacement of native thrips species.

Human health consequences

Some thrips species have been recorded as irritants to field workers or the public. When large numbers are present they can be quite irritating; some species "bite", causing an itching and pricking sensation that may provoke rashes or inflammation in the ears and nose (Morse & Hoddle 2006)

The establishment of these two thrips species in New Zealand is likely to cause moderate economic and low environmental and human health consequences.

11.1.2.5. Risk estimation

F. tritici and *T. inconsequens* have a low to moderate likelihood of entry, moderate likelihood of exposure and high likelihood of establishment in New Zealand. The economic impacts are likely to be moderate and the environmental and human health impacts are likely to be low. The risk associated with *F. tritici* and *T. inconsequens* on fresh stonefruit imported from the Pacific Northwest is non negligible and phytosanitary measures can be justified.

11.1.3. Risk management

Biosecurity New Zealand requires risk mitigation measures for *F. tritici* and *T. inconsequens* on stonefruit from California and cherries from the Pacific Northwest.

11.1.3.1. Options

Pest free area or pest free place of production

These species are likely to be widespread in the Pacific Northwest and pest-free areas are not a viable option.

Orchard management, harvest and post-harvest processing

Pest management prior to harvest and/or insecticide dips after harvest are important control methods (Morse & Hoddle 2006). Post harvest washing and/or brushing may dislodge some thrips, but it may not be effective in removing any sheltering under the calyx.
Historically, control of *T. inconsequens* in fruit orchards was obtained with insecticides directed against the adult and larval stages in the tree. Recently applications of diazinon, azinphosmethyl, malathion, and oxamyl have all been effective on thrips attacking apple (CPCI 2008).
Neither species has been identified at the New Zealand border on fresh produce.

Cold treatment (pre-export or in transit)

There appears to be little information on the thermal tolerances of either species. In Vermont, adults of *T. inconsequens* overwinter in the soil and emerge when soil temperatures reach 5 to 7 °C (Parker *et al*. 1995), so this stage at least is highly unlikely to be affected by cold treatment.

Visual inspection

Several aspects of their biology and behaviour make thrips difficult to detect on produce:

- they are minute: adults are about 1.3 mm long (Agnello 1996)
- they tend to be present in cryptic, tight areas such as the stem end of the fruit due in part to a behaviour known as thigmotaxis (Morse & Hoddle 2006)
- their habit of inserting eggs into plant tissue (Funderburk & Stavisky 2004).

Methyl bromide fumigation

A search of the USDA-APHIS Treatment Manual showed eight treatment schedules involving various species of thrips and food commodity combinations, and all stipulate disinfestation treatment with methyl bromide (USDA Treatment Manual 2008). International protocols also rely heavily on methyl bromide fumigation.

Ozone fumigation

Ozone (O3) fumigation has been investigated as a potential quarantine treatment for controlling *Frankliniella* thrips on fresh agricultural commodities (Hollingsworth & Armstrong 2005). A 30 minute treatment of O3 at 200 ppm in 100% CO2 at 37.8 °C killed 98.0% of adult female thrips. This treatment can be damaging so only has potential on selected commodities.

11.1.3.2. Risk management options in descending order of stringency

Option 1: treatment with methyl bromide
Option 2: orchard management, particularly post harvest insecticide dipping
Option 3: packhouse procedures, for example washing and brushing

11.1.4. Assessment of uncertainty

- there is little information available about temperature tolerances of either thrips species.

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12. Analysis of potential hazards – Bacteria

This chapter assesses the biosecurity risks from bacteria that are potentially associated with stonefruit imported from the Pacific Northwest into New Zealand.

12.1. *Pseudomonas syringae* pv. *morsprunorum* (Psm)

Scientific name: *Pseudomonas syringae* pv. *morsprunorum* (Wormald 1931) Young *et al.* 1978 (1978) (Proteobacteria: Pseudomonadales: Pseudomonadaceae)

Common name/s: bacterial canker of stone fruits, leaf spot of stone fruits, shoot wilt of stone fruits, gummosis, blossom blast

Other scientific names: *Pseudomonas morsprunorum*, *Agrobacterium morsprunorum*, *Bacterium morsprunorum*, *Phytomonas morsprunorum*

PNW status

Recorded from Washington and Oregon and assumed to be present in Idaho (USDA 2003, OSU 2007, WSPRS 2008)

New Zealand status

Absent (Landcare NZFUNGI Database 2008). Not recorded by: CPCI (2008).

General geographic distribution

Psm is present in Asia (India, Japan, Lebanon); widespread in Europe (CPCI 2008); present in the USA, Canada, South Africa and Australia (CPCI 2008). In the USA, it is widely prevalent in several states (USDA 2003) and it can be moved freely within the continental USA (USDA 2008).

Hosts

Only species of *Prunus* are considered to be significant hosts. Major hosts are *Prunus avium* (sweet cherry), *Prunus domestica* (plum), *Prunus salicina* (Japanese plum) (CPCI 2008).

Plant part(s) affected

Fruits/pods, inflorescence, leaves and stems (CPCI 2008); dry necrotic lesions on leaves (CPCI 2008); shoots (Roos & Hattingh 1987); necrotic lesions on cherry fruit (Roos & Hattingh 1988); isolated from plum and cherry blossoms (Liang *et al.* 1994); leaf and fruit infections of sweet and sour cherry, plums and prunes occur sporadically in Michigan and Ontario (Jones & Sutton 1996); overwinters in cankers and other diseased tissues, in contaminated buds and occasionally in the vascular system of the tree (Crosse & Garrett 1966).

12.1.1.2. Hazard identification conclusion

Psm is present in the Pacific Northwest and has not been recorded from New Zealand. It affects *Prunus* species and can be present on or in fruit. However there do not appear to be any reliable records of infection of fruit other than cherry. Moreover, symptoms on leaves, blossoms, and fruit (reported as common elsewhere) are rare in Washington cherry orchards (WSPRS 2008). Accordingly, Psm is not classed as a potential hazard in this analysis.

12.1.1.3. Assessment of uncertainty

It appears that this bacterium can sometimes be a very severe pathogen, causing apoplexy-like symptoms in apricot, peach-tree short life, and nectarine decline. Its frequent association with *pv. syringae* makes it difficult to distinguish the relative roles of the two pathogens (S. Pennycook, pers. comm. 2008). In these circumstances, the potential risk posed by possible epiphytic populations present on fruit should not be completely discounted.

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13. Analysis of potential hazards – Fungi

This chapter assesses the biosecurity risks from fungi that are potentially associated with stonefruit imported from the Pacific Northwest into New Zealand.

13.1. *Blumeriella jaapii* (anamorph *Phloeosporella padi*) (cherry leaf spot)

Scientific name: *Blumeriella jaapii* (Rehm) Arx, 1961 (anamorph *Phloeosporella padi* (Lib.) Arx, 1961) (Ascomycota: Helotiales: Dermateaceae)

Common name/s: cherry leaf spot, leaf blight, anthracnose, shot-hole

Other scientific names: *Hainesia feurichii* (anamorph), *Sporonema feurichii* (anamorph), *Cylindrosporium padi* (anamorph), *Ascochyta padi* (anamorph), *Phlyctema padi* (anamorph), *Cylindrosporium hiemalis* (anamorph), *Phloeosporella hiemalis* (anamorph), *Septoria padi* (anamorph), *Cylindrosporium prunophorae* (anamorph), *Cylindrosporium lutescens* (anamorph), *Cylindrosporium tubeufianum* (anamorph), *Coccomyces hiemalis, Higginsia hiemalis, Blumeriella hiemalis, Coccomyces prunophorae, Higginsia prunophorae, Blumeriella prunophorae, Coccomyces lutescens, Higginsia lutescens, Pseudopeziza jaapii, Sporonema feurichii, Higginsia jaapii*

PNW status

B. jaapii has been recorded from Idaho (Farr *et al.* 1989), Washington and Oregon (Farr *et al.* 1989, 2008)

New Zealand status

Absent (Landcare NZFUNGI Database 2008); not recorded by CPCI (2008)

General geographic distribution

Azerbaijan, Bhutan, China, Republic of Georgia, Pakistan, Turkey, eastern and central Europe, Scandinavia, the former USSR, the UK, Canada, USA (Blumer 1958, CPCI 2008)

Hosts

The primary hosts are cherries (Ogawa *et al.* 1995, CPCI 2008). Farr *et al.* (2008) and Ogawa *et al.* (1995) record plums as hosts (as *Coccomyces prunophorae*). Janes and Kahu (2000) tested twelve plum cultivars and found that all were susceptible to *B. jaapii* in varying degrees, while Burkowicz (1966) found that plums and apricots were less susceptible than cherries. Farr *et al.* (2008) do not record peach as a host, and Smith *et al.* (1988) reported peach as being resistant, but several authors have recorded it on this host outside North America (Kornilov & Petrushova 1978, Zaharia & Rafaila 1975). Farr *et al.* (2008) record apricots as hosts in California and Florida.

Plant part(s) affected

Buds (Diaz *et al.* 2007); leaves (Bengtsson *et al*. 2006, Farr *et al.* 2008); fruit (rare) (Ogawa *et al.* 1995); leaves, stems and whole plant (CPCI 2008)

Biology

B. jaapii produces acervuli, which contain conidiophores and conidia on the lower surface of the leaves. Stroma develop in association with conidiomata just beneath the epidermis. The pathogen overwinters in this stage. Several “waves” of production are seen during a season (Ogawa *et al* 1995, CPCI 2008). The fungus overwinters on leaves on the ground (Keitt *et al.*1937). In spring, apothecia are produced in the stroma remaining from the previous year.

Primary symptoms are visible on the upper side of the leaves, followed by the development of conidiomata. The first symptoms are red to purple spots, which later turn brown. Affected leaves turn yellow, but the areas around the lesions can remain green resulting in spot-like disease symptoms, normally more associated with obligate parasites (Blumer 1958). Although leaves are never too old to be infected, their susceptibility decreases with age. The fungus gradually penetrates the whole leaf, growing intercellularly and developing haustoria. *In vitro* mycelial growth was shown to start at 3˚C (Blumer 1958), with optima clearly different between isolates of the fungus. Haustoria do not develop until at least 5 days after the onset of infection. Lesions become visible in 5 to 15 days. Optimum temperatures for lesion development are between 15 and 20˚C, with high humidity. A wet period of at least a few hours is needed for spore germination (Blumer 1958), with ascospore discharge highest between 16 and 30˚C and lowest between 4 and 8˚C. The discharge happens mainly during and shortly after rainfall. Infections are worse in years with above average rainfall (Blumer 1958). Any noticeable development of leaf spot is immediately preceded by a period of rain (Dutton & Wells 1925).

Infected leaves abscise, which can result in severe defoliation. *Prunus* species vary in susceptibility, with environmental conditions modulating the expression of this variation (Diaz *et al*. 2007). In some species, for example plum, the necrotic circulations drop out, producing shot-hole symptoms. Defoliation causes losses in subsequent years for an indefinite period (Dutton & Wells 1925).

Conidia are dispersed by water splash and air currents. The short incubation time of the disease and the leaves being sensitive the whole season provides the background for a possible epidemic cycle (Blumer 1958).

13.1.1.2. Hazard identification conclusion

B. jaapii is recorded from the Pacific Northwest and is not known to be present in New Zealand. The primary hosts are cherries but there are scattered reports of this pathogen affecting apricots, plums and peaches. *B. jaapii* is nearly always reported as a foliar pathogen. Infection of fruit pedicels can occur when weather conditions are optimum for the disease. Infection of fruit is rare but can occur in severe epidemics (Ogawa *et al*. 1995) and the fungus can overwinter in lesions on pedicels or fruit, but only "occasionally" (Keitt *et al*. 1937). Additionally, fruit are only susceptible to infection for a brief period while stomata are present (Ogawa *et al.* 1995). The Import Health Standard for cherries from the Pacific Northwest requires risk mitigation measures for cherry leaf spot, but the IHS for stonefruit (excluding cherries) from California does not. Measures consist of visual inspection of produce and associated packaging and a requirement that the consignment be free from extraneous plant material. The likelihood that this pathogen will be present on harvested fruit is considered to be negligible because cherries are the main host, and fruit infection is rare. On the assumption that consignments of stonefruit will be free of extraneous plant material, *B. jaapii* is not considered to be a potential hazard in this analysis.

13.2. *Mycosphaerella cerasella* (anamorph *Passalora circumscissa*) (leaf spot)

Scientific name: *Mycosphaerella cerasella* Aderh., 1900 (anamorph *Passalora circumscissa* (Sacc.) U. Braun, 1995 (Ascomycota: Mycosphaerellales: Mycosphaerellaceae)

Common name/s: cercospora leaf spot, shot hole, leaf spot

Other scientific names: *Cercospora circumscissa* (anamorph), *Pseudocercospora circumscissa* (anamorph), *Cercospora cerasella* (anamorph), *Cercospora padi* (anamorph), *Cercospora pruni-persicae* (anamorph), *Sphaerella cerasella*

PNW status

Recorded from Idaho and Washington (Crous & Braun 2003)

New Zealand status

Absent (Landcare NZFUNGI Database 2008, as *P. circumcissa*); not recorded in PPIN (2008).

General geographical distribution

Temperate and subtropical regions (Farr *et al.* 2008). Known from: Africa, Asia, Australia (excluding Western Australia and Tasmania), Europe, the former USSR, Yugoslavia, North and South America (Little 1987).

Hosts

Probably specific to *Prunus* species. Most prevalent on cherry, but has been recorded on a number of other species including apricot, peach and plum (Farr *et al.* 2008).

Plant parts affected

M. cerasella is primarily a leaf pathogen, causing necrotic spots on upper and lower leaf surfaces (Ogawa *et al*. 1995). As they enlarge, necrotic regions may coalesce and drop out, giving leaves the typical 'shot-hole' symptoms (Ogawa *et al*. 1995). In severe cases trees may be completely defoliated in early summer (Little 1987, Ogawa *et al*. 1995). Shallow circular necrotic spots may also form on branches and fruit (Little 1987). Little (1987) records this pathogen from fruit, and from the follwing hosts: *Prunus amygdalus*, *P. avium*, *P. cerasus*, *P. domestica*, *P. persica* and *P. spinosa*, but does not specify which host records involve fruit. The pathogen has been isolated from cherry fruit (Wattal *et al.* 2003).

Biology

The fungus overwinters as substomatal stroma in leaf debris on the orchard floor (Ogawa *et al*. 1995). In spring, conidia are produced and these function as a primary inoculum source. Conidia that are dispersed by wind and water-splash from current season lesions produce secondary cycles (Ogawa *et al*. 1995). Disease development is favoured by high humidity, rain, dew, and optimal temperature ranges of 20 to 25°C (Ogawa *et al*. 1995). The fungus is likely to be capable of producing large numbers of spores from overwintering dormant fungi on infected plant material.

13.2.1.2. Hazard identification conclusion

This fungus is present in the Pacific Northwest and is not known to be present in New Zealand. It has been recorded on apricot, peach and plum, and has also been reported causing symptoms on fruit. It is therefore classed as a potential hazard in this analysis.

13.2.2. Risk assessment

13.2.2.1. Entry assessment

M. cerasella is a primary pathogen of non-fruiting plant and leaf tissue and is rarely reported on fruit. Apart from one study recording it as a post-harvest disease of cherries (Wattal *et al.* 2003), it is usually stated to be primarily a leaf pathogen.

Routine harvest and post harvest practices are likely to further reduce the probability of introducing infected fruit. Symptomatic fruit is likely to be removed during harvesting operations as symptoms are distinctive (Ogawa 1995). Post-harvest washing and brushing may remove some spores present on the fruit surface, but would not remove infections in the fruit. Grading and packing procedures are likely to result in culling of symptomatic fruit. Air or sea transit times would range from a few days to several weeks.

Given the low level of infection on fruit, and assuming standard production and post-harvest practices in the USA and an absence of extranoeus plant material, the likelihood of *M. cerasella* entering New Zealand on stone fruit is considered negligible.

The likelihood of M. cerasella entering New Zealand on fresh stonefruit imported from the Pacific Northwest is considered to be negligible. This fungus is therefore considered of negligible risk on this pathway and no phytosanitary measures are required.

13.2.2.2. Assessment of uncertainty

No information was found stating actual levels of incidence of this pathogen on fruit.

13.3. *Mycosphaerella pyri* (anamorph *Septoria pyricola*) (pear leaf spot)

Scientific name: *Mycosphaerella pyri* (Auersw.) Boerema, 1970 (anamorph *Septoria pyricola* (Desm.) Desm., 1850) (Ascomycota: Mycosphaerellales: Mycosphaerellaceae)
Common name/s: leaf fleck of pear, white spot of pear, pear leaf spot, white leaf spot
Other scientific names: *Depazea pyricola* (anamorph), *Septoria nigerrima* (anamorph), *Septoria piricola* (anamorph; variant of '*S. pyricola*'), *Septoria pyri* (anamorph), *Sphaerella pyri*, *Sphaerella sentina*, *Sphaeria sentina*, *Mycosphaerella sentina*, *Phaeosphaerella sentina*

PNW status

Recorded from Washington (Farr *et al*. 2008)

New Zealand status

Not known to be present in New Zealand. Not recorded by Pennycook (1989), Landcare NZFUNGI Database (2008), PPIN (2008).

Hosts

The vast majority of records are from *Pyrus* species, and this fungus can probably be considered specific to *Pyrus*. Reports of *M. pyri* infecting *Malus* are likely to be misidentifications of *Sphaeria sentina* (Sivanesan 1990). The only records of this fungus from *Prunus* are from plum in Brazil (as *M. sentina*, Hanlin 1992, a citation of an earlier record) and from apricots in China (Tai 1979, as *Septoria piricola*). These records are considered to be mistaken or anomalies, and *Prunus* species are not considered to be hosts for *Mycosphaerella pyri.*

13.3.1.2. Hazard identification conclusion

M. pyri is present in the Pacific Northwest and has not been recorded from New Zealand. Records on *Prunus* species are considered to be mistaken or anomalies. Accordingly, *M. pyri* is not classed as a potential hazard in this analysis.

13.4. *Taphrina communis* (plum pockets)

***Scientific name*: *Taphrina communis* (Sadeb.) Giesenh., 1895 (Ascomycota: Taphrinales: Taphrinaceae)
Common name(s): plum pockets, plum leaf curl, bladder plum, mock plum, fruit pocket
Other scientific names: *Exoascus communis*, *Lalaria communis* (anamorph), *Taphrina decipiens, Exoascus decipiens*, *Exoascus mirabilis*, *Exoascus longipes*, *Taphrina longipes*, *Taphrina mirabilis*, *Taphrina mirabilis* var. *tortilis*, *Taphrina rhizipes*

PNW status

Recorded from Washington (Farr *et al*. 2008)

New Zealand status

Absent (Landcare NZFUNGI Database 2008)

General geographic distribution

Central and eastern North America (Farr *et al*. 2008)

Hosts

Prunus besseyi, *P. angustifolia*, *P. mexicana*, *P. americana, P. nigra. P. pumila, P. cuneata, P. domestica, P. glandulosa, P. hortulana, P. maritima, P. munsoniana, P. salicina, P. subcordata, P. tarda,* wild *Prunus* spp. (Wylie 1966; Ogawa *et al.* 1995; University of Nebraska 2003). Rodrigues and Fonseca (2003) studied the molecular systematics of the genus *Taphrina*. Although this study included only a very small number of North American isolates labelled as either "*T. communis*" or "*T. pruni*", it does give some confirmation of the assumption of Mix (1949) that it is doubtful if *T. pruni* is present in North America, and that all "plum pockets" in North America should be ascribed to *T. communis*.

Biology

T. communis overwinters on dormant twigs and buds scales as conidia, but does not penetrate them (Buchholtz & Nagel 1945). Primary infections occur mainly during cool and wet weather in spring. Leaves, shoots, and fruit are all susceptible but symptom development is most common on fruit (University of Nebraska 2003). The fungal hyphae proliferate rapidly throughout developing fruit, producing intense hyperplasia and characteristics fruit bladders (Kramer 1987). Soon after symptoms become apparent, enlarging asci break through the cuticle. A compact layer of asci appears as powdery gray (Kramer 1987). The ascospores can multiply by budding inside or outside the ascus during warm, moist weather. These may continue to bud and produce enormous amounts of spores. The ascosphores and conidia are dispersed via air, water or insects (Kramer 1987). They become lodged in cracks and bud scales, where they germinate and produce yeast-like colonies. Whereas the filamentous state is strictly phytoparasitic, the yeast state is saprobic (Rodrigues & Fonseca 2003).
Infected fruit is reddish at first and later becomes velvety gray, giving a wrinkled and puckered appearance. The seed in these fruits is shrunken or destroyed as it develops, leaving a large empty cavity in the centre (University of Nebraska 2003). The misshapen fruits have thick spongy flesh and may be up to 10 times the size of healthy plums. Twig and leaf infections are much less common, but exhibit the same type of irregular growth, where the host tissue becomes enlarged and curled (Ogawa *et al.* 1995, University of Nebraska 2003).

Plant part(s) affected

Leaves, shoots, and (most commonly) fruit (University of Nebraska 2003)

13.4.1.2. Hazard identification conclusion

T. communis is present in the Pacific Northwest and is considered absent from New Zealand. It is a pathogen of *Prunus* species and is most prevalent on fruit. Therefore *T. communis* is treated as a potential hazard in this assessment.

13.4.2. Risk assessment

13.4.2.1. Entry assessment

This disease appears to be relatively common in the southern, central and eastern USA (Farr *et al.* 2008, University of Nebraska 2003) but records from the Pacific Northwest are limited. Farr *et al*. (2008) record it from Washington. Glawe (2008) records it from the PNW without further detail, based on Shaw (1973). As Farr *et al.* (2008) was based Shaw (1973), it is likely that the records referred to by Glawe (2008) are covered by Farr *et al.* (2008), and do not refer to *T. communis* outside of Washington State. The lack of records from the Pacific Northwest suggests that levels of infection will be very low.

The likelihood of entry of is considered to be low.

13.4.2.2. Exposure assessment

Symptomatic infected fruit would probably be disposed of before sale, while infected fruit suitable for sale would be either consumed and the remains disposed of, or disposed of whole. Bagged waste disposed of into landfill, or waste disposed of into sewage via domestic waste disposal would have a negligible likelihood of exposure. Infected fruit/remains disposed of into compost or randomly by the roadside would have a higher likelihood of exposure to a suitable host. Infected fruit would need to be discarded near susceptible hosts. In its natural habitat, the disease is spread by water-splash, wind and insects (Kramer 1987), but many modern cultivars are resistant, meaning even though they are infected, spores are not produced externally (Ogawa *et al.* 1995).

Hosts of *T. communis* include plum and several wild *Prunus* species, which would be reasonably widely available throughout rural and urban areas in New Zealand.

The likelihood of exposure is considered to be low.

13.4.2.3. Establishment assessment

T. communis has a phytoparasitic phase and a saprobic phase, which can survive on plant debris. Ascospores and conidia form thick weather-resistant walls, making them capable of surviving hot dry summers and freezing winters (University of Illinois 1999), indicating there is no obvious climatological reason why it would not be able to establish throughout New Zealand.

The organism is capable of existing in the yeast stage from one season to the next (Kramer 1987). After a tree breaks dormancy, an ongoing infection cannot be controlled. The fungus can spread considerably from very few infections (Buchholtz & Nagel 1945).

The likelihood of establishment is considered to be moderate.

13.4.2.4. Consequence assessment

Economic consequences

T. communis is currently of little economic importance for commercial plum producers (Ogawa *et al*. 1995) or general stonefruit production (University of Nebraska 2003), although there are historical records that show more than 50% of fruit being lost during periods of severe infection (Young 1924). The disease can be controlled by a single fungicide spray during dormancy (Ogawa *et al.* 1995), but a relative lack of infection does not ensure freedom from infection in following years (Buchholtz & Nagel 1945). Plants free of infection for two years as a result of spraying can still give rise to a high infection rate if not sprayed in the third year. This suggests that once the fungus has established, annual sprays will be necessary (Buchholtz & Nagel 1945), however the “European” “plumpockets”/“bladder plum” pathogen *T. pruni* has been present in New Zealand since at least the 1890s. Symptoms are very rarely seen (unlike the frequent symptoms of the related peach leaf curl pathogen *T. deformans*), and are easily prevented by a single pre-blossom fungicide application. It is unlikely that the presence of *T. communis* would cause any additional economic consequences additional to those already incurred by the presence of *T. pruni*. Establishment of *T. communis* in New Zealand could cause disruption of access to some markets.

Environmental consequences

The only known hosts are in the genus *Prunus*. *Prunus* species are well known amenity species. Many of these species are widely spread as ornamental species in gardens and cities throughout New Zealand and it is likely that some of the species and cultivars present will be susceptible to plum pockets disease.

Human health consequences

There are no known human health consequences.

The establishment of T. communis in New Zealand is likely to have low economic and environmental impacts.

13.4.2.5. Risk estimation:

T. communis has a low likelihood of entry and exposure and moderate likelihood of establishment in New Zealand. The economic and environmental impacts are likely to be low. The risk associated with this fungus on fresh stonefruit imported from the Pacific Northwest is non negligible and phytosanitary measures can be justified.

13.4.3. Risk management

Biosecurity New Zealand requires risk mitigation measures for *T. communis* on *Prunus* nursery stock (MAF Standard 155.02.06).

13.4.3.1. Options

Pest free area or pest free place of production

In the PNW, *T. communis* is only recorded from Washington and the distribution in that state is not known. Pest free areas or places of production might be applied to manage the risk posed by this species. The requirements for the establishment of a pest free area is described in the International Standards for Phytosanitary Measures (ISPM) number 4, while the requirements for the establishment of a pest free place of production are described in ISPM number 10 (IPPC 2007). Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the place of production.

Orchard management, harvest and post-harvest processing

Use of resistant cultivars is the preferred control measure for this disease. It can be controlled on susceptible cultivars by a single fungicide application in late autumn or before budbreak in spring. Effective fungicides include Bordeaux mixture, liquid lime-sulphur, ferbam and chlorothalonil. Thiram can also be used as a dormant spray either in the spring or autumn. Fungicides used against peach leaf curl (*Taphrina deformans*) are also likely to provide

control of this pathogen (Ogawa *et al.* 1995), so no specific control may be needed. There do not appear to be any reports of fungicide resistance in this species.
In modern cultivars, symptoms can be difficult to detect, and may only be seen in cut fruit (Ogawa *et al.* 1995), making it unlikely that all infected fruit would be culled during harvesting and processing. Once the fungus enters the leaf or fruit, the disease cannot be controlled (University of Illinois 1999), so treatments that fruit are subjected to during processing would not have any effect.

Visual inspection

Detection of symptoms may be difficult, and may only be seen in cut fruit because of the limited symptoms on modern cultivars.

13.4.3.2. Risk management options in descending order of stringency

Option 1: pest freedom
Option 2: orchard management
Option 3: use of resistant cultivars
Option 4: post harvest inspection.

13.4.4. Assessment of uncertainty

- the distribution and population levels of *T. communis* within Pacific Northwest orchards is not known.
- many modern stonefruit cultivars are resistant, meaning spores are not produced externally. It is not known if, and with what efficiency, the fungus can spread without the production of external spores.

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14. Analysis of potential hazards – Viruses

This chapter assesses the biosecurity risks from viruses that are potentially associated with stonefruit imported from the Pacific Northwest into New Zealand.

14.1. Apricot ring pox

Other names: apricot ring spot, apricot pit pox (Ogawa *et al*. 1995)
Taxonomic position: Apricot ring pox is a virus-like disease whose cause is still unknown. Results of graft transmission tests suggested that cherry twisted leaf and apricot ring pox could be related (Lott & Keane 1960).

PNW status

Recorded from Washington, Oregon and Idaho (CPCI 2008)

New Zealand status

Apricot ring pox is not known to be present in New Zealand.
Not recorded by Wood (1983), Pearson *et al*. (2006), CPCI (2008), PPIN (2008).

General geographical distribution

Canada, the USA (including California and Utah) (CPCI 2008). In Europe, Denmark, Italy and Romania have diseases reported that are similar to, but not confirmed to be, apricot ring pox (CPCI 2008), while (Desvignes 1990) has claimed that Europe is free of apricot ring pox.

Biology

The causal agent of apricot ring pox is currently unknown, but recently an 800 nm long, rod-shaped virus has been transmitted from trees symptomatic for ring pox to susceptible tobacco plants. Moreover, a high-molecular-weight dsRNA was consistently recovered from sweet cherry twisted leaf disease, supporting the viral aetiology (Ogawa *et al.* 1995).
In infected apricot trees, the first emerging leaves develop without symptoms, while later-emerging leaves show vein-banding, chlorotic spots, streaks and rings, especially in the rapid growing shoots (Hansen *et al.* 1976). Symptoms increase during the growing season and are especially conspicuous in years of below average temperature. Many of the spots and rings become necrotic and drop off, giving a shot-hole appearance later in the growing season. Dark purple discoloration of petioles and current-season twigs can occur (CPCI 2008). The most typical symptoms are concentric rings on fruit (Ogawa *et al.* 1995), which appear just before ripening, starting at the pit-hardening stage (Hansen *et al.* 1976). The black rings or pox can extend deep into the flesh, forming plug-like structures. These structures can reach as far as the endocarp, but do not affect the seed coat. The size and depth of these plug-like structures can vary from a few millimetres up to 2 cm (CPCI 2008). In other cases symptoms are very mild and disappear altogether by harvest time. Fruit drop due to apricot ring pox infection has been observed in Washington (Hansen *et al.* 1976).
Foliar symptoms in plum are similar to those in apricots, but generally less severe, while plum fruit remains unaffected (Hansen *et al*. 1976). In sweet cherry, the most consistent symptom is a twist in the midrib or petiole of leaves during the beginning of the growing season. The lower leaves may abscise after the first third of the growing season and irregular symptoms may appear on fruit (Ogawa *et al.* 1995).
Apricot ring pox can be transferred to healthy apricot trees via grafting (Diekmann & Putter 1996), from budwood, scions, fruit and leaf tissue. A general incubation time of one year has been observed after grafting (Hansen *et al*. 1976). The disease can easily spread in an orchard (Lott & Keane 1960).

Hosts

Natural infections of ring pox and twisted leaf have been reported from apricot (*Prunus armeniaca*), cherry (*P. avium*), chokecherry (*P. virginiana var. demissa*) and hybrid plum (*Prunus salicina x P. simonii*). All apricot cultivars are susceptible (although some are symptomless). Almond, nectarine, peach, sour cherry, Japanese plum, desert peach (*P. andersonii*), black cherry and Bessey cherry (*Prunus pumila* var. *besseyi*) have been experimentally infected (Hansen *et al.* 1976, CPCI 2008).

Affected plant parts

Fruits, leaves/pods, rapidly growing shoots and current season twig bark (Hansen *et al.* 1976); fruit, leaves, shoots, branches, trunk (Ogawa *et al.* 1995).

14.1.1.2. Hazard identification conclusion

Apricot ring pox disease is present in the Pacific Northwest and has not been recorded from New Zealand. It affects *Prunus* species and the symptoms are displayed in fruit, and it is thus classed as a potential hazard in this analysis.

14.1.2. Risk assessment

14.1.2.1. Entry assessment

The effects of apricot ring pox appear to vary between *Prunus* species and cultivars. Some fruit expresses symptoms strongly, some mildly and others are symptomless (Hansen *et al.* 1976). Fruit displaying symptoms would likely be culled during harvesting, but symptomless fruit would not. It is unlikely that treatments that fruit are subjected to during processing (washing, brushing *etc*.) would have any effect on virus inside the fruit. The effects of cold transit on the pathogen are unknown, but it is likely the virus would survive as long as the commodity is viable.

The likelihood of entry is considered to be low.

14.1.2.2. Exposure assessment

Apricot ring pox spreads naturally within orchards (Ogawa *et al.* 1995), but little is known about its transmission. Research has suggested it is not seed transmitted (Cochran & Calavan 1957). It is thought to spread via arthropod transmission, but no vector has been identified (Lott & Keane 1960). Transmission would probably have to take place either by contact between infected fruit and susceptible cultivars, or by a vector. Plant feeding arthropods known to vector viruses are present in New Zealand, and it is possible these agents could vector apricot ring pox.

For the pathogen to spread by either mechanism, infected fruit would need to be discarded near susceptible hosts. Symptomatic infected fruit would probably be disposed of before sale. There is very little information available regarding industry disposal pathways and practices in New Zealand.

Infected fruit suitable for sale would be either consumed and the remains disposed of, or disposed of whole. Bagged waste disposed of into landfill or waste disposed of into sewage via domestic waste disposal would have a negligible likelihood of exposure. Infected fruit/remains disposed of into domestic compost or randomly by the roadside would have a higher likelihood of exposure to a suitable host.

Apricot ring pox can infect a number of *Prunus* species. These are widely distributed throughout suburban and rural areas in New Zealand.

The likelihood of exposure is considered to be low.

14.1.2.3. Establishment assessment

There are no obvious climatological barriers to the establishment of apricot ring pox throughout New Zealand. The detection and eradication of apricot ring pox is potentially problematic because of the possibility of non-symptomatic hosts, and susceptible ornamental species being widespread. Apricot ring pox is not known to have established anywhere outside the western USA and Canada. No vector has been identified for the spread of the virus, although it has been suggested that it is transferred by an arthropod vector.
The likelihood of establishment is considered to be moderate.

14.1.2.4. Consequence assessment

Economic consequences

Distribution of affected fruit in a tree can be very irregular and some apricot cultivars are symptomless. During the first summer following infection only a few fruit may have symptoms, but in subsequent years 30 to 100 percent of fruit can be infected (Hansen *et al.* 1976, Ogawa *et al.* 1995). Although no severe regional outbreaks have been reported, the disease takes a constant toll in many apricot-growing areas (Hansen *et al.* 1976). Wood (1983) discussed apricot ring pox as a severe disease of stonefruit in the Pacific Northwest. The only known control measure is the rapid removal of the infected trees, as well as removing infected ornamental hosts like chokecherry *(Prunus virginiana*) bushes from within 500 m of orchards, to prevent new infections (Ogawa *et al.* 1995, CPCI 2008). The establishment of apricot ring pox in New Zealand could cause disruption of access to some trading partners currently free of the disease.

Environmental consequences

Apricot ring pox has no known hosts outside the genus *Prunus.* While New Zealand has no native species in this genus, *Prunus* species are valued as ornamental trees and are therefore a widespread amenity species.

Human health consequences

There are no known effects on human health.

The establishment of apricot ring pox in New Zealand is likely to cause moderate economic and low environmental consequences

14.1.2.5. Risk estimation

Apricot ring pox has a low likelihood of entry and exposure and moderate likelihood of establishment in New Zealand. The economic impact is likely to be moderate and the environmental impact low. The risk associated with apricot ring pox on fresh stonefruit imported from the Pacific Northwest is non negligible and phytosanitary measures can be justified.

14.1.3. Risk management

14.1.3.1. Options

Pest free area or pest free place of production

No recent reports have been found of apricot ring pox affecting orchards in the Pacific Northwest. The disease is not mentioned by WSU (2007). Pest free areas might be applied to manage the risk posed this disease, following ISPM No 4, which describes the requirements for the establishment and use of pest free areas (IPPC 2007). The requirements for the establishment of a pest free place of production are described in ISPM No 10 (IPPC 2007).

Pest freedom is established by surveys and/or growing season inspections and maintained as necessary by other systems to prevent the entry of the pest into the area.

Orchard management, harvest and post-harvest processing

Preventive measures are used to impede the introduction and establishment of apricot ring pox. The use of virus-free propagation material and the fast elimination of symptomatic trees prevent the wide dissemination of the diseases in affected areas. Removing infected alternate hosts (chokecherry) has been found to prevent new infections (Ogawa *et al.* 1995, CPCI 2008). Fruit displaying symptoms would likely be culled during harvesting and processing, but symptomless fruit would not. It is unlikely that treatments that fruit are subjected to during processing (among others washing, brushing) would have any effect on virus inside the fruit.

Visual inspection

Wood (1983) recommended careful screening against this pathogen, but due to the possibility of symptomless hosts, visual inspection alone is not sufficient as a sole risk management option.

14.1.3.2. Risk management options in descending order of stringency

Option 1: pest freedom
Option 2: orchard management, particularly removal of infected alternate hosts
Option 3: post harvest inspection.

14.1.4. Assessment of uncertainty

- the causal agent of apricot ring pox is still unknown, so there is significant uncertainty regarding all aspects of the disease, particularly transmission mechanisms and possible treatments
- the only method available for diagnosis of the disease is biological assay
- spread of the disease is thought to be arthropod-mediated but no vector has yet been identified.

14.2. Cherry rasp leaf virus

Scientific name: Cherry rasp leaf virus
Common name/s and synonyms: Cherry rasp leaf virus, Cherry rasp leaf nepovirus, flat apple virus, CRLV
Taxonomic position: Nepovirus

PNW status

Cherry rasp leaf virus has been recorded from Washington, Oregon and Idaho (CPCI 2008)

New Zealand status

There is conflicting evidence regarding the status of cherry rasp leaf virus (CRLV) in New Zealand. Chamberlain (1961 in Dingley 1969) reported a low incidence of a rasp leaf symptom in cherry in a few orchards in central Otago, but suggested that it was doubtful that this was caused by the North American rasp leaf virus. Wood (1979) recorded CRLV as “doubtful”, with records of CRLV-like symptoms, but the presence of the virus was not determined. Pennycook (1989) and Brunt *et al*. (1996) recorded the species as present. McLaren *et al.* (1999) stated that the virus was present in New Zealand, but was restricted to central Otago and that the incidence was low except on cv. “Bing”.
However EPPO/CABI (2006) listed it as an “absent/unreliable record” in the EPPO A1 list distribution map. Smith *et al*. (1988) and CPCI (2008) also recorded it as “Absent/Doubtful” and Pearson *et al.* (2006) recorded it as “not confirmed”.
CRLV is therefore currently considered to be absent from New Zealand.

General geographical distribution

Cherry rasp leaf virus was first found in 1935 in Colorado, USA (Bodine & Newton 1942). The virus is native to western North America where it occurs over a wide geographic area, although typically primary outbreaks are usually limited to only one or a few trees. The virus occurs primarily in the foothills west of the Rocky Mountains from Colorado, Utah and California, and north to southern British Columbia (Stace-Smith & Hansen 1976). As other viruses can sometimes induce leaf enation symptoms similar to those of CRLV (Nyland 1976), older reports of CRLV occurring in areas outside western North America may be questionable. CLRV is listed as being present in Canada, but few occurrences recorded (EPPO/CABI 2006). In the USA it is listed as having a restricted distribution (EPPO/CABI 2006) (CA, CO, ID, MT, NE, NM, OR, UT, WA, WI, WY: CPCI 2008). Biosecurity Australia (2008) reported it from Australia.

Hosts

Major hosts are apple, sweet cherry, sour cherry, mahaleb cherry and peach. Minor hosts include raspberry (all Rosaceae). Wild hosts are *Balsamorhiza sagittata* (Asteraceae), *Plantago major* (Plantaginaceae) and *Taraxacum* (dandelion, Asteraceae) (CPCI 2008)

Plant part(s) affected

Fruits/pods, flowers, leaves, stems and whole plant (CPCI 2008)

Biology

Cherry rasp leaf virus (CRLV) is a spherical virus (DPVWeb 2008). The protein shell is composed of two polypeptide molecules. The virus is a member of the nepovirus group (Ogawa *et al*. 1995). The thermal inactivation point is 58°C (ICTVdb 2004).
CRLV has been found to naturally infect cherry, peach and apple trees in orchards (Hansen *et al*. 1974). Natural latent infections can occur into several common weeds, for example

balsamroot, dandelion, plantain and bindweed. CRLV can be transferred to bait plants of cucumber and mazzard cherry (Ogawa *et al.* 1995).
On cherry and peach, leaf-like projections occur along the midrib on the underside of affected leaves. The enations are formed between the lateral veins. As a result, the leaves become deformed and folded, looking very narrow (Hansen *et al.* 1974). Virus infection leads to fruit yield and quality reductions, particularly in cherry and apple (EPPO/CABI 1997m). All cherry cultivars seem to react similarly. Severity (but not the type) of symptoms varies between virus isolates. Infection leads to a general decline of the tree (CPCI 2008). On apples, symptoms consist of rolling of the leaf and flattening of the fruit. In contrast, on *Rubus* the infection is symptomless EPPO/CABI (1997m). Diagnoses strictly based on fruit symptoms should be avoided, because chemical sprays can mimic the symptoms (James *et al.* 2001). Disease symptoms are initially limited to the lower branches and limbs of mature trees, because the virus is introduced via the roots. The virus can be recovered from dormant cherry budwood, but no virus could be recovered from apparently healthy above-ground parts of infected trees (Hansen *et al*. 1974). In recent infections, symptoms are often restricted to one or two limbs (EPPO/CABI 1997m). Healthy trees may become infected when they are replanted in a site formerly planted with infected trees (Nyland *et al.* 1969). Symptoms vary according to the season, even when grown in a greenhouse under constant temperatures (Hansen *et al*. 1974). Infected trees generally decline and die.

Transmission

CRLV is transmitted by the root dagger nematode *Xiphinema revesi* and to a lesser extent *X. californicum*. The Biglerville strain of *X. americanum* transmitted the virus, while the Boonville and Parlier strains did not. These results suggest limited adaptation of vector and virus (Brown *et al*. 1994). Virus-transmitting nematodes can be found up to depths of 60cm in the soil (Hansen *et al*. 1974). The virus is easily sap-transmitted (Ogawa *et al.* 1995) and has been detected in pollen from infected cherry trees, but transmission via pollen has not been confirmed (EPPO/CABI 1997m).

Detection

An RT-PCR detection method has been developed that allows for screening and certification of materials throughout the year. The virus can be detected in fresh, frozen (-80°C), or freeze-dried herbaceous, leaf, and budwood (bark) tissues (James *et al*. 2001).

14.2.1.2. Hazard identification conclusion

Cherry rasp leaf virus is present in the Pacific Northwest and there is some uncertainty about its presence in New Zealand. It affects *Prunus* species and the symptoms are displayed in fruit, and it is thus considered further in this analysis.

14.2.2. Risk assessment

14.2.2.1. Entry assessment

CRLV infects *Prunus* species such as peach systemically from the roots upwards (Hansen *et al.* 1974). In general, occurrences have been local and limited, with only a few trees in an orchard being infected (Hansen *et al.* 1974). The effects of transit on the pathogen are unknown, but it is likely the virus would survive as long as the commodity is viable.
The likelihood of entry is considered to be low.

14.2.2.2. Exposure assessment

Transmission of CRLV would have to take place either by direct contact between infected fruit and susceptible host cultivars, or by contact between infected fruit and a suitable nematode vector. The disease spreads slowly based on movement of its vector, about 1 m

annually (CPCI 2008). *Xiphinema* species are widespread throughout New Zealand, and *X. diversicaudatum* has been found associated with apple, citrus and apricot trees (Sturhan *et al*. 1997). The *X. americanum* group is represented by three species, which have been found associated with various cultivated plants and bowling greens throughout in New Zealand (Sturhan *et al*. 1997). Suitable hosts are very widely distributed throughout urban and rural areas in New Zealand.
The likelihood of exposure is considered to be low.

14.2.2.3. Establishment assessment

There are no obvious climatological barriers to the establishment of CRLV throughout New Zealand. The virus is transmitted via *Xiphinema* vectors, and several species of this genus are present in New Zealand. The detection and eradication of CRLV is potentially problematic because of the possibility of non-symptomatic hosts like *Rubus* and susceptible ornamental species being widespread. Moreover, natural symptomless infections can occur into several common weeds, which can act as reservoirs for the disease (CPCI 2008).
The likelihood of establishment is considered to be moderate to high.

14.2.2.4. Consequence assessment

Economic consequences

CRLV is considered to be an A1 quarantine organism for EPPO (EPPO/CABI 1997m) but the disease has usually only been of minor economic importance in most parts of western North America because of its relatively slow rate of spread (Hansen *et al*. 1974, CPCI 2008). A survey in Colorado showed a slow but steady (5%) increase of CRLV over a six year period. In older orchards, infection rates of up to 38% were found (CPCI 2008). Diseased trees are less resistant to cold winters (Ogawa *et al.* 1995). CRLV infection can lead to stunting and eventual decline and death (Ogawa *et al.* 1995). Infection with CRLV leads to fruit quality and yield losses and trees planted in previously infected sites often become infected (EPPO/CABI 1997m).

Environmental consequences

Major hosts of CRLV are all in the family Rosaceae, mostly *Prunus* species, many of which are important amenity trees in modified areas throughout New Zealand.
It is also known to infect herbaceous plants; wild hosts in the families Asteraceae and Plantaginaceae are recorded (CPCI 2008). Both families include many native species, some threatened (New Zealand Plant Conservation Network), but it is not known how likely CRLV is to infect these species. Some weed species (e.g. dandelion, *Rubus* species; CPCI 2008) reported to be symptomless hosts of CRLV are present in New Zealand. The presence of the virus in these weed species, which can be found growing in and around some orchards and gardens may become reservoir hosts for the virus to spread into orchards by nematodes.

Human health consequences

There are no known effects on human health.

The establishment of CRLV in New Zealand is likely to have low to moderate economic and low to moderate environmental impacts.

14.2.2.5. Risk estimation

CRLV has a low likelihood of entry and exposure and moderate to high likelihood of establishment in New Zealand. The economic and environmental impacts are likely to be low to moderate. The risk associated with CRLV on fresh stonefruit imported from the Pacific Northwest is non negligible and phytosanitary measures can be justified.

14.2.3. Risk management

14.2.3.1. Options

Pest free area or pest free place of production

The distribution of CRLV in the Pacific Northwest may be restricted, in which case pest freedom would be an option.

Pest free area (PFA)
The requirements for the establishment and use of a pest free area as a risk management option for meeting phytosanitary requirements are described in the International Standards for Phytosanitary Measures number 4 (ISPM No.4). The standard identifies three main components or stages that must be considered in the establishment and subsequent maintenance of a PFA:

- systems to establish freedom
- phytosanitary measures to maintain freedom
- checks to verify freedom has been maintained.

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. In crops that show symptoms, such as cherry and apple, the virus could be detected by visual inspection of the growing crop for typical symptoms. Inspections would need to occur at the appropriate times of the year when symptoms would be most obvious. Sampling and laboratory testing would then be required to confirm the identity of the causal agent as CRLV. It therefore should be considered possible that a reliable PFA determination could be obtained once an appropriate official delimiting or detection survey had been completed.

Pest free place of production (PFPP)
The requirements for the establishment and use of a pest free area as a risk management option for meeting phytosanitary requirements are described in the International Standards for Phytosanitary Measures number 10 (ISPM No.10). A pest free place of production is defined in the standard as a "place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period". Pest freedom is established by surveys and/or growing season inspections and maintained as necessary by other systems to prevent the entry of the pest into the place of production.

In crops that show symptoms, such as cherry and apple, the virus could be detected by visual inspection of the growing crop for typical symptoms. Inspections would need to occur at the appropriate times of the year when symptoms would be most obvious. Sampling and laboratory testing would then be required to confirm the identity of the causal agent as CRLV. Given the slow rate of spread of the virus through infected populations, measures that effectively maintain the PFPP should be relatively straightforward. It therefore should be considered possible that a reliable PFPP determination could be obtained once an appropriate official delimiting or detection survey had been completed and appropriate controls are implemented.

Orchard management, harvest and post-harvest processing

CRLV is controlled by orchard hygiene, including the removal of infected trees and those immediately adjacent to these, broadleaf weed control to eliminate alternate hosts, and soil-fumigation to reduce populations of vector-nematodes. Additionally the use of certified, disease-free planting material is essential (CPCI 2008). Routine harvest and post harvest practices are unlikely to reduce the probability of introducing infected fruit.

Visual inspection before export and on arrival

Nursery management to prevent CRLV establishing and standard visual inspection for the absence of symptoms in the consignment before export to New Zealand should be undertaken. Upon arrival, the commodity should be inspected to verify the absence of disease. The virus vectors are root nematodes that are not associated with fruit, so no special measurements need to be taken.

Detection

An RT-PCR method was developed that can be used as a successful and sensitive detection method. For places that are unable to obtain a pest-free declaration, shipments need to be assessed for the absence of the virus using the sensitive RT-PCR method.

14.2.3.2. Risk management options in descending order of stringency

Option 1: pest freedom
Option 2: orchard management
Option 3: post harvest inspection
Option 4: detection by testing

14.2.4. Assessment of uncertainty

- the status of cherry rasp leaf virus in New Zealand is uncertain
- there is little information on the presence of CRLV in fruit other than apple and cherries
- the virus is transmitted between roots by nematodes in the USA, and it is not known whether New Zealand nematodes will vector CRLV
- the likely impact of this virus on native plants species in the families Asteraceae and Plantaginaceae is not known.

14.3. Plum pox potyvirus (PPV)

Scientific name: Plum pox potyvirus (PPV)
Other names: Plum pox, sharka, *Prunus* virus 7, Scharka-virus, Sarka virus, Variole du prunier, Scharka-Krankheit, Vaiolatura delle drupacee
Taxonomic position: PPV is a member of the genus Potyvirus in the Potyviridae family

Geographical distribution

First detected in Macedonia in 1910 (Kegler & Hartmann 1998). Since then PPV has spread through Europe: by the 1960s it was reported in the Netherlands, Switzerland, Greece, England and Turkey and by the 1970s in France, Italy and Belgium. During the 1980s PPV spread to Spain, Portugal, Egypt, Syria and Cyprus (Levy *et al*. 2000). Recent spread includes to Chile (Acuna 1993), India (Bhardwaj *et al.* 1995) and Jordan (EPPO 2000).
In North America, PPV was first recorded in Pennsylvania, in 1999 (Levy *et al*. 2000). The next detection was in the Canadian state of Ontario (Ferguson & Prange 2000). Following the detection in Pennsylvania in 1999, an eradication program was conducted in the USA, along with a series of national surveys. These surveys detected the virus in Niagara County, New York State, in July 2006 and in Michigan in August 2006. These outbreaks are subject to ongoing monitoring and eradication efforts (Johanns 2007).

PNW status

Not recorded as being present (CPCI 2008).

New Zealand status

PPV is not known to be present in New Zealand. Not recorded by Pearson *et al*. (2006) and recorded as being absent by CPCI (2008). New Zealand has Country Freedom status.

Host range

Plum pox infects most cultivated fruit tree species in the genus *Prunus*, including apricot, peach, plum and nectarine. The host range also includes ornamental and wild *Prunus* species and other non-*Prunus* species (Levy *et al*. 2000), for example walnut trees (*Juglans regia*) (Baumgartnerova 1996). A detailed host list is provided by Farr *et al.* (2008).

Biology

Symptoms may appear on leaves or fruit. In peach, symptoms are chlorotic spots, bands or rings, vein clearing, or even leaf deformation. Some peach cultivars may also show flower breaking symptoms while infected fruit show chlorotic spots or rings (CPCI 2008). Diseased plums and apricots are deformed and show internal browning of the flesh; while apricot stones show pale rings or spots (CPCI 2008). Symptoms vary with species and cultivar, age, nutrient status, strain or isolate, season and location (Gildow *et al*. 2000; Levy *et al*. 2000). Leaves and fruit can be infected but symptomless, and where symptoms occur they may become less obvious as the season progresses (Levy *et al.* 2000). Plums are good indicator species because they usually show obvious, severe symptoms on the leaves. However, the strain of virus present in Pennsylvania has been detected in symptomless plum fruit (Gildow *et al*. 2004). It may take up to three years from the initial infection for symptoms to show (Gildow *et al*. 2000) and may take several years for the disease to spread through the tree, resulting in an irregular distribution within trees (Smith *et al.* 1997). In the 1999 outbreak of PPV-D in Pennsylvania, 18 of 218 orchard blocks sampled were found to be infected. Visual symptoms were only detected in two of the 18 infected blocks (Gildow *et al*. 2000).

Strains

Six distinct strains of PPV have been identified based on serological and nucleic acid tests (Myrta *et al.* 2006).

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

Transmission

Infected *Prunus* trees are the major source of inoculum. Long distance dispersal of PPV occurs through the movement of infected *Prunus* material. Movements of nursery stock, seedlings, rootstocks or budding material are all high-risk activities (Gildow *et al*. 2000). Transmission can occur through grafting, and most strains are transmitted non-persistently by aphids (Gildow *et al.* 2004; Glasa *et al.* 2004). In a given season the number of trees infected in an orchard is directly related to numbers of winged aphids. Aphids feed on infected leaves, and then fly to other trees, not ajdacent but usually several trees away to feed again (CPCI 2008). In summer aphids may also migrate to various herbaceous species to feed, and then come back to the fruit trees to lay their winter eggs (EPPO/CABI 1997n). *Phorodon humuli* has been shown to be capable of spreading PPV over long distances 2-3 hours after acquisition (Krczal & Kunze 1972). The capacity for vector transmission varies considerably between virus strains (EPPO/CABI 1997n).
Evidence of aphid transmission from infected fruit has been presented (Labonne & Quiot 2001, Gildow *et al.* 2004).
Transmission through seed is less certain. The PPV-M strain was reported to be seed-transmitted, according to Nemeth and Kolber (1983) and Nemeth (1986). In contrast, Pasquini *et al.* (2000) concluded that seeds have no role in PPV-D and PPV-M epidemiology. They showed that a high percentage of ripe seed from PPV-D and PPV-M infected trees was infected. During germination the virus remained in the reserve tissues and did not replicate in the meristem. Six-monthly testing using IC-RT-PCR in peach and apricot seedlings produced negative results. Other evidence suggests that the W strain is seed-transmissible, though this has not been tested (James *et al.* 2003). It is possible that seed transmission may take place at extremely low rates.

Vectors

The main aphid vectors are *Aphis spiraecola*[1] and *Myzus persicae*[1]. Other aphid species have been shown to transmit at lower frequencies than the two main vectors, including *Aphis craccivora*[1], *A. fabae*, *Brachycaudus cardui, B. helychrysi*[1], *B. persicae*[1], *Hyalopterus pruni*, *Myzus varians* and *Phorodon humuli*. *Aphis gossypii*[1], *A. hederae*[1] and *Rhopalosiphum padi*[1] are minor vectors in Europe (EPPO/CABI 1997n). The plum rust mite, *Aculus fockeui*[1], has been reported to transmit PPV to susceptible plum cultivars in Romania (Isac *et al.* 1998).

([1]species present in New Zealand)

14.3.1.2. Hazard identification conclusion

PPV is absent from New Zealand, it affects *Prunus* species and the symptoms are displayed in fruit.

PPV is absent from the Pacific Northwest and should not be considered a hazard at this time. However, the high impact of this pathogen, its spread in the eastern USA and concerns over domestic movement restrictions have prompted a full assessment of the risks it poses.

14.3.2. Risk assessment

14.3.2.1. Entry assessment

USA national monitoring for PPV has focussed on nursery stock, budwood trees and rootstock trees, as these are the most likely pathways for long distance spread of the pathogen. Official controls are in place for the movement of nursery stock for host species from infected areas (US EPA Federal Register), but there are no movement controls for fruit. Fruit has been demonstrated as a potential pathway for the movement of PPV (Gildow *et al*. 2004, Wallis *et al.* 2005), although it poses a much lower risk than nursery stock.

Plum pox potyvirus has been detected in New Zealand during post-entry quarantine in apricot propagation material from Italy in 1996. Identification of the virus was based on symptoms on graft-inoculated woody indicators, electron microscopy and ELISA (MAF 2001). It has not been detected on imported fresh fruit (Quancargo database). The elaborate detection methods for propagation material are normally not used in the detection of hazards on imported fruit and symptomless fruit would not be intercepted.

Although it is possible that movement of fruit from the USA east to the west coast could carry PPV, the likelihood of this occurring is very low, since the Pacific Northwest states are major producers of stone fruit, and the volume of stone fruit entering these states from the eastern USA is expected to be small.

If PPV does reach the Pacific Northwest, the incursion would need to stay undetected for some time for PPV to be present in fruit destined for export. Surveys and monitoring are carried out by crop scouts in commercial orchards, but because of the delay in symptom expression, it may be several years before a PPV incursion is detected. If PPV did establish in the PNW and the virus infected fruit for export, it is likely that symptomatic fruit would be culled during harvest or processing. Asymptomatic fruit or fruit with mild symptoms could escape detection.

The likelihood of entry is considered to be negligible at this time. However a full risk assessment is presented here for reference in the event of an incursion into the Pacific Northwest.

14.3.2.2. Exposure assessment

Infected fruit could transmit virus in two ways:

- transmission through seed. For this to occur, discarded stones must germinate and give rise to infected plants. Research on seed transmission of PPV suggests that it is unlikely to occur and if it does so, it is likely to be at extremely low rates
- vector transmission. For vector transmission to occur, a vector must feed on infected fruit and transmit the virus to a host plant nearby. Transmission of both the PPV-D and PPV-M strains from infected fruit by aphids feeding on the fruit has been shown (Labonne & Quiot 2001). Labonne and Quiot (2001) also demonstrated that aphids will feed on picked fruit, but it is not known whether or how often this occurs naturally, or whether this mechanism is important in the establishment of the virus in new locations. Many of the known vectors of PPV are established and common in suburban and rural New Zealand.

Symptomatic infected fruit would probably be disposed of before sale.There is very little information available regarding industry pathways and practices. Infected fruit suitable for sale would be either consumed and the remains disposed of, or disposed of whole. Bagged waste disposed of into landfill or waste disposed of into sewage via domestic waste disposal would have a negligible likelihood of exposure via either seed or vector transmission. Infected fruit/remains disposed of into domestic compost or randomly by the roadside would have a higher likelihood of exposure. Stone fruit is likely to arrive in New Zealand from June until late October. For seed transmission, the time of arrival of infected fruit is unlikely to be important, but viruses in fruit arriving in mid-winter are highly unlikely to be transmitted by vectors.

PPV can infect many *Prunus* species. These are widely distributed throughout suburban and rural areas in New Zealand.

The likelihood of exposure is considered to be very low.

14.3.2.3. Establishment assessment

Plum pox infects most cultivated and some ornamental fruit tree species in the genus *Prunus*, which are spread throughout New Zealand. PPV is established in areas with similar climates to many parts of New Zealand. Because of the delay in symptom expression, it may be several years before PPV is detected. The results of a plum pox survey in Canada (EPPO 2001) indicated that the disease may have been present for three to five years before detection. Over such a time period infected material could be distributed throughout New Zealand and have possibly been propagated from. In addition, the disease could already be spread by aphid or mite vectors within orchards and to alternative hosts outside orchards.

The likelihood of establishment is considered to be high.

14.3.2.4. Consequence assessment

Economic consequences

The severity of PPV symptoms and therefore the economic consequences vary with the *Prunus* species, cultivar, age, nutrient status, PPV strain or isolate, season and location (Gildow *et al*. 2000; Levy *et al*. 2000). The disease reduces fruit quality and can cause premature fruit drop, resulting in large yield losses, reaching 90-100% in highly susceptible varieties (Nemeth 1994, Kegler & Hartmann 1998). Plum pox potyvirus is of great economic importance in the fruit-producing areas of central and eastern Europe (CPCI 2008), and is considered to be a threat to USA stonefruit crops, a real danger to the USA national economy and a potential serious burden on interstate and foreign commerce (Johanns 2007).

New Zealand currently has country freedom status from PPV. PPV would have a major economic impact on the New Zealand stonefruit industry through loss of earning from export and domestic fruit sales.

The severity of the economic consequences of having PPV in New Zealand and the likelihood of containing or eradicating the disease would depend on the length of time to detection, species and cultivars of stonefruit infected, PPV strain(s) present, availability of hosts outside the orchard and degree to which aphids and mite vectors spread the disease. Where PPV occurs overseas there are severe economic consequences due to yield losses and unmarketability of fruit. There would be similar consequences in New Zealand. The removal of infected trees, replanting and aphid control would impose additional costs on growers. Increased monitoring costs may also alter the economic viability of some crops.

Environmental consequences

The hosts of PPV are mainly in the genus *Prunus*, although other genera have been experimentally infected. New Zealand has no native species in this genus, but *Prunus* species are valued as ornamental trees and are therefore a widespread amenity species. Establishment of PPV could also lead to increased pesticide use in modified habitats.

Human health consequences

There are no known human health consequences.

Establishment of plum pox virus in New Zealand is likely to cause high to severe economic and low environmental consequences.

14.3.2.5. Risk estimation

PPV has a negligible likelihood of entry at this time. It has a low likelihood of exposure and high likelihood of establishment in New Zealand. The economic impact is likely to be high to severe and the environmental impact low. The risk associated with this virus on fresh stonefruit imported from the Pacific Northwest is currently negligible and phytosanitary measures cannot be justified.

14.3.3. Risk management

Plum pox virus is not established in the Pacific Northwest. Therefore the risk associated with this virus on fresh stonefruit imported from the Pacific Northwest is currently negligible and phytosanitary measures cannot be justified.
Should Plum pox virus be detected in the Pacific Northwest:

- APHIS should inform Biosecurity New Zealand immediately of the changed pest status
- the following known vectors of PPV have been identified in this analysis as being present on the pathway: *Aculus fockeui, Aphis gossypii, Aphis spiraecola, Brachycaudus helichrysi*, *Myzus persicae* and *Rhopalosiphum padi.* All are present in New Zealand and would currently not require any measures to be taken against them if they were intercepted on fresh stonefruit shipments from the Pacific Northwest. Should PPV become established in the Pacific Northwest, measures should be taken against these species on imported stonefruit.

14.3.4. Assessment of uncertainty

- due to the delay in symptom expression there is uncertainty about the how quickly PPV would be detected if there was an incursion of the disease into the Pacific Northwest
- there is uncertainty about the possible exposure of PPV in the months the commodity is most likely imported into New Zealand.

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Glossary of definitions and abbreviations

AFFA	Australian Government Department of Agriculture Fisheries and Forestry
AQIS	Australian Quarantine and Inspection Service
APHIS	Animal and Plant Health Inspection Service (a department within USDA)
CPCI	Crop Protection Compendium. Internet Database
Diapause	A physiological state of arrested development that enables an organism to survive more easily a period of unfavourable conditions
Endemic	an animal, plant, pest, or disease that is native to and is not naturally found outside a defined geographical area
Establishment	perpetuation, for the foreseeable future, of an organism or disease within an area after entry.
Exposure	the process of the hazard organism moving from the commodity it arrived on to another host
Exotic	this word has different meanings in different fields, but in this document is defined as an animal, plant, pest or disease that is not indigenous to New Zealand.
Hitch-hiker	an organism that has an opportunistic association with a commodity or item with which it has no biological host relationship.
Indigenous	native; organism originating or occurring naturally in a specified area.
Introduced	not indigenous, not native to the area in which it now occurs, having been brought into this area directly or indirectly by human activity.
IHS	Import Health Standard
IRA	Import risk analysis
MAF	Ministry of Agriculture and Forestry, New Zealand
MAFBNZ	MAF Biosecurity New Zealand

Quancargo	MAFBNZ database of commercial consignments and interceptions of pests made by quarantine inspection at the New Zealand border.
PPIN	Plant Pest Information Network database, MAF.
Regulated Pest	a pest of potential economic importance to New Zealand and not yet present here, or present but either not widely distributed and being officially controlled, having the potential to vector another organism, or a regulated non-quarantine pest.
Risk	in the context of this document risk is defined as the likelihood of the occurrence and the likely magnitude of the consequences of an adverse event.
USDA	United States Department of Agriculture.
Viable	capable of living; able to maintain a separate existence (on its own accord).
Vector	an organism or object that transfers a pest, parasite, pathogen or disease from one area or host to another

Appendix 1: Categorisation of arthropods associated with stone fruit production in the Pacific Northwest

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Mites									
Diptacus gigantorhynchus (Nalepa) [Acari: Diptilomiopidae]	big-beaked plum mite				Y (Manson 1984b)	N			N
Aculus fockeui Nalepa & Trouessart (Acari: Eriophyidae)	plum rust mite, peach silver mite	Y (Oldfield 1984)			Y (Manson 1984b)	Y (v) [2]	peach, plum and nectarine (Manson 1984b, Beers *et al.* 1993)	see Appendix 4	N
Eriophyes inaequalis Wilson and Oldfield [Acari: Eriophyidae]	Erinea gall Mite	Y (Davidson Jr *et al.* 1994, Beers *et al.* 1993)	Y (Beers *et al.* 1993		N[1] (Manson 1984a, PPIN 2008)	Y	N (Beers *et al.* 1993)	buds (Beers *et al.* 1993); *Eriophyes* spp. feed on leaves (Bentley & Day 2006a)	N
Galendromus occidentalis Nesbitt [Acari: Phytoseiidae]		Y (CPCI 2008)	Y (CPCI 2008)	N (CPCI 2008)	Y (Spain & Luxton 1971	N			N
Neoseiulus californicus (McGregor) [Acari: Phytoseiidae]	predatory mite	Recorded from California (CPCI 2008); but not known to be present in the PNW, although field releases have been made in Oregon (Pratt & Croft 2000)			N (Zhang 2003, CPCI 2008, PPIN 2008)	N			N
Tarsonemus bakeri Ewing [Acari: Tarsonemidae]			tentatively present (Quancargo interception)		N (Zhang *et al.* 2000); not recorded from NZ (Z-Q. Zhang pers. comm. 2008)	Y	plums peaches, nectarines (Quancargo)	intercepted on plums, peaches and nectarines from USA (Quancargo)	Y

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Tarsonemus smithi Ewing [Acari: Tarsonemidae]		PNW: not recorded by Jeppson *et al*. (1975), no information on presence (LaGasa 2000), CA only (CDFA 2006); New Zealand: Not recorded by Zhang *et al*. (2000), PPIN (2008); not present in NZ according to Zhang (Z-Q. Zhang, pers. comm.. 2007), but Biosecurity Australia (2006 and 2008) state that this species has been intercepted on stonefruit from New Zealand.				N			N
Brevipalpus phoenicis (Geijskes) [Acari: Tenuipalpidae]		No evidence of presence in PNW			Y (Spain & Luxton 1971, Manson 1967, Manson 1987)	N			N
Bryobia rubrioculus (Scheuten) [Acari: Tetranychidae]	Brown mite	No evidence of presence in PNW			Y (Spain & Luxton 1971, CPCI 2008)	N			N
Eotetranychus carpini (Oudemans) [Acari: Tetranychidae]	yellow spider mite		Y (Pritchard & Baker 1955, Beers *et al.* 1993)		N (Zhang & Rhode in press, PPIN 2008)	Y	plum (Bolland *et al.* 1998)	bark, leaves, buds (Westigard & Berry 1970); feed under leaves, overwinter on bark, oviposit on fruit buds (Jeppson *et al.* 1975)	N
Panonychus ulmi (Koch) [Acari: Tetranychidae]	European red mite	Y (LaGasa 2000, CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	Y (Collyer 1976, Spain & Luxton 1971)	N			N
Tetranychus canadensis (McGregor) [Acari: Tetranychidae]	fourspotted spider mite	No evidence of presence in PNW			N (Zhang & Rhode in press, PPIN 2008)	N	plum (Bolland *et al.* 1998)		N
Tetranychus homorous Pritchard & Baker [Acari: Tetranychidae]		known only from the far eastern United States (Pritchard & Baker 1955); no published evidence of presence in PNW found but intercepted on Californian stonefruit			N (Zhang & Rhode in press, PPIN 2008)	Y	peaches/nectarines (interception data)	intercepted on peaches and nectarines from California (Quancargo C2004/90467)	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Tetranychus mcdanieli McGregor [Acari: Tetranychidae]	McDaniel spider mite	Y (Pritchard & Baker 1955, Beers *et al.* 1998, CPCI 2008)	Y (Beers *et al.* 1998)		N (CPCI 2008, PPIN 2008)	Y	apricot, peach (Beers *et al.* 1993), plum (Pritchard & Baker 1955)	intercepted alive on peaches from USA (Quancargo)	Y
Tetranychus neocaledonicus Andre [Acari: Tetranychidae]	vegetable mite	no evidence of presence in PNW. Bolland *et al.* (1998) record it from "USA", referencing Pritchard & Baker (1955); however Pritchard & Baker (1955) only record this species from New Caledonia. Jeppson *et al*. (1975) and Martin & Mau (1991) record it from the "southeastern United States"			N (PPIN 2008); not recorded from NZ (Z-Q. Zhang, pers. comm. 2007)	N			N
Tetranychus pacificus McGregor [Acari: Tetranychidae]	Pacific spider mite	Y (CPCI 2008)	Y (Pritchard & Baker 1955, CPCI 2008)	Y (Pritchard & Baker 1955)	N (CPCI 2008); not present (PPIN 2008)	Y	peach, plum (Bolland *et al.* 1998)	intercepted on peaches, plums and nectarines from USA (Quancargo)	Y
Tetranychus turkestani (Ugarov and Nikolskii) [Acari: Tetranychidae]	Strawberry spider mite	Y (LaGasa 2000)			Y (Zhang 2003, Flechtmann & Knihinicki 2002)	N			N
Tetranychus urticae Koch [Acari: Tetranychidae]	Twospotted spider mite	Y (CPCI 2008, LaGasa 2000)	Y (CPCI 2008)		Y (CPCI 2008)	N			N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Insects									
Coleoptera (beetles)									
Melalgus confertus (LeConte) [Coleoptera: Bostrichidae]			Y (ONR 2005, Wilson & Lovett 1913)		genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	Y	apricot, peach (Herbert 1920)	twigs and small branches (Herbert 1920); not associated with fruit. Bostrichidae larvae are wood borers on moribund or freshly-felled trees (Lawrence & Britton 1991)	N
Chrysobothris mali Horn [Coleoptera: Buprestidae]	Pacific flat head borer	Y (LaGasa 2000)			genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	Y		wood only (McNelly *et al.* 1969, Coates *et al.* 2007a)	N
Chrysobothris femorata [Coleoptera: Buprestidae]	Flatheaded apple tree borer		Y (Chamberlin 1921)		genus not recorded (Leschen *et al.* 2003), N (CPCI 2008, PPIN 2008)	Y		stem-borers (Thakur 1999)	N
Anelaphus (*Elaphionoides*) *villosus* (F.) [Coleoptera: Cerambycidae]	oak twig pruner, southeastern gray twig pruner		No information		genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	Y	no specific reference, “flowering fruit trees” (Barrett 2001)	recently dead branches (Gosling 1981); female oviposits near a twig tip, the larva bores into the twig and feeds on the wood, infested branches usually fall to the ground and pupae overwinter in them (Barrett 2001)	N
Prionus californicus Motschulsky [Coleoptera: Cerambycidae]		Y (AQIS 2000)	Y (AQIS 2000)	Y (AQIS 2000, Bishop *et al.* 1984)	genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	Y		roots, trunk (Steffan & Alston 2005), larvae develop in roots (Bishop *et al.* 1984)	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Synaphaeta guexi (LeConte) [Coleoptera: Cerambycidae]		Y (AQIS 2000)	Y (AQIS 2000)	Y (AQIS 2000)	Genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	Y		adults feed on wood, roots, leaves, pollen and rarely other insects. Larvae bore into bark and wood (Arnett 1997)	N
Diabrotica undecimpunctata Mannerheim [Coleoptera: Chrysomelidae]	spotted cucumber beetle	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	Genus not recorded (Leschen *et al.* 2003), N (CPCI 2008, PPIN 2008)	Y (v)	apricot, peach (Mackie 1937)	adults attack apricots and peach fruit (Mackie 1937)	Y
Syneta albida LeConte [Coleoptera: Chrysomelidae]		Y (Yothers 1916)	Y (Wilson & Moznette 1915)		Genus not recorded (Leschen *et al.* 2003): N (PPIN 2008)	Y	adults feed on peach, plum (Wilson & Moznette 1915)	larvae feed on fibrous roots and adults on flowers and foliage of fruit trees (Wilson & Moznette 1915); buds(Yothers 1916); adults reported feeding on developing but not mature fruit (Berry 1998)	N
Hippodamia convergens Guérin-Méneville [Coleoptera: Coccinellidae]	convergent lady beetle	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	N (Cameron *et al.*1989), genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	Y	Indirect	intercepted on nectarines from USA	Y
Stethorus picipes Casey [Coleoptera: Coccinellidae]		Y (Newcomer & Yothers 1929)			N (Houston 1990; N (PPIN 2008)	Y	Indirect	predatory (Newcomer & Yothers 1929), indirect association	N
Anthonomus quadrigibbus (Say) [Coleoptera: Curculionidae]		Y (Burke & Anderson 1989, CPCI 2008)	Y (Burke & Anderson 1989, CPCI 2008)	Y (Burke & Anderson 1989, CPCI 2008)	N (CPCI 2008), genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	Y	peach, plum (Beers *et al.* 2003)	fruits/pods, inflorescence and seeds (CPCI 2008); eggs, larvae and pupae internal in fruit (Burke & Anderson 1989)	Y

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Asynonychus cervinus (Boheman) [Coleoptera: Curculionidae]	Fuller rose weevil	N (LaGasa 2000)	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	N			N
Cleonidius poricollis (Mannerhein) [Coleoptera: Curculionidae]		Y (Beers *et al.* 2003)			genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	Y	apricot (Beers *et al.* 2003)	buds (Beers *et al.* 2003)	N
Coccotorus scutellaris (LeConte) [Coleoptera: Curculionidae]		no evidence of presence in PNW			Genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	N			N
Conotrachelus nenuphar [Coleoptera: Curculionidae]	Plum cucurlio	not known to be present in PNW (CPCI 2008, (EPPO/CABI 1997b)			genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	N			N
Dyslobus nigrescens (Pierce) [Coleoptera: Curculionidae]		Y (Beers *et al.* 2003)			Genus not recorded (Leschen *et al.* 2003) N (PPIN 2008)	Y	peach (Beers *et al.* 2003)	buds (Beers *et al.* 2003)	N
Magdalis aenescens LeConte [Coleoptera: Curculionidae]	bronze appletree weevil	Y (Beers *et al.* 2003)	Y (Beers *et al.* 2003)		genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	Y	prune (Beers *et al.* 2003)	stems and trunks of apple trees (Beers *et al.* 2003); injured wood of apple trees (Brittain 1914); attacks dead bark tissues (Teehebne 1913)	N
Magdalis gracilis LeConte [Coleoptera: Curculionidae]	black fruit tree weevil	Unsure			genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	Y	plum, peach, apricot (Beers *et al.* 2003)	plum foliage (Beers *et al.* 2003),	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Omias saccatus (LeConte) [Coleoptera: Curculionidae]		Y (Beers *et al.* 2003)	Y (Beers *et al.* 2003)		genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	Y	peach, apricot (Beers *et al.* 2003)	buds and leaves (Beers *et al.* 2003)	N
Ophryastes cinerascens (Pierce) [Coleoptera: Curculionidae]		Y (Beers *et al.* 2003)			genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	Y	plum, apricot (Beers *et al.* 2003)	buds (Beers *et al.* 2003)	N
Otiorhynchus cribricollis Gyllenhal [Coleoptera: Curculionidae]		Y (Beers *et al.* 2003)			N (CPCI 2008, PPIN 2008)	Y	peach, apricot (Beers *et al.* 2003)	leaves, bark, growing shoots, roots (Beers *et al.* 2003)	N
Otiorhynchus ovatus (Linnaeus) [Coleoptera: Curculionidae]		Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	Y (PPIN 2008)	N			N
Otiorhynchus singularis (Linnaeus) [Coleoptera: Curculionidae]		Y (CPCI 2008, Beers *et al.* 2003)			N (CPCI 2008, PPIN 2008)	Y	peach (Beers *et al.* 2003)	inflorescence, leaves, roots and stems (CPCI 2008)	N
Panscopus aequalis (Horn) [Coleoptera: Curculionidae]		Y (Beers *et al.* 2003)		Y (College of Idaho 2008)	genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	Y	peach (Beers *et al.* 2003)	buds (Beers *et al.* 2003)	N
Paraptochus sellatus Boheman [Coleoptera: Curculionidae]				Y (Beers *et al.* 2003)	genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	Y	apricot (Beers *et al.* 2003)	adults on buds and leaves (Beers *et al.* 2003), foliage and newly opened buds (Wilson 1913/14); larvae probably root feeding (Wilson 1913/14)	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Sciopithes obscurus Horn [Coleoptera: Curculionidae]	obscure root weevil	Y (Beers *et al.* 2003)	Y (Beers *et al.* 2003)		genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	Y	fruit trees (Beers *et al.* 2003)	larvae root-feeders, adults feed on leaves, eggs laid on leaves (Berry 1998)	N
Sitona californicus (Fahraeus) [Coleoptera: Curculionidae]		Y (Beers *et al.* 2003)			N (Phillips *et al.* 2002, PPIN 2008)	Y	peach (Beers *et al.* 2003)	adults feed on leaflets and newly developing stems; larvae feed on the outside of the tap root and lateral roots (Thompson 1999)	N
Stamoderes lanei Van Dyke [Coleoptera: Curculionidae]		Y (Beers *et al.* 2003)			genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	Y	peach (Beers *et al.* 2003)	buds, cut shoots (Beers *et al.* 2003)	N
Thricolepis inornata Horn [Coleoptera: Curculionidae]		Y (Beers *et al.* 2003)	Y (Beers *et al.* 2003)		genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	Y	peach, plum (Beers 2003)	foliage (Beers *et al.* 2003), foliage and newly opened buds (Wilson 1913/14)	N
Agriotes lineatus (L.) [Coleoptera: Elateridae]	lined click beetle	Y (LaGasa *et al*. 2001)			N (CPCI 2008, PPIN 2008), genus not recorded (Leschen *et al.* 2003)	Y	peach (CPCI 2008)	larvae soil-dwelling, feeding on seeds, plant roots and general organic material (LaGasa *et al.* 2001)	N
Carpophilus dimidiatus (F.) [Coleoptera: Nitidulidae]					Y (Carlton & Leschen 2007, Leschen & Marris 2005)	N			N
Carpophilus freemani Dobson [Coleoptera: Nitidulidae]		no evidence of presence in PNW			N (Carlton & Leschen 2007, PPIN 2008)	N			N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Carpophilus fumatus (Boheman) [Coleoptera: Nitidulidae]		no evidence of presence in PNW			N (Carlton & Leschen 2007, PPIN 2008)	N			N
Carpophilus hemipterus (L.) [Coleoptera: Nitidulidae]		California (CPCI 2008)			Y (Carlton & Leschen 2007, Leschen & Marris 2005)	N			N
Carpophilus mutilatus Erichson [Coleoptera: Nitidulidae]		not present in USA, what has been referred to as *C. mutilatus* is actually *C. dimidiatus* (A. Cline, pers. comm. 15 Nov 2007)			N (Leschen & Marris 2005, Carlton & Leschen 2007); PPIN (2008) wrongly records as present	N			N
Conotelus mexicanus Murray [Coleoptera: Nitidulidae]		no records from PNW (A. Cline, pers. comm., Dec 2007)			N (Ewing & Cline 2005, PPIN 2008)	N			N
Urophorus humeralis (F.) [Coleoptera: Nitidulidae]	pineapple sap beetle				Y (Leschen & Marris 2005, PPIN 2007)	N			N
Pleocoma crinita Linsley [Coleoptera: Pleocomidae]			Y (Fellin 1975)		N (Scholtz & Browne 2005, PPIN 2008)	Y		larvae feed on roots, soil and fungus (Fellin 1975), adults do not feed (Scholtz & Browne 2005)	N
Pleocoma minor Linsley [Coleoptera: Pleocomidae]			Y (Fellin 1975)		N (Scholtz & Browne 2005, PPIN 2008)	Y		larvae feed on roots, soil and fungus (Fellin 1975), adults do not feed (Scholtz & Browne 2005)	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Pleocoma oregonensis Leech [Coleoptera: Pleocomidae]			Y (Ellertson 1956)		N (Scholtz & Browne 2005, PPIN 2008)	Y		larvae feed on roots, adult females are in soil (Ellertson 1956), adults do not feed (Scholtz & Browne 2005)	N
Polyphylla decemlineata (Say) [Coleoptera: Scarabaeidae]		Y (Yothers 1916)			genus not recorded (Leschen *et al.* 2003); N (PPIN 2008)	Y		buds (Yothers 1916); adults feed on coniferous foliage, but larvae feed on roots of many kinds of plants (Sutherland *et al.* 1989)	N
Popillia japonica Newman [Coleoptera: Scarabaeidae]	Japanese beetle	Erad. (CPCI 2008, NAPIS 2005	Erad. (CPCI 2008, NAPIS 2005)	Y (EPPO/CABI 2006a, CPCI 2008)	genus not recorded (Leschen *et al.* 2003), N (CPCI 2008, PPIN 2008)	Y	peach, plum, nectarine (CPCI 2008)	larvae feed on roots (Gyeltshen and Hodges 2005). Adults may aggregate and feed on fruit (CPCI 2008) but are reasonably large (8-11mm long) and very mobile insects which are unlikely to remain on fruit during harvesting, processing and packing	N
Ambrosiodmus rubricollis (Eichoff) [Coleoptera: Scolytidae]	Bark beetle	No information			N (Brockerhoff *et al.* 2003, PPIN 2008)	Y	peach wood (Kovach & Gorsuch 1985)	wood-boring ambrosia beetle (Kovach & Gorsuch 1985)	N
Ambrosiodmus tachygraphus (Zimmerman) [Coleoptera: Scolytidae]	Bark beetle	No information			N (Brockerhoff *et al.* 2003, PPIN 2008)	Y	peach wood (Kovach & Gorsuch 1985)	wood-boring ambrosia beetle (Kovach & Gorsuch 1985)	N
Monarthrum fasciatum (Say) [Coleoptera: Scolytidae]	Ambrosia beetle	N (LaGasa 2000)	Y (Ross 2000)		N (Brockerhoff *et al.* 2003, PPIN 2008)	Y	peach wood (Kovach & Gorsuch 1985)	wood-boring ambrosia beetle (Kovach & Gorsuch 1985)	N

	Common name	WA	OR	ID	Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
Phloeotribus liminaris (Harris) [Coleoptera: Scolytidae]	Peach bark beetle	N (LaGasa 2000)	no information	no information	N (Brockerhoff *et al.* 2003, PPIN 2008)	Y	peach wood (Kovach & Gorsuch 1985)	wood-boring bark beetle (Kovach & Gorsuch 1985)	N
Scolytus rugulosus (Ratzburg) [Coleoptera: Scolytidae]	Shot hole borer	Y (CPCI 2008, Anthon 1949)	Y (CPCI 2008)	N (CPCI 2008)	N (Brockerhoff *et al.* 2003, CPCI 2008, PPIN 2008)	Y	apricot, peach (Anthon 1949)	cambium layer (Pickel *et al.* 2006a); sapwood (Beers *et al.* 1993)	N
Xyleborinus saxeseni (Ratzeburg) [Coleoptera: Scolytidae]					Y (Brockerhoff *et al.* 2003)	N			N
Xyleborus dispar (F.) [Coleoptera: Scolytidae]	Ambrosia beetle	restricted distribution (CPCI 2008), Ross 2000	restricted distribution (CPCI 2008)	restricted distribution (CPCI 2008)	N (Brockerhoff *et al.* 2003, CPCI 2008, PPIN 2008)	Y	peach wood (Kovach & Gorsuch 1985)	stems and whole plant (CPCI 2008); bore into wood of trees, forming galleries in which both adults and larvae live feeding on cultivated fungus (Beers *et al.* 1993), ambrosia beetle (Kovach & Gorsuch 1985, USDA FS 2007)	N
Xyleborus xylographus (Say) [Coleoptera: Scolytidae]	Ambrosia beetle	N (PEET2004)	Y (PEET 2004)	N (PEET 2004)	N (Brockerhoff *et al.* 2003, PPIN 2008)	Y		*Xyleborus* spp. bore into sapwood and heartwood and feed on fungi there (Lawrence & Britton 1991)	N
Xylosandrus crassiusculus (Motschulsky) [Coleoptera: Scolytidae]	Ambrosia beetle	N (LaGasa 2000)	Y (Ross 2000)		N (Brockerhoff *et al.* 2003, PPIN 2008)	Y	peach wood (Kovach & Gorsuch 1985)	wood-boring ambrosia beetle (Kovach & Gorsuch 1985)	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Diptera (flies)									
Drosophila melanogaster Meigen [Diptera: Drosophilidae]	Common fruit fly, vinegar fly		Y (Nagel & Grossbach 2000)		Y (CPCI 2008)	Y (v)	Stone fruit (CPCI 2008)	no reliable evidence of *Drosophila* ever attacking intact fruit (CPCI 2008)	N
Bactrocera correcta (Bezzi) [Diptera: Tephritidae]	Guava fruit fly	Not recorded from PNW. Single fly detected in California in 2006 (Frances 2006).			N (CPCI 2008, PPIN 2008)	N			N
Bactrocera cucurbitae (Coquillett) [Diptera: Tephritidae]	Melon fruit fly	No evidence of presence in PNW. Recorded from California, but eradicated (EPPO/CABI 1997c)			N (CPCI 2008, PPIN 2008)	N			N
Ceratitis capitata (Wiedemann) [Diptera: Tephritidae]	Mediterranean fruit fly (med fly)	No (CPCI 2008, EPPO/CABI 2006b)	No (CPCI 2008, EPPO/CABI 2006b)	No (CPCI 2008, EPPO/CABI 2006b)	Erad. (EPPO/CABI 2006b); eradicated May 1997 (PPIN 2008)	N			N
Rhagoletis completa Cresson [Diptera: Tephritidae]	Walnut husk fly	Yes (CPCI 2008, EPPO/CABI 1997d)	Yes (CPCI 2008, EPPO/CABI 1997d)	Yes (CPCI 2008, EPPO/CABI 1997d)	N (CPCI 2008, EPPO/CABI 1997d, PPIN 2008)	Y	peaches are an occasional host (EPPO/CABI 1997d)	eggs and larvae in fruit, pupation in soil (EPPO/CABI 1997d)	Y
Rhagoletis fausta (Osten Sacken) [Diptera: Tephritidae]	black cherry fruit fly	Y (EPPO/CABI 1997e)	Y (EPPO/CABI 1997e)	Y (EPPO/CABI 1997e)	N (EPPO/CABI 1997e, White & Elson-Harris 1992, PPIN 2008)	Y	hosts are various cherry species only, not recorded from apricot, plum, peach or nectarine (White & Elson-Harris 1992, CPCI 2008, EPPO/CABI 1997e)		N
Rhagoletis indifferens Curran [Diptera: Tephritidae]	western cherry fruit fly	Y (EPPO/CABI 1997f), White & Elson-Harris 1992)	Y (EPPO/CABI 1997f)	Y (EPPO/CABI 1997f)	N (EPPO/CABI 1997f, White & Elson-Harris 1992, PPIN 2008)	Y	Hosts are *Prunus avium*, *P. virginiana*, *P. salicina*, *P. subcordata, P. cerasus* and *P. emarginata* (White & Elson-Harris 1992); all varieties of cultivated and wild cherries (Beers *et al*. 1993). Not recorded from apricot, plum, peach or nectarine (White & Elson-Harris 1992, CPCI 2008)		N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Rhagoletis pomonella (Walsh) [Diptera: Tephritidae]	apple maggot	Y (CPCI 2008, EPPO/CABI 1997g, LaGasa 2000)	Y (CPCI 2008, Gahan 1930, EPPO/CABI 1997g)	Y (CPCI 2008, Gahan 1930)	N (CPCI 2008, EPPO/CABI 1997g, PPIN 2008)	Y	peach (CPCI 2008), apricot (EPPO/CABI 1997g), plum (Beers *et al.* 1993)	eggs and larvae in fruit, pupation in the soil (CPCI 2008)	Y
Hemiptera (aphids, bugs, mealybugs, scale, whiteflies)									
Dialeurodes citri (Ashmead) [Hemiptera: Aleyrodidae]	citrus whitefly	Y (CPCI 2008)			N (CPCI 2008, PPIN 2008)	Y	*Prunus* species (CPCI 2008)	adults oviposit and nymphs feed almost exclusively on undersides of leaves; fruit may be affected by honeydew (CPCI 2008)	N
Siphoninus phillyreae Haliday [Hemiptera: Aleyrodidae]	ash whitefly				Y (Charles & Froud 1996)	N			N
Trialeurodes vaporariorum (Westwood) [Hemiptera: Aleyrodidae]	greenhouse whitefly	Y (CPCI 2008, LaGasa 2000)	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	Y (v)	peach (USDA 2006)	feeds on leaves, honeydew may affect fruit (CPCI 2008)	N
Orius insidiosus (Say) [Hemiptera: Anthocoridae]	minute pirate bug, insidious flower bug	Y (Newcomer & Yothers 1929)			N (Larivière & Larochelle 2004, CPCI 2008, PPIN 2008)	Y	peach (Atanassov *et al.* 2003)	predatory (Atanassov *et al.* 2003)	Y
Orius tristicolor White [Hemiptera: Anthocoridae]		Y (Horton 2004)	Y (Westigard *et al.* 1986)	Y (Hollingsworth & Bishop 1982)	N (Larivière & Larochelle 2004, PPIN 2008)	Y	peach (Tamaki & Halfhill 1968)	predatory (Horton 2004), predator of *Myzus persicae* (Hollingsworth & Bishop 1982)	Y
Aphis gossypii Glover [Hemiptera: Aphididae]	cotton aphid, melon aphid	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	Y (Charles 1998, Teulon *et al.* 2004)	Y (v)	apricot, peach (CPCI 2008); plum (Blackman & Eastop 2000)	see Appendix 4	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Aphis spiraecola Patch [Hemiptera: Aphididae]	Spirea aphid	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	Y (Teulon *et al.* 2004)	Y (v)	peach, plum (Blackman & Eastop 2000)	see Appendix 4	N
Brachycaudus cardui (L.) [Hemiptera: Aphididae	Thistle aphid		Y (EMEC 2008)		N (CPC, Blackman & Eastop 2000, PPIN 2008)	Y	plum (Blackman & Eastop 2000), apricot (Beers *et al.* 1993)	leaves (Strazynski 2003); dense colonies occur at the base of flower heads and on leaves (INRA 1997); stem (Hoffmann *et al.* 2003); rolled leaves, stems, flower heads (Blackman & Eastop 2000)	N
Brachycaudus helichrysi (Kaltenbach) [Hemiptera: Aphididae]	leaf-curling plum aphid	Y (Baker 1920, LaGaza 2000)		Y (CPCI 2008, Helton & Portman 1965)	Y (Cameron *et al.* 1992, Charles 1998, Teulon *et al.* 2004)	Y (v)	peach, plum (Blackman & Eastop 2000)	fruits/pods, growing points, leaves and whole plant (CPCI 2008); intercepted on fruit (*Malus pumila*) from the USA (Townsend 1984), see Appendix 4	N
Brachycaudus persicae (Passerini) [Hemiptera: Aphididae]		N (LaGasa 2000, CPCI 2008)	N (CPCI 2008)	N (CPCI 2008)	Y (Teulon *et al.* 2004)	N			N
Eriosoma lanigerum (Hausmann) [Hemiptera: Aphididae]	woolly apple aphid	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008, Teulon *et al.* 2004)	N			N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Hyalopterus pruni Geoffroy [Hemiptera: Aphididae]	mealy plum aphid	Y (LaGasa 2000)		Y (Helton & Portman 1965)	N (Teulon *et al.* 2004, PPIN 2008)	Y	apricot, plum (Blackman & Eastop 2000), peach (Beers *et al.* 1993)	eggs laid in bark and branches, nymphs and adults feed on buds and leaves (CPCI 2008); eggs laid in buds, adults feed on undersides of leaves (Bentley & Day 2006b)	N
Hysteroneura setariae (Thomas) [Hemiptera: Aphididae]	rusty plum aphid	Y (Beers *et al.* 1993)			N (Teulon *et al.* 2004, PPIN 2008)	Y	peach, plum (Beers *et al.* 1993)	spikelets, leaves, unripe seeds (Blackman & Eastop 2000); eggs laid on twigs, aphids feed on undersides of leaves (Beers *et al.* 1993)	N
Macrosiphum euphorbiae (Thomas) [Hemiptera: Aphididae]	potato aphid	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	Y (Teulon *et al.* 2004, CPCI 2008)	Y (v)	peach (Stoetzel & Miller 1998)	foliage, stems or fruits (CPCI 2008), see Appendix 4	N
Myzus persicae (Sulzer) [Hemiptera: Aphididae]	green peach aphid	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	Y (Charles 1998, Teulon *et al.* 2004, CPCI 2008)	Y (v)	peach, nectarine (Blackman & Eastop 2000); apricot (CPCI 2008)	growing points, inflorescence, leaves, stems and whole plant (CPCI 2008); feeding directly on young nectarine fruit (Beers et al 1993), see Appendix 4	N
Phorodon humuli (Schrank) [Hemiptera: Aphididae]		Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	N (Teulon *et al.* 2004, PPIN 2008), Y (Blackman & Eastop 2000)	Y	apricot, plum (Beers *et al.* 1993)	new growth, undersides of leaves; fruit not known to carry the pest in trade/transport (CPCI 2008); eggs on twigs, aphids feed on undersides of leaves (Beers *et al.* 1993)	N
Rhopalosiphum nymphaeae (L.) [Hemiptera: Aphididae]	Plum aphid				Y (Teulon *et al.* 2004)	N			N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Philaenus spumarius (L.) [Hemiptera: Cercopidae]	meadow froghopper, meadow spittlebug, cuckoo-spit insect	Y (CPCI 2008)	Y (CPCI 2008)	N (CPCI 2008)	Y (Hamilton & Morales 1992)	Y (v)	peach (CPCI 2008)	Stems and whole plant, petioles and twigs, external feeding (CPCI 2008). Vectors *Xylella fastidiosa*, the causal agent of Pierce's disease	N
Colladonus clitellarius (Say) [Hemiptera: Cicadellidae]	Saddled leafhopper	no evidence of presence in PNW			N (PPIN 2008)	N			N
Colladonus geminatus (Van Duzee) [Hemiptera: Cicadellidae]		Y (Wolfe 1958)	Y (Nielson 1968)		N (McKamey 2007, PPIN 2008)	Y	peach (Wolfe 1955)	seedlings (Wolfe 1955); feed in xylem and phloem, sometimes parenchyma (Insects of Australia)	N
Colladonus montanus (Van Duzee) [Hemiptera: Cicadellidae]	mountain leafhopper	Y (Landis & Hagel 1969)	Y (AQIS 2000)	Y (AQIS 2000)	N (PPIN 2008)	Y (v)	apricot, peach, plum (CPCI 2008)	this pest is of economic importance as a virus vector (western X disease, buckskin of cherry) but there is no information to suggest that it is associated with fruit	N
Cuerna costalis (F.) [Hemiptera: Cicadellidae]		no evidence of presence in PNW			N (PPIN 2008)	N			N
Edwardsiana rosae (L.) [Hemiptera: Cicadellidae]		Y (Anthon & Wolfe 1951) (as *Typhlocyba rosae*)			N (PPIN 2008)	Y	peach (CPCI 2008)	leaves (Dozier 1927, Caesar & Ross 1926)	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Erythroneura elegantula Osborn [Hemiptera: Cicadellidae]	Western grape leafhopper	Y (Dmitriev & Dietrich 2006)			N (Dmitriev & Dietrich 2006, PPIN 2008)	Y	stone fruit (CPCI 2008)	leaves (Jensen *et al.* 1969)	N
Fieberiella florii (Stål) [Hemiptera: Cicadellidae]		Y (Wolfe & Anthon 1954)	Y (Swenson 1974)		N (CPCI 2008, McKamey 2007, PPIN 2008)	Y (v)	peach (Wolfe & Anthon 1954)	seedlings (Swenson 1974)	N
Graphocephala versuta (Say) [Hemiptera: Cicadellidae]		no evidence of presence in PNW			N (PPIN 2008)	N			N
Homalodisca vitripennis (Germar) [Hemiptera: Cicadellidae]		No evidence of presence in PNW (Takiya & Dmitriev 2007)			N (Takiya & Dmitriev 2007, CPCI 2008, PPIN 2008)				N
Oncometopia orbona (F.) [Hemiptera: Cicadellidae]		no evidence of presence in PNW			N (PPIN 2008)	N			N
Scaphytopius acutus (Say) [Hemiptera: Cicadellidae]		Y (Wolfe 1958)	Y (AQIS 2000)	Y (AQIS 2000)	N (Larivière 2005, CPCI 2008, PPIN 2008)	Y (v)	peach (Wolfe 1955, 1958; CPCI 2008)	feed on sap of above-ground stems or leaves of plants; vector of peach X disease (Wolfe 1955)	N
Typhlocyba jucunda (Herrich-Schäffer) [Hemiptera: Cicadellidae]	potato leafhopper, fruit tree leafhopper	no evidence of presence in PNW			N (Larivière 2005, PPIN 2008)	N			N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Typhlocyba pomaria McAtee [Hemiptera: Cicadellidae]	White apple leafhopper	Y (Beers *et al.* 1993)	Y (Haegele 1930)	Y (Haegele 1930)	N (Larivière 2005, PPIN 2008)	Y	peach (Beers *et al.* 1993)	bark (eggs), leaves and shoots (nymphs and adults) (Beers *et al.* 1993)	N
Ceroplastes floridensis Comstock [Hemiptera: Coccidae]	Florida wax scale	no evidence of presence in PNW			N (Hodgson & Henderson 2000, ScaleNet 2008)	N			N
Coccus longulus (Douglas) [Hemiptera: Coccidae]		N (ScaleNet 2008)	N (ScaleNet 2008)	N (ScaleNet 2008)	Y (Hodgson & Henderson 2000, ScaleNet 2008)	N			N
Eulecanium excrescens (Ferris) [Hemiptera: Coccidae]	excrescent scale, Wisteria Scale Insect	N (ScaleNet 2008)	Y (Gill 1988, ScaleNet 2008, CSL 2005)	N (ScaleNet 2008)	N (Hodgson & Henderson 2000, ScaleNet 2008, PPIN 2008)	Y	apricot, peach (CSL 2005, Malumphy 2005)	twigs (Gill 1988); bark, undersides of foliage (Malumphy 2005)	N
Neopulvinaria innumerabilis (Rathvon) [Hemiptera: Coccidae]	cottony maple scale	Y (ScaleNet 2008)	Y (ScaleNet 2008)	N (ScaleNet 2008)	N (Hodgson & Henderson 2000, ScaleNet 2008, PPIN 2008)	Y	*Prunus* spp. (ScaleNet 2008)	foliage (Hill 1987); overwinters as an adult on stem and branches, nymphs feed on both leaf surfaces (Babayan 1993); feed on upper and lower surfaces of leaves and overwinter on woody branches (Scaltriti 1977); leaves and wood (Canard 1966)	N
Parthenolecanium corni (Bouche) [Hemiptera: Coccidae]	European fruit lecanium	Y (CPCI 2008, Antonelli & Collman 1991)	Y (Wilson & Lovett 1913)	Y (CPCI 2008)	Y (Hodgson & Henderson 2000, ScaleNet 2008)	N			N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Parthenolecanium persicae (F.) [Hemiptera: Coccidae]	European peach scale	N (ScaleNet 2008, CPCI 2008), probable (LaGasa 2000)	Y (ScaleNet 2008, CPCI 2008)	Y (ScaleNet 2008, CPCI 2008)	Y (Hodgson & Henderson 2000, ScaleNet 2008)	N			N
Saissetia oleae (Olivier) [Hemiptera: Coccidae]		Y (CPCI 2008, ScaleNet 2008)	N (CPCI 2008, ScaleNEt 2008)	N (CPCI 2008, ScaleNet 2008)	Y (Hodgson & Henderson 2000, ScaleNet 2008)	N			N
Aspidiotus nerii Bouche [Hemiptera: Diaspididae]		N (ScaleNet 2008)	N (ScaleNet 2008)	N (ScaleNet 2009)	Y (Charles & Henderson 2002)	N			N
Aulacaspis rosae (Bouché) [Hemiptera: Diaspididae]	Rose scale	Y (LaGasa 2000)	N (ScaleNet 2008)	N (ScaleNet 2008)	Y (Charles & Henderson 2002, ScaleNet 2008)	N			N
Chionaspis furfura (Fitch) [Hemiptera: Diaspididae]	scurfy scale	N (ScaleNet 2008)	N (ScaleNet 2008)	Y (ScaleNet 2008)	N (Charles & Henderson 2002, ScaleNet 2008, PPIN 2008)	Y	peach, plum (ScaleNet 2008)	causes reddish spots and small pits on the bark of twigs (ScaleNet 2008)	N
Diaspidiotus ancylus (Putnam) [Hemiptera: Diaspididae]	Howard scale, Putnam scale	N (CPCI 2008, ScaleNet 2008); Y (Crowley 1937, LaGasa 2000)	N (ScaleNet 2008, CPCI 2008, Ben-Dov & German 2003)	N (ScaleNet 2008, CPCI 2008, Ben-Dov & German 2003)	N (Charles & Henderson 2002, ScaleNet 2008, CPCI 2008, PPIN 2008)	Y	apricot (ScaleNet 2008); peach, plum (CPCI 2008)	occurring on bark, leaves or fruit (ScaleNet 2008); on nectarines after packhouse procedures (Curtis *et al*. 1992)	Y

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Diaspidiotus forbesi (Johnson) [Hemiptera: Diaspididae]	Forbes scale	Y (LaGasa 2000); N (ScaleNet 2008)	N (ScaleNet 2008)	N (ScaleNet 2008)	N (Charles & Henderson 2002, ScaleNet 2008, PPIN 2008)	Y	peach, plum (ScaleNet 2008)	bark (Gill 1997); twigs, branches and fruit (Grantham 2006)	Y
Diaspidiotus juglansregiae (Comstock) [Hemiptera: Diaspididae]	Walnut scale	Y (LaGasa 2000); N (ScaleNet 2008)	N (ScaleNet 2008)	N (ScaleNet 2008)	N (Charles & Henderson 2002, ScaleNet 2008, PPIN 2008)	Y	peach (ScaleNet 2008); prune, nectarine (Townsend 1984)	on prune and nectarine fruit at NZ border (Townsend 1984); on nectarine fruit after packhouse procedures (Curtis *et al*. 1992)	Y
Diaspidiotus ostreaeformis (Curtis) [Hemiptera: Diaspididae]	pear oyster scale	Y (CPCI 2008, ScaleNet 2008)	Y (CPCI 2008, ScaleNet 2008)	Y (CPCI 2008, ScaleNet 2008)	Y (Charles & Henderson 2002, ScaleNet 2008)	N			N
Diaspidiotus perniciosus (Comstock) [Hemiptera: Diaspididae]	San Jose scale	Y (ScaleNet 2008)	Y (ScaleNet 2008)	Y (ScaleNet 2008)	Y (Charles & Henderson 2002, ScaleNet 2008)	N			N
Hemiberlesia rapax (Comstock) [Hemiptera: Diaspididae]	Greedy scale	Y (ScaleNet 2008)	Y (ScaleNet 2008)	Y (ScaleNet 2008)	Y (Charles & Henderson 2002, ScaleNet 2008)	N			N
Howardia biclavis (Comstock) [Hemiptera: Diaspididae]	Mining scale	no evidence of presence in PNW			N (Charles & Henderson 2002, PPIN 2008)	N			N
Lepidosaphes ulmi (L.) [Hemiptera: Diaspididae]		N (ScaleNet 2008)	N (ScaleNet 2008)	N (ScaleNet 2008)	Y (Charles & Henderson 2002, ScaleNet 2008)	N			N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Parlatoria desolator McKenzie [Hemiptera: Diaspididae]		N (ScaleNet 2008)	N (ScaleNet 2008)	N (ScaleNet 2008)	Y (Charles & Henderson 2002, ScaleNet 2008)	N			N
Parlatoria oleae (Colvée) [Hemiptera: Diaspididae]	olive scale	present in CA , no evidence of presence in PNW (ScaleNet 2008)			N (Charles & Henderson 2002, PPIN 2008)	N			N
Pseudaulacaspis pentagona (Targioni-Tozzetti) [Hemiptera: Diaspididae]	white peach scale	N (CPCI 2008, ScaleNet 2008, LaGasa 2000)	Y (CPCI 2008, ScaleNet 2008)	Y (Maskew 1915)	N (Charles & Henderson 2002, PPIN 2008)	Y	polyphagous, including apricot, peach, plum, nectarine (CPCI 2008)	tree trunks and older branches, rarely on roots; leaves and fruit are not generally infested, but fruit infestions can occur (Watson 2007a); fruit (Hely *et al.* 1982)	Y
Metcalfa pruinosa (Say) [Hemiptera: Flatidae]		no evidence of presence in PNW			N (PPIN 2008)	N			N
Icerya purchasi Maskell [Hemiptera: Margarodidae]	cottony cushion scale	N (ScaleNet 2008)	N (ScaleNet 2008)	N (ScaleNet 2008)	Y (CPCI 2008)	N			N
Ceresa alta [Hemiptera: Membracidae]	buffalo tree hopper	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	N (CPCI 2008, Larivière 2005, PPIN 2008)	Y	peach (CPCI 2008)	leaves and stems (CPCI 2008)	N
Stictocephala inermis (F.) [Hemiptera: Membracidae]			Y (Wilson 1913/14)		N (Larivière 2005, PPIN 2008)	Y	apricot, peach (Burke *et al.* 1994)	eggs laid in twigs, nymphs feed on plant juices	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Closterotomus norwegicus (Gmelin) [Hemiptera: Miridae]	potato mirid				Y (Eyles 1999)	N			N
Lygus elisus Van Duzee [Hemiptera: Miridae]	pale/plant legume bug	Y (Tanigoshi & Babcock 1989)		Y (Scott *et al.* 1966)	N (CPCI 2008, Larivière & Larochelle 2004, PPIN 2008)	Y	peach (Pickel *et al.* 2006b), nectarine (Bentley & Day 2006c)	can insert eggs in fruit, feed on ripe fruit (Pickel *et al.* 2006b)	Y
Lygus hesperus Knight [Hemiptera: Miridae]		Y (CPCI 2008, Tanigoshi & Babcock 1989)	Y (CPCI 2008)	Y (CPCI 2008)	N (CPCI 2008, Larivière & Larochelle 2004, PPIN 2008)	Y	peach (Pickel *et al.* 2006b), nectarine (Bentley & Day 2006c)	can insert eggs in fruit, feed on ripe fruit (Pickel *et al.* 2006b)	Y
Lygus lineolaris (Palisot de Beauvois) [Hemiptera: Miridae]	Tarnished plant bug	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	N (CPCI 2008, Larivière & Larochelle 2004, PPIN 2008)	Y	peach (major host, CPCI 2008)	Fruits/pods, growing points, inflorescence, leaves, seeds, stems and whole plant (CPCI 2008)	Y
Acrosternum hilare (Say) [Hemiptera: Pentatomidae]	Green stink bug	Y (CPCI 2008)	N (CPCI 2008)	N (CPCI 2008)	N (Larivière & Larochelle 2004, CPCI 2008, PPIN 2008)	Y	peach (Woodside 1946)	insert mouthparts into developing fruit to feed (Pickel *et al.* 2006c); present on fruit for brief feeding periods only; highly mobile and would be removed during harvesting and/or processing	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Chlorochroa sayi (Stål) [Hemiptera: Pentatomidae]	peach stink bug		Y (McPherson & McPherson 2000)	Y (McPherson & McPherson 2000)	N (Larivière & Larochelle 2004, CPCI 2008, PPIN 2008)	Y		insert mouthparts into developing fruit to feed (Pickel *et al.* 2006c); present on fruit for brief feeding periods only; highly mobile and would be removed during harvesting and/or processing	N
Chlorochroa uhleri (Stal) [Hemiptera: Pentatomidae]	stink bug	Y (McPherson & McPherson 2000)		Y (McPherson & McPherson 2000)	N (Larivière & Larochelle 2004, PPIN 2008)	Y	peach, nectarine (Pickel *et al.* 2006c)	insert mouthparts into developing fruit to feed (Pickel *et al.* 2006c); present on fruit for brief feeding periods only; highly mobile and would be removed during harvesting and/or processing	N
Euschistus conspersus Uhler [Hemiptera: Pentatomidae]	consperse stink bug	Y (Alcock 1971, Krupke & Brunner 2003)	N (CPCI 2008)	N (CPCI 2008)	N (Larivière & Larochelle 2004, CPCI 2008, PPIN 2008)	Y	peach (Wolfe 1958)	insert mouthparts into developing fruit to feed (Pickel *et al.* 2006c); present on fruit for brief feeding periods only; highly mobile and would be removed during harvesting and/or processing	N
Euschistus tristigmus (Say) [Hemiptera: Pentatomidae]	dusky stink bug	No (LaGasa 2000)	Y (Schaefer & Panizzi 2000)	Y (Schaefer & Panizzi 2000)	N (Larivière & Larochelle 2004, CPCI 2008, PPIN 2008)	Y	peach (Woodside 1950)	insert mouthparts into developing fruit to feed (Pickel *et al.* 2006c); present on fruit for brief feeding periods only; highly mobile and would be removed during harvesting and/or processing	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Euschistus variolarius (Palisot de Beauvois) [Hemiptera: Pentatomidae]	onespotted stink bug	Y (LaGasa 2000)	Y (McPherson & McPherson 2000)	N (CPCI 2008)	N (Larivière & Larochelle 2004, PPIN 2008)	Y (v)	peach (CPCI 2008)	insert mouthparts into developing fruit to feed (Pickel *et al.* 2006c); present on fruit for brief feeding periods only; highly mobile and would be removed during harvesting and/or processing	N
Halyomorpha halys (Stal) [Hemiptera: Pentatomidae]	brown marmorated stink bug	Y (CPCI 2008)			N (Larivière & Larochelle 2004, PPIN 2008)	Y	peach (Bernon 2004, CPCI 2008)	insert mouthparts into developing fruit to feed (Pickel *et al.* 2006c); present on fruit for brief feeding periods only; highly mobile and would be removed during harvesting and/or processing	N
Murgantia histrionica (Hahn) [Hemiptera: Pentatomidae]		N (McPherson & McPherson 2000)	N (McPherson & McPherson 2000)	N (McPherson & McPherson 2000)	N (Larivière & Larochelle 2004, PPIN 2008)	N			N
Nezara viridula (L.) [Hemiptera: Pentatomidae]	Southern green stink bug	N (CPCI 2008, LaGasa 2000)	N (CPCI 2008)	N (CPCI 2008)	Y (Larivière & Larochelle 2004, CPCI 2008)	N			N
Thyanta custator (F.) [Hemiptera: Pentatomidae]		N (CPCI 2008, Ruckes 1957)	N (CPCI 2008, Ruckes 1957)	N (CPCI 2008, Ruckes 1957)	N (Larivière & Larochelle 2004, CPCI 2008, PPIN 2008)	N			N
Thyanta pallidovirens (Stal) [Hemiptera: Pentatomidae]		Y (Ruckes 1957)	Y (Ruckes 1957)	Y (Ruckes 1957)	N (Larivière & Larochelle 2004, PPIN 2008)	Y	peach (Pickel *et al.* 2006c)	severe damage to unharvested fruit (Pickel *et al.* 2006c), but likely to be disturbed during harvest	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Maconellicoccus hirsutus (Green) [Hemiptera: Pseudococcidae]	pink hibiscus mealybug	N (CPCI 2008, APHIS 2005, ScaleNet 2008)	N (CPCI 2008, APHIS 2005, ScaleNet 2008)	N (CPCI 2008, APHIS 2005, ScaleNet 2008)	N (CPCI 2008, ScaleNet 2008, PPIN 2008)	N			N
Pseudococcus calceolariae (Maskell) [Hemiptera: Pseudococcidae]	Citrophilus mealybug	N (CPCI 2008, ScaleNet 2008)	N (CPCI 2008, ScaleNet 2008)	N (CPCI 2008, ScaleNet 2008)	Y (ScaleNet 2008)	N			N
Pseudococcus comstocki (Kuwana) [Hemiptera: Pseudococcidae]	Comstock mealybug	N (CPCI 2008, ScaleNet 2008)	N (CPCI 2008, ScaleNet 2008)	N (CPCI 2008, ScaleNet 2008)	N (ScaleNet 2008)	N			N
Pseudococcus longispinus (Targioni Tozzetti) [Hemiptera: Pseudococcidae]	Long-tailed mealybug	Y (CPCI 2008, ScaleNet 2008)	N (CPCI 2008, ScaleNet 2008)	N (CPCI 2008, ScaleNet 2008)	Y (Cox 1987, ScaleNet 2008)	Y (v)	peach, plum (CPCI 2008)	fruits/pods, growing points, inflorescence, leaves and stems (CPCI 2008), see Appendix 4	N
Pseudococcus maritimus (Ehrhorn) [Hemiptera: Pseudococcidae]	grape mealybug	Y (CPCI 2008, ScaleNet 2008)	Y (ScaleNet 2008)	N (CPCI 2008, ScaleNet 2008)	N (CPCI 2008, ScaleNet 2008, PPIN 2008)	Y	peach, plum (CPCI 2008); all fruit trees (Beers *et al.* 1993)	mainly leaves and trunk (ScaleNet 2008), under rough bark and on grape clusters (Grimes & Cone 1985), intercepted on pear fruit from the USA (Quancargo C2005/289367)	Y
Pseudococcus viburni (Signoret) [Hemiptera: Pseudococcidae]	Obscure mealybug	Y (ScaleNet 2008)	Y (ScaleNet 2008)	N (ScaleNet 2008)	Y (ScaleNet 2008)	N			N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Rhizoecus falcifer Kunckel d'Herculais [Hemiptera: Pseudococcidae	Ground mealybug	Y (LaGasa 2000)	N (ScaleNet 2008)	N (ScaleNet 2008)	Y (ScaleNet 2008)	N			N
Cacopsylla pyricola (Förster) [Hemiptera: Psyllidae]	Pear psylla	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	N (CPCI 2008, PPIN 2008)	Y	pear is the sole reproductive host (Ullman & McLean 1988)		N
Boisea rubrolineatus (Say) [Hemiptera: Rhopalidae]	western Boxelder Bug	Y (USDA Crop Profiles: Apples from Washington)	Y (Schowalter 1986)		N (Larivière & Larochelle 2004, PPIN 2008)	Y	peach, plum (Alston & Reding 2003)	adults can damage fruit, particularly apples, but no records have been found of this species damaging *Prunus* fruit	N
Boisea trivittata (Say) [Hemiptera: Rhopalidae]	eastern Boxelder Bug	No evidence of presence in PNW			N (Larivière & Larochelle 2004, PPIN 2008)	N			N
Hymenoptera (ants, sawflies)									
Solenopsis invicta Buren Hymenoptera: Formicidae]	Red imported fire ant (RIFA)	N (CPCI 2008, CAPSP 2008)	N (CPCI 2008, CAPSP 2008)	N (CPCI 2008, CAPSP 2008)	N (Berry 2007); eradicated 2003 (PPIN 2008)	N	intercepted on peaches (worker,Female,1,Alive-Fruit)	intercepted on peaches from CA, viability unknown (Quancargo database, Consignment C2003/209840)	N
Caliroa cerasi (L.) [Hymenoptera: Tenthredinidae]	pear and cherry slugworm				Y (Berry 2007, CPCI 2008)	N			N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Hoplocampa cookei (Clarke) [Hymenoptera: Tenthredinidae]		Y (Melander 1924)	Y (Essig 1914, Foster 1913)		N (Berry 2007, PPIN 2008)	Y	mainly cherry; plums and occasionally apricots, peaches (Duruz 1922, Essig 1914)	flowers, inside fruit (Foster 1913); larvae bore through fruit into the kernel and discoloured fruit falls to the ground (Essig 1914); attacks predominantly very immature fruit, which drop off the trees well before maturation (Aphis 2005)	N
Lepidoptera (butterflies and moths)									
Estigmene acrea (Drury) [Lepidoptera: Arctiidae]		Y (Opler *et al.* 2006)		Y (Opler *et al.* 2006)	N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	peach (Fenton 1937)	leaves (AQIS 1999), ripening fruit of peaches (Fenton 1937). No records from mature fruit.	N
Hyphantria cunea (Drury) [Lepidoptera: Arctiidae]	Fall webworm	Y (LaGasa 2000, CPCI 2008, Opler *et al.* 2006)	Y (CPCI 2008, Opler *et al.* 2006)	Y (CPCI 2008, Opler *et al.* 2006)	N (Eradicated, PPIN 2008)	Y	plum (Warren & Tadic 1970)	pupae overwinter under debris on the ground, in soil or in bark crevices; eggs and larvae are associated with foliage, but larvae may feed on fruit if it is enclosed in feeding webs (Beers *et al.* 1993). Unlikely to be associated with clean mature fruit.	N
Pyrrharctia isabella (Smith) [Lepidoptera: Arctiidae]		Y (Opler *et al.* 2006)	Y (Opler *et al.* 2006)	Y (Opler *et al.* 2006)	N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	peach (Fenton 1937, Zhang 1994a)	feeding on ripening peaches (Fenton 1937); live larvae intercepted on multiple occasions	Y

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Spilosoma virginica (F.) [Lepidoptera: Arctiidae]		Y (Opler *et al.* 2006)	Y (Opler *et al.* 2006, Grimble & Beckwith 1992)	Y (Opler *et al.* 2006)	N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	peach (Fenton 1937)	feeding on ripening peaches (Fenton 1937). No records from mature fruit.	N
Bondia comonana Kearfott [Lepidoptera: Carposinidae]		no evidence of presence in PNW			N (Dugdale 1988, Hoare 2001, PPIN 2008)	N			N
Zeuzera pyrina (L.) [Lepidoptera: Cossidae]	Leopard Moth	no evidence of presence in PNW			N (Dugdale 1988, Hoare 2001, PPIN 2008)	N			N
Cadra figulilella (Gregson) [Lepidoptera: Crambidae]	Raisin moth	no evidence of presence in PNW			N (Dugdale 1988, Hoare 2001, PPIN 2008)	N	intercepted on peaches from California (Quancargo consignment C2003/27707, as *Ephestia*)	primarily infests fruit in orchards or vineyards or while it is drying (Ebeling 1996); has been found feeding on packed nectarines near the stem cavity (Curtis *et al.* 1992)	N
Anarsia lineatella Zeller [Lepidoptera: Gelechiidae]	Peach twig borer	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	N (Dugdale 1988, Hoare 2001, PPIN 2008, CPCI 2008)	Y	apricot, peach, plum (CPCI 2008), apricot, peach (Lainq & Caltagirone 1969)	intercepted on apricots, cherries, peaches, plums and nectarines from USA	Y
Recurvaria nanella (Denis & Schiffermuller) [Lepidoptera: Gelechiidae]		Y (LaGasa & Welch 2005)			N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	apricot (Macan *et al.* 1987, CPCI 2008), apricot, peach, plum (Zhang 1994)	mines leaves, leaf-buds and flower buds causing serious damage (Scott & Paine 1914)	N
Biston betularia (L.) [Lepidoptera: Geometridae]			Y (Grimble & Beckwith 1992)		N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	plum (Chapais 1919, Zhang 1994)	on foliage (Carter 1984)	N

	Common name	WA	OR	ID	Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
Chloroclystis rectangulata (L.) [Lepidoptera: Geometridae]	Green pug moth	PNW (Maier 2002)			N (Dugdale 1988, Hoare 2001, PPIN 2008)		N (Maier 2002)	buds, flowers, and occasionally developing leaves (Maier 2002)	N
Operophtera brumata (L.) [Lepidoptera: Geometridae]	winter moth	Y (CPCI 2008)	Y (CPCI 2008)		N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	apricot, peach, plum (Zhang 1994); plum (Kimberling *et al.* 1986)	primarily foliage feeders, but sometimes feed on fruitlets (CPCI 2008), not associated with mature fruit	N
Phyllonorycter elmaella Doganlar & Mutuura [Lepidoptera: Gracillariidae]		Y (Beers *et al.* 1993)	Y (Beers *et al.* 1993)		N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	?	causes damage only to the foliage, does not directly damage or affect fruit (Beers *et al.* 1993)	N
Malacosoma californicum Packard [Lepidoptera: Lasiocampidae]		unconfirmed record (CPCI 2008), Y (Collman & Antonelli 1994)	unconfirmed record (CPCI 2008), Y (Mitchell 1990)	N (CPCI 2008)	N (Dugdale 1988, Hoare 2001, CPCI 2008, PPIN 2008)	Y	plum (Bentley & Day 2006d)	leaves (Bentley & Day 2006d)	N
Malacosoma disstria Hubner [Lepidoptera: Lasiocampidae]	forest tent caterpillar	Y (WSDA 2008, CPCI 2008), Y (Collman & Antonelli 1994)	Y (CPCI 2008, Grimble & Beckwith 1992, Swenson 1957)	Y (CPCI 2008)	N (Dugdale 1988, Hoare 2001, CPCI 2008, PPIN 2008)	Y	plum (Bentley & Day 2006d)	leaves (Bentley & Day 2006d), fruit is not directly attacked (Beers *et al.* 1993)	N
Malacosoma fragilis (Stretch) [Lepidoptera: Lasiocampidae]	western tent caterpillar	throughout western US (Beers *et al.* 1993)			N (Dugdale 1988, Hoare 2001, PIN 2008)	Y	most fruit trees (Beers *et al.* 1993)	fruit is not directly attacked (Beers *et al.* 1993)	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Lymantria dispar (L.) [Lepidoptera: Lymantriidae]	Asian gypsy moth (AGM)	Asian strain eradicated on an annual basis (CPCI 2008), N (GISD 2005)	Asian strain eradicated on an annual basis (CPCI 2008), N (GISD 2005)	Intercepted only (CPCI 2008), N (GISD 2005)	N (CPCI 2008); eradicated (PPIN 2008)	Y	apricot, plum (Zhang 1994); peach (Hood 1932)	larvae feed on buds, leaves and flowers (CPCI 2008), pupate on a variety of substrates including foliage; oviposition on a range of substrates including foliage, tree boles, rocks and objects associated with lights	N
Orgyia antiqua (L.) [Lepidoptera: Lymantriidae]	vapourer	N (CPCI 2008)	N (CPCI 2008)	N (CPCI 2008)	N (Dugdale 1988, Hoare 2001; PPIN 2008)		*Prunus (*Zhang 1994); plum (Di Stefano 1939, Trenchev & Pavlov 1982)	larvae are foliage feeders; pupation occurs on trunk or branches (Di Stefano 1939), among leaves, in wall crevices or any protected spot. Eggs are laid on the cocoon (CPCI 2008)	N
Orgyia leucostigma (Smith) [Lepidoptera: Lymantriidae]	white-marked Tussock Moth		Y (Dustan 1923)		N (Dugdale 1988, Hoare 2001, PPIN 2008)		peach (Britton 1917)	defoliation [of conifers] (Hawboldt 1947)	N
Orgyia vetusta (Boisduval) [Lepidoptera: Lymantriidae]	western tussock moth	Y (Furniss & Knopf 1971)	Y (Wilson & Lovett 1913)		N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	*Prunus* (Zhang 1994), apricot (Coates *et al*. 2007c)	larvae feed on foliage and young fruit (Furniss & Knopf 1971), pupation occurs on twigs and flightless females lay eggs nearby, usually on the cocoon (Coates *et al*. 2007c)	N
Abagrotis barnesi (Benjamin) [Lepidoptera: Noctuidae]		Y (Rings 1972, Zhang 1994)		Y (Rings 1972, Zhang 1994)	N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	peach (Rings 1972, Zhang 1994)	feeds on fruit buds and blossoms (Rings 1972)	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Agrotis ipsilon (Hufnagel) [Lepidoptera: Noctuidae]	black cutworm	*Agrotis ipsilon* is recorded from WA and ID (CPCI 2008) and OR (West & Miller 1989, CPCI 2008), with no information about subspecific status. *A. ipsilon* is recorded from New Zealand as the subspecies *Agrotis ipsilon aneituma* Walker, 1865 (Dugdale 1988). This species was therefore considered further, since it was possible that different subspecies were present in the PNW and New Zealand. *Agrotis ipsilon* was originally described from Europe by Hufnagel in 1766, and the subspecies recorded from Europe is *A. ipsilon ipsilon*. *A. i. aneituma* is based on a single male specimen from the island of Anietyum (PNG), and is said to have an Australasian distribution including Australia, New Zealand and Papua New Guinea (Dugdale 1988). However neither Common (1958) nor Dugdale (1988) were able to find any characters to distinguish the putative subspecies, and Edwards (1996) lists *anietuma* (Walker, 1865: *Noctua*) as a synonym of *ipsilon* (Hufnagel, 1766: *Phalaena*). As there is no evidence of subspecific differences *Agrotis ipsilon* is not considered to be a potential hazard in this analysis.							
Amphipyra pyramidoides Guenee [Lepidoptera: Noctuidae]	pyramidal fruit worm	Y (LaGasa 2000, Chapman & Lienk 1974)	Y (West & Miller 1989)	N (Chapman & Lienk 1974)	N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	apricot (Coates *et al.* 2007b)	young leaves and fruit (Coates *et al.* 2007b); eggs hatch around bud burst and larvae feed on leaves and buds, late instar larvae (20-35 mm long) may feed on and seriously damage developing fruit. They drop to the soil to pupate before the fruit is mature and are not present during harvest (Rings 1968)	N
Apamea devastator (Brace) [Lepidoptera: Noctuidae]	glassy cutworm	Y (Landolt & Hammond 2001)	Y (Kamm 1990)		N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	peach (Robinson *et al.* 2008)	subterranean pest of grasses (Kamm 1990)	N
Helicoverpa zea (Boddie) [Lepidoptera: Noctuidae]		Y (CPCI 2008)	Y (CPCI 2008, Drapek *et al.* 1997, Wilson *et al.* 1991)	Y (CPCI 2008)	N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	peach (Robinson *et al.* 2008)	immature peaches and plums attacked (Capinera 2007)	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Lacanobia subjuncta (Grote & Robinson) [Lepidoptera: Noctuidae]		Y (Doerr *et al.* 2005, Landolt 1998, 2002)	Y (Doerr *et al.* 2005, Landolt 1998)		N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	plum (Landolt 1998); ?apricot (Landolt 2002)	plum leaves (Landolt 1998), defoliate trees, excavate holes in apple fruit, cause problems on packing lines; eat fruit and leaves (Warner 1998); overwinter as adults and lay eggs in the spring. Fruit feeding is restricted to the later instars. Larvae drop to the soil in the first weeks of summer to pupate, therefore not associated with fruit during harvest (Rings 1973)	N
Lithophane antennata Walker [Lepidoptera: Noctuidae]	green fruit worm	Y (LaGasa 2000)			N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	stonefruit (LaGasa 2000)	fruit (LaGasa 2000); eggs hatch around bud burst and larvae feed on buds and young leaves.Larvae from the third instar may also feed on fruit, but the most serious damage is caused by the late instar larvae (21-41mm long). These eat large sections of fruit causing serious damage, but drop to the ground to pupate before harvest (Rings 1970)	N
Orthosia hibisci Guenee [Lepidoptera: Noctuidae]	Speckled Green fruit worm	Y (LaGasa 2000)	Y (Grimble & Beckwith 1992)	N (CPCI 2008)	N (Dugdale 1988, Hoare 2001, CPCI 2008, PPIN 2008)	Y	apricot (Raski & Borden 1949); apricot, *Prunus* (Zhang 1994)	associated with leaves and immature fruit only (Raski & Borden 1949; Coates *et al.* 2007b)	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Peridroma saucia (Hubner) [Lepidoptera: Noctuidae]	pearly underwing moth	Y (CPCI 2008)	Y (CPCI 2008, Grimble & Beckwith 1992)	N (CPCI 2008)	N (Dugdale 1988, Hoare 2001, CPCI 2008, PPIN 2008)	Y	apricot, peach, plum (CPCI 2008), nectarine (Molinari *et al.* 1995)	fruits/pods (CPCI 2008); peach & nectarine fruit damage (Molinari *et al.* 1995); skeletonise leaves and feed on epicarp of peach fruit, causing severe damage to fruit (Castellari 1976). Early instar larvae feed only on leaves. Late instar larvae may feed on fruit and cause scarring, but they return to the soil during the day (Castellari 1976), and are unlikely to be associated with mature harvested fruit	N
Xestia c-nigrum (L.) [Lepidoptera: Noctuidae]	Spotted cutworm	Y (CPCI 2008, Wennemann *et al.* 2003)	Y (CPCI 2008, Zhang 1994)	Y (CPCI 2008)	N (Dugdale 1988, Hoare 2001, CPCI 2008, PPIN 2008)	Y	peach (CPCI 2008)	most feeding activity is on foliage (CPCI 2008) but it has been recorded damaging fruit (WSU 2008, CPCI 2008). Larvae feed at night (Dashevskii & Rybakova 1979) and hide during the day (Babchuk *et al*. 1978), thus are unlikely to be harvested.	N
Egira curialis Grote [Lepidoptera: Noctuidae]	Citrus cutworm	No info (LaGasa 2000)	Y (Grimble & Beckwith 1992)		N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	peach, plum (Quezada *et al.* 1976); plum (McDonough *et al.* 1982, Bentley & Day 2006e)	larvae feed on leaves, blossoms, or fruit, but mature fruit are rarely attacked; older larvae drop to the ground when disturbed (Bentley & Day 2006e)	N

	Common name	WA	OR	ID	Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
Datana ministra Drury [Lepidoptera: Notodontidae]	Yellownecked caterpillar	Y (Opler *et al.* 2006)	Y (Opler *et al.* 2006)	Y (Edmundson 1916)	N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	most fruit trees (Beers *et al.* 1993), peach (Zhang 1994)	leaves, pupate in soil (Beers *et al.* 1993); defoliater: almost entire defoliation of a large number of young apple trees (Brittain 1914)	N
Schizura concinna (Smith) [Lepidoptera: Notodontidae]	Redhumped caterpillar	Y (Opler *et al.* 2006)	Y (Opler *et al.* 2006)	Y (Opler *et al.* 2006)	N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	apricot, plum (Beers et a. 1993); especially Rosaceae (Arnett 1997); Prunus (Zhang 1994)	leaves (Bentley & Day 2006f); prune foligae (Hendrickson 1921); foligae of peach, apricot, plum, prune (Anonymous 1918)	N
Papilio eurymedon Lucas [Lepidoptera: Papilionidae]	Pale swallowtail	Y (Opler *et al.* 2006)	Y (Opler *et al.* 2006, Grimble & Beckwith 1992)	Y (Opler *et al.* 2006)	N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	*Prunus* (CPCI 2008)	leaves (Opler *et al.* 2006)	N
Papilio rutulus Lucas [Lepidoptera: Papilionidae]	Western tiger swallowtail	Y (Opler *et al.* 2006)	Y (Opler *et al.* 2006)	Y (Opler *et al.* 2006)	N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	*Prunus* (Opler *et al.* 2006)	leaves (Opler *et al.* 2006)	N
Acrobasis tricolorella (Grote) [Lepidoptera: Pyralidae]	destructive pruneworm, Mineola moth		Y (Shull & Wakeland 1941)	Y (Pack & Dowdle 1930)	N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	apricot and prune (Pack & Dowdle 1930); cherry (Oatman 1964); plum (Essig & Keifer 1933)	considerable injury to apricot and prune fruits in southern Idaho (Pack & Dowdle 1930); maybe found within cherry fruit (Oatman 1964); feed on Sierra plum fruit flesh (Essig & Keifer 1933)	Y
Amyelois transitella (Walker) [Lepidoptera: Pyralidae]	navel orange worm	Y (Riedl *et al.* 1979)	Y (Riedl *et al.* 1979)	N (CPCI 2008)	N (Dugdale 1988, Hoare 2001, CPCI 2008, PPIN 2008)	Y	nectarines (Curtis *et al.* 1992)	larvae excavate feeding chambers beneath nectarine fruit skin; pupation in feeding chamber (Curtis *et al*. 1992)	Y

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Ostrinia nubilalis (Hubner) [Lepidoptera: Crambidae]	European corn borer	Y (Anonymous 1942)	Y (Felt 1921)	N (CPCI 2008)	N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	peach (Ciampolini *et al.* 1987, CPCI 2008, Cravedi *et al.* 1991)	fruits/pods (CPCI 2008); damage to peach tree limbs (Tedders *et al.* 1981); sporadic damage to peach fruit in Italy (Cravedi *et al.* 1991)	N
Antheraea polyphemus (Cramer) [Lepidoptera: Saturniidae]	Polyphemus moth	Yes (Opler *et al*. 2006)	Yes (Opler *et al*. 2006)	Yes (Opler *et al.* 2006)	N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	peach, plum (Oehlke 2006)	leaves (Opler *et al.* 2006)	N
Hemileuca eglanterina (Boisduval) [Lepidoptera: Saturniidae]		Y (Opler *et al.* 2006)	Y (Opler *et al.* 2006)	Y (Opler *et al.* 2006)	N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	plum (Robinson *et al*. 2008)	leaves (Vosler 1915)	N
Synanthedon exitiosa (Say) [Lepidoptera: Sesiidae]	peach tree borer	Y (LaGasa 2000)	Y (Jones 1940, Lathrop 1924, Thompson 1926, 1927)	Y (Edmundson 1916)	N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	Peach (Jones 1940)	larvae bore into roots or stems (Thompson 1927); crown and trunk, woodborer (Pickel *et al*. 2006d); larvae feed on trunk near or below ground level (Beers *et al.* 1993)	N
Synanthedon pictipes (Grote & Robinson) [Lepidoptera: Sesiidae]	lesser peach tree borer	No evidence of presence in PNW			N (Dugdale 1988, Hoare 2001, PPIN 2008)	N			N
Sphinx drupiferarum Smith [Lepidoptera: Sphingidae]		Y (Opler *et al.* 2006)	Y (Opler *et al.* 2006, Grimble & Beckwith 1992)	Y (Opler *et al.* 2006)	N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	plum (Zhang 1994)	defoliater (Brittain 1914)	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Archips argyrospilus (Walker) [Lepidoptera: Tortricidae]	Fruit tree leafroller	Y (Anthon 1951, Melander 1924, Wolfe & Anthon 1953, Beers *et al.* 1993)	Y (Fulton 1921a, Zhang 1994)	Y (Anonymous 1926, 1928, Edmundson 1916, Smith 1922)	N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	apricot, plum (Beers *et al.* 1993)	feeds first on buds, then on fruit (Haseman 1913, Haseman & Brown 1939, Weldon 1913)	Y
Archips fuscocupreanus Walsingham [Lepidoptera: Tortricidae]		Y (CPCI 2008, ODA 2004, Maier 2006)	N (CPCI 2008)	N (CPCI 2008)	N (Dugdale 1988, Hoare 2001, CPCI 2008, PPIN 2008)	Y	plum (Maier 2006)	fruits/pods, inflorescence and leaves (CPC); young fruit, pupate in webbed leaves, "black egg masses ... remain on trees until following spring" "egg masses on the trunks and limbs" (Maier 2006)	Y
Archips podana (Scopoli) [Lepidoptera: Tortricidae]	Great brown twist moth	Y (LaGasa *et al*. 2003)			N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	plum (LaGasa *et al*. 2003)	fruit (LaGasa *et al*. 2003)	Y
Archips rosana L. [Lepidoptera: Tortricidae]	European leaf roller, filbert leafroller	Y (Beers *et al.* 1993)	Y (CPCI 2008, AliNiazee 1976, Beers *et al.* 1993)	N (CPCI 2008)	N (Dugdale 1988, Hoare 2001, CPCI 2008, PPIN 2008)	Y	apricot, peach (CPCI 2008); plum (Zhang 1994)	fruits/pods, growing points, inflorescence and leaves (CPCI 2008); peach leaves and fruit (Van Rossem 1948)	Y
Argyrotaenia citrana (Fernald) [Lepidoptera: Tortricidae]	orange tortrix	Y (restricted CPC, Coop *et al.* 1989), Y (Breakey & Batchelor 1948)	Y (restricted CPC, Coop *et al.* 1989)	N (CPCI 2008)	N (Dugdale 1988, Hoare 2001, CPCI 2008, PPIN 2008)	Y	apricot (CPCI 2008), peach, plum (Breakey & Batchelor 1948)	fruits/pods, growing points, inflorescence, leaves and stems (CPC); feed mainly on the foliage, but also attack the flowers and ripening fruit of raspberries and contaminate fruit in processing plant (Breakey & Batchelor 1948)	Y

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Choristoneura rosaceana (Harris) [Lepidoptera: Tortricidae]	Obliquebanded leafroller	Y (CPCI 2008, Zhang 1994)	Y (CPCI 2008, Grimble & Beckwith 1992, Zhang 1994)	N (CPCI 2008)	N (Dugdale 1988, Hoare 2001, CPCI 2008, PPIN 2008)	Y	plum, prune, seldom peach (Fulton 1921a)	external feeders, primarily on foliage but can damage fruit near leaves or fruit in clusters (Beers *et al.* 1993); surface of fruit, especially on peaches with opened split pits where they feed around the opened stem end and down into the fleshy areas around the pit (Kaethler *et al.* 1982); defoliates and prevents formation of fruit buds (Fulton 1921a)	Y
Clepsis persicana Fitch [Lepidoptera: Tortricidae]			Y (Grimble & Beckwith 1992)		N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	peach (Robinson *et al.* 2008)	foliage, shallow feeding on apple fruit surface only if bound to leaves (Gilliatt 1930)	N
Cnephasia longana (Haworth) [Lepidoptera: Tortricidae]	omnivorous leaftier	Y (Coop *et al.* 1989, CPCI 2008, Zhang 1994)	Y (Coop *et al.* 1989, CPC, Zhang 1994)	N (CPCI 2008)	N (Dugdale 1988, Hoare 2001, CPCI 2008, PPIN 2008)	Y	apricot (Robinson *et al.* 2008)	mine leaves (CPCI 2008); feed in spun leaves, esp. terminal shoots, web foliage; also attack flowers and blossom trusses, may bore into shoot tips; pupate on ground (Meijerman & Ulenberg 2008)	N
Cydia latiferreana (Walsingham) [Lepidoptera: Tortricidae]	Filbertworm	Y (CPCI 2008)	Y (CPCI 2008)	N (CPCI 2008)	N (Dugdale 1988, Hoare 2001, CPCI 2008, PPIN 2008)	Y	apricot, peach (Dohanian 1940); apricot minor host (CPCI 2008)	Interception	Y
Cydia pomonella (L.) [Lepidoptera: Tortricidae]	Codling moth	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	Y (Dugdale 1988,CPCI 2008, PPIN 2008)	N			N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Enarmonia formosana (Scopoli) [Lepidoptera: Tortricidae]	cherry bark tortrix	Y (Klaus 1992)			N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	apricot, peach, plum (Tanigoshi & Stary 2003)	bark, cambium; larvae cause damage by feeding under the bark, making irregular tunnels, which causes the bark to loosen and crack; tunnel beneath bark (Beers *et al.* 1993)	N
Grapholita molesta (Busck) [Lepidoptera: Tortricidae]	Oriental fruit moth	Y (CPCI 2008)	N (CPCI 2008)	N (CPCI 2008)	Y - North Island only (Murrell and Lo 1998, Dugdale 1988, PPIN 2008) No national measures are in place to prevent spread.	N	apricot, peach, plum, nectarine (CPCI 2008)	fruits/pods, leaves, stems and whole plant; larvae borne externally, visible to the naked eye (CPCI 2008); fruit, shoot, twig (PPIN 2008); larvae in tunnels bored into fruit, pupae in stem cavity (Curtis *et al.* 1992)	N
Grapholita packardi (Zeller) [Lepidoptera: Tortricidae]	cherry fruitworm	Y (CPCI 2008, Zhang 1994)	Y (CPCI 2008)		N (Dugdale 1988, Hoare 2001, CPCI 2008, PPIN 2008)	Y	peach, plum (CPCI 2008)	Fruits/pods and growing points (CPCI 2008); internal apple-feeding pest (Barcenas *et al.* 2005)	Y
Grapholita prunivora (Walsh) [Lepidoptera: Tortricidae]	Lesser apple worm	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	N (Dugdale 1988, Hoare 2001, CPCI 2008, PPIN 2008)	Y	apricot, peach, plum (CPCI 2008); plum, peach (Zhang 1994)	present in PNW on fruit (CPCI 2008); internal apple-feeding pest (Barcenas *et al.* 2005)	Y
Pandemis pyrusana Kearfott [Lepidoptera: Tortricidae]		Y (CPCI 2008, Pfannenstiel *et al.* 2004, Zhang 1994)			N (Dugdale 1988, Hoare 2001, CPCI 2008, PPIN 2008)	Y	apricot, peach (Brunner & Beers 1990); apricot (Newcomer & Carlson 1952); apricot, prune (Carlson & Newcomer 1950)	leaves, fruit (Brunner & Beers 1990); external feeders, primarily on foliage but can damage fruit near leaves or fruit in clusters (Beers *et al.* 1993); fruit damage (Walker & Welter 2001)	Y

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Platynota idaeusalis (Walker) [Lepidoptera: Tortricidae]		No evidence of presence in PNW			N (Dugdale 1988, Hoare 2001, PPIN 2008)	N			N
Platynota stultana Walsingham [Lepidoptera: Tortricidae]	Omnivorous leafroller	Recorded from California, but the only reference found for its presence in the PNW is an unreferenced record in AQIS (1999).			N (Dugdale 1988, Hoare 2001, CPCI 2008, PPIN 2008)	N	peach (Pickel *et al.* 2006e), plum (Bentley & Day 2006g), nectarine (Bentley & Day 2006h)	Intercepted on cherries and peaches/nectarines from California	N
Spilonota ocellana (F.) [Lepidoptera: Tortricidae]	Eyespotted bud moth	Y (LaGasa & Welch 2005)	Y (Oregon Department of Fish & Wildlife 2005)		N (Dugdale 1988, Hoare 2001, PPIN 2008)	Y	all stonefruit (Beers *et al.* 1993); plum (Zhang 1994); plum, prune (Mackie 1940)	fruit, leaves, bark (Beers *et al.* 1993); underside of leaves, flower and leaf-buds (Wilson & Moznette 1915)	Y
Neuroptera (lacewings)									
Chrysopa species [Neuroptera: Chrysopidae]	lacewings	Y, see assessment	Y, see assessment	Y, see assessment	genus not recorded from NZ (Wise 1992, Macfarlane in press)	Y	predatory	intercepted frequently on apricot, peach/nectarine, plum from USA	Y
Orthoptera (crickets, grasshoppers)									
Melanoplus femur-rubrum (De Geer) [Orthoptera: Acrididae]	Red legged grasshopper	Y (LaGasa 2000, Rockwood 1950)	Y (Fulton 1921b)		N (CPCI 2008, PPIN 2008)	Y	none found	grass, foliage and sometimes bark (Pfadt 1996)	N
Oecanthus fultoni Walker [Orthoptera: Gryllidae]	Snowy Tree Cricket	Y (Walker & Moore 2008)	Y (Walker & Moore 2008)	Y (Walker & Moore 2008)	N (Johns in press, PPIN 2008)	Y	none found	flowers, foliage, fruit (enature.com 2007); stems (Funt *et al.* 1999)	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Scudderia furcata Brunner [Orthoptera: Tettigoniidae]	Forktailed bush katydid	probably (Walker & Moore 2008)	probably (Walker & Moore 2008)	Y (Walker & Moore 2008)	N (Johns in press, PPIN 2008)		peach (Pickel *et al.* 2006f), plum (Bentley & Day 2006i), nectarine (Bentley & Day 2006j)	leaves, fruit; tends to take single bites from a number of fruit; jumps readily when disturbed (Bentley & Day 2006i) thus would be likely to be dislodged during harvesting and unlikely to be on graded fruit	N
Thysanoptera (thrips)									
Leptothrips mali Fitch [Thysanoptera: Phlaeothripidae]	black hunter thrips	Y (James 2003)	N (CPCI 2008)	N (CPCI 2008)	N (CPCI 2008, Mound & Walker 1986; PPIN 2008)	Y	predator of *Panonychus ulmi* (CPCI 2008)	Indirect association	N
Frankliniella bispinosa (Morgan) [Thysanoptera: Thripidae]		N (CPCI 2008, Nakahara 1997)	N (CPCI 2008, Nakahara 1997)	N (CPCI 2008, Nakahara 1997)	N (CPCI 2008, Nakahara 1997, Mound & Walker 1982, PPIN 2008)	N			N
Frankliniella fusca (Hinds) [Thysanoptera: Thripidae]	tobacco thrips	Y (CPCI 2008)	N (CPCI 2008)	N (CPCI 2008)	N (Mound & Walker 1982, CPCI 2008, PPIN 2008)	Y (v)	no stonefruit association found	external feeding on fruit/pods (CPCI 2008)	N
Frankliniella intonsa (Trybom) [Thysanoptera: Thripidae]	Taiwan flower thrips, Intonsa flower thrips	Y (CPCI 2008)	N (CPCI 2008)	N (CPCI 2008)	Y (Teulon and Nielsen 2005)	Y (v)	major hosts include peach (CPCI 2008)	fruits/pods and inflorescence (CPCI 2008), see Appendix 4	N
Frankliniella minuta Moulton [Thysanoptera: Thripidae]	Minute flower thrips	Y (Frick 1964)	Y (Frick 1964)		N (Mound & Walker 1982, PPIN 2008)	Y	Peach (Mound 2006)	flowers (Mound 2006); flowers, leaves (AQIS 2000); flower, leaf, stem, bud (AQIS 1999)	N

	Common name				Present in New Zealand	Continue	Associated with *Prunus* spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Frankliniella occidentalis (Pergande) [Thysanoptera: Thripidae)]	Western flower thrips	Y (CPCI 2008)	Y (CPCI 2008	Y (CPCI 2008	Y (Teulon and Nielsen 2005, CPCI 2008)	Y (v)	polyphagous; hosts include apricot, peach, plum and nectarine (CPCI 2008)	fruit (CPCI 2008), see Appendix 4	N
Frankliniella tritici (Fitch) [Thysanoptera: Thripidae]	Flower thrips	Y (LaGasa 2000)	Y (Phillips & Poos 1940)	Y (CPCI 2008)	N (CPCI 2008, Mound & Walker 1982, PPIN 2008)	Y	nectarine (Yonce *et al.* 1990); peach (Lewis 1997)	on fruit, skin blemished (Lewis 1997)	Y
Scirtothrips (*Euthrips*) *citri* (Fitch) [Thysanoptera: Thripidae]	California citrus thrips	N (Smith *et al.* 1997, Joseph Morse, pers. comm. 2007)	N (Smith *et al.* 1997, Joseph Morse, pers. comm. 2007)	N (Smith *et al.* 1997, Joseph Morse, pers. comm. 2007)	N (CPCI 2008, Smith *et al.* 1997, PPIN 2008)	N			N
Scirtothrips perseae Nakahara [Thysanoptera: Thripidae]		N (CPCI 2008)	N (CPCI 2008)	N (CPCI 2008)	N (Mound & Walker 1982, PPIN 2008)	N			N
Taeniothrips inconsequens (Uzel) [Thysanoptera: Thripidae]	pear thrips, fruit tree thrips	Y (CPCI 2008)	Y (CPCI 2008)		N (CPCI 2008, Mound & Walker 1982, PPIN 2008)	Y	peach, nectarine (Lewis 1997)	on fruit, skin blemished (Lewis 1997)	Y
Thrips tabaci Lindeman [Thysanoptera: Thripidae]	onion thrips, potato thrips	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	Y (Mound & Walker 1982)	Y (v)	peach, plum (Prado 1991)	growing points, inflorescence and leaves (CPCI 2008), see Appendix 4	N
Neohydatothrips variabilis (Beach) [Thysanoptera: Thripidae]		No evidence of presence in the PNW			N (Mound & Walker 1982, PPIN 2008)	N			N

[1] N: not listed in this geographical area by (or no entry in) this database/publication, not that the organism is necessarily stated to be absent.

[2]Y(v): species is present in New Zealand but is a known vector.

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Appendix 2: Categorisation of pathogens associated with stone fruit production in the Pacific Northwest[1]

Scientific name	Common name				Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Bacteria									
Erwinia amylovora (Burrill) Winslow *et al.* [Enterobacteriales: Enterobacteriaceae]	fireblight	Y (CPCI 2008)	Y (CPCI 2008)	Y (Mohan *et al.* 2002)	Y (Landcare NZFUNGI Database 2008)	N			N
Pseudomonas syringae pv. *morsprunorum* (Wormald) Young *et al.* [Pseudomonadales: Pseudomonadaceae]	bacterial canker of stone fruit	Y (WSU Horticulture 2003	Y (OSU 2007)	possibly (OSU 2007)	Absent (Landcare NZFUNGI Database 2008)	Y	plum (Jones & Sutton 1996)	fruits/pods, inflorescence, leavesand stems (CPCI 2008), flowers, short shoots, twigs and fruits (Massfeller & Schmidle 1966)	Y
Pseudomonas syringae pv. *syringae* van Hall [Pseudomonadales: Pseudomonadaceae]		Y (WSU Horticulture 2003)			Y (Landcare NZFUNGI Database 2008)	N			N
Pseudomonas viridiflava (Burkholder) Dowson [Pseudomonadales: Pseudomonadaceae]	bacterial leaf blight of tomato	Y (CPCI 2008)	Y (CPCI 2008)		Y (CPCI 2008, Landcare NZFUNGI Database 2008)	N			N

Scientific name	Common name	WA	OR	ID	Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
Rhizobium radiobacter (Beijerinck & van Delden) Young *et al.* (*Agrobacterium tumefaciens*) [Rhizobiales: Rhizobiaceae]	crown gall		Y (CPCI 2008)		Y (CPCI 2008, Landcare NZFUNGI Database 2008)	N			N
Xanthomonas arboricola pv. *pruni* Vauterin *et al.* [Xanthomonadales: Xanthomonadaceae]	bacterial spot		Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008, Landcare NZFUNGI Database 2008)	N			N
Xylella fastidiosa (Wells *et al.*) [Xanthomonadales: Xanthomonadaceae]	phoney peach disease	Present in California. Not recorded from the PNW (Diekmann & Putter 1996, CPCI 2008)			Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	N			N
Fungi									
Alternaria alternata (Fr.) Keissl. [anamorphic Pleosporaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008, Landcare NZFUNGI Database 2008)	N			N
Alternaria mali Roberts [anamorphic Pleosporaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)		N[2] (Landcare NZFUNGI Database 2008, PPIN 2008)	Y	no host association found	fruit (English 1940), leaves (Shin *et al.* 2001)	N
Apiosporina morbosa (Schwein.) Arx [Ascomycota: Pleosporales: Venturiaceae]	black knot	Y (CPCI 2008, Farr *et al.* 2008)	Y (CPCI 2008, Farr *et al.* 2008)	Y (CPCI 2008, Farr *et al.* 2008)	Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	plum (Shaw, 1973, Diekmann & Putter 1996); apricot, peach	twigs (Farr *et al.* 2008); stem causing black knot (Sutton and Waterston 1970)	N

Scientific name	Common name	WA	OR	ID	Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
							(Farr *et al.* 2008)		
Armillaria gallica Marxm. & Romagn. [Basidiomycota: Agricales: Marasmiaceae]	Armillaria root rot	Y (Farr *et al.* 2008)	Y (Baumgartner & Rizzo 2001)		N (Farr *et al.* 2008, PPIN 2008)	Y		soil-borne root pathogen,not associated with mature fruit (Ogawa *et al*. 1995)	N
Armillaria mellea (Vahl.) P. Kumm. [Basidiomycota: Agricales: Marasmiaceae]	Armillaria root rot	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (CPCI 2008, Farr *et al.* 2008)	Absent (Landcare NZFUNGI Database 2008 2008), Y (Farr *et al.* 2008), N (PPIN 2008)	Y	apricot, peach, plum (Farr *et al.* 2008)	wood decay fungus (Pegler & Gibson 1972); roots (Jones & Aldwinckle 1990); base of trunks, root rot (Teng 1996); rotten wood (Zhuang 2005)	N
Armillaria nabsnona Volk & Burdsall [Basidiomycota: Agricales: Marasmiaceae]	Armillaria root rot	Y (Farr *et al.* 2008)	probably (Baumgartner & Rizzo 2001)	Y (Baumgartner & Rizzo 2001)	N (Farr *et al.* 2008, Baumgartner & Rizzo 2001, PPIN 2008)	Y		soil-borne root pathogen, not associated with mature fruit (Ogawa *et al.* 1995); saprobe on dead understory hardwoods (Baumgartner & Rizzo 2001)	N
Armillaria ostoyae (Romagn.) Herink [Basidiomycota: Agricales: Marasmiaceae]	Armillaria root rot	Y (CPCI 2008, Farr *et al.* 2008)	Y (CPCI 2008)	Y (CPCI 2008)	Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	peach (CPCI 2008)	leaves, roots, stems (Bendel *et al.* 2006); root rot (CPCI 2008)	N
Aspergillus flavus Link [anamorphic Trichocomaceae]	postharvest fruit decay	Y (CPCI 2008, Farr *et al.* 2008)	Y (CPCI 2008, Farr *et al.* 2008)	Y (CPCI 2008)	Y (CPCI 2008, Farr *et al.* 2008, Landcare NZFUNGI Database 2008)	N			N
Aspergillus niger Tiegh. 1867 [anamorphic Trichocomaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Landcare NZFUNGI Database 2008, Farr *et al.* 2008)	N			N

Scientific name	Common name				Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Athelia rolfsii (Curzi) Tu & Kimbr. (anam: *Sclerotium rolfsii*) [Basidiomycota: Polyporales: Atheliaceae]	Sclerotium stem rot	Y (CPCI 2008, Farr *et al.* 2008)	Y (CPCI 2008, Farr *et al.* 2008)		Y (CPCI 2008, Farr *et al.* 2008, Landcare NZFUNGI Database 2008)	N			N
Aureobasidium prunicola (Ellis & Everh.) Herm.-Nijh. [anamorphic Hyphomycetes]		"Northern United States" (Farr *et al.* 1989), no evidence of presence in the Pacific Northwest			N (Landcare NZFUNGI Database 2008, PPIN 2008)	N			N
Aureobasidium pullulans (de Barry) G. Arnaud [anamorphic Hyphomycetes]		Y (CPCI 2008, Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Landcare NZFUNGI Database 2008, Farr *et al.* 2008)	N			N
Blumeriella jaapii (Rehm.) Arx (anam: *Phloeosporella padi*) [Ascomycota: Helotiales: Dermateaceae]	cherry leaf spot	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)		Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	apricot, plum (Smith *et al.* 1988a)	buds (Diaz et al. 2007); leaves (Bengtsson *et al.* 2006, Farr *et al.* 2008); infection of fruit is rare but can occur in severe epidemics (Ogawa *et al.* 1995);); leaves, stems and whole plant (CPCI 2008)	Y
Botryosphaeria obtusa (Schwein.) Shoemaker (anam: *Sphaeropsis malorum*) [Ascomycota: Dothideales: Botryosphaeriaceae]	Botryospha eria fruit rot	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008, Landcare NZFUNGI Database 2008)	N			N
Botryotinia fuckeliana (de Bary) Whetzel (anam: *Botrytis cinerea*) [Ascomycota: Helotiales: Sclerotiniaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Landcare NZFUNGI Database 2008, Farr *et al.* 2008)	N			N

Scientific name	Common name				Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Butlerelfia eustacei Weresub & Illman [Basidiomycota Agaricomycetes: Atheliaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	N (Landcare NZFUNGI Database 2008, Farr *et al.* 2008, PPIN 2008)	Y	peach (Shaw 1973)	fisheye rot of stored apples (Farr *et al.* 2008)	N
Calocera cornea (Batsch) Fr. [Basidiomycota : Dacrymycetales: Dacrymycetaceae]		Y (Farr *et al.* 2008)		Y (Farr *et al.* 2008)	UNCERTAIN (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	peach (Farr *et al.* 2008)	wood decay (Papetti & Papetti 1999)	N
Calosphaeria pulchella (Pers.) J. Schröt. [Ascomycota: Calosphaeriales: Calosphaeriaceae]		Y (Farr *et al.* 2008)			N (PPIN 2008)	Y	peach (Farr *et al.* 2008)	on limbs, twigs and trunks (Farr *et al.* 2008)	N
Ceratocystis fimbriata Ellis & Halst. [Ascomycota: Microascales: Ceratocystidaceae]	Ceratocystis blight		Y (CPCI 2008)	Y (CPCI 2008)	Y (Landcare NZFUNGI Database 2008)	N			N
Ceriporia spissa (Schwein.) Rajchenb. [Basidiomycota: Polyporales: Hapalopilaceae]	wood rot	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008), Uncertain (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	peach (Farr *et al.* 2008)	on wood and on treated pine poles, generally hosts are hardwoods (Farr *et al*. 2008)	N
Chondrostereum purpureum (Pers.) Pouzar [Basidiomycota: Polyporales: Meruliaceae]	silver leaf	Y (WSDA 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Landcare NZFUNGI Database 2008)	N			N

Scientific name	Common name				Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Cladosporium herbarum (Pers.) Link [Ascomycota: Mycosphaerellales: Mycosphaerellaceae]	postharvest fruit decay	Y (CPCI 2008, Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008, Landcare NZFUNGI Database 2008)	N			N
Coriolopsis gallica (Fr.) Ryvarden [Basidiomycota: Polyporales: Polyporaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	apricot (Farr *et al.* 2008)	wood decay fungus (Laks *et al*. 1992)	N
Corticium roseum Pers. 1794 [Basidiomycota: Polyporales: Corticiaceae] syn*: Laeticorticium roseum* (Pers.) Donk		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)		Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	peach (Farr *et al.* 2008)	wood (Farr *et al.* 2008)	N
Dermea cerasi (Pers.) Fr. (anam: *Foveostroma drupacearum*) [Ascomycota: Helotiales: Dermateaceae]			Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	plum (Farr *et al.* 2008)	limbs, bark and twigs (Farr *et al.* 2008)	N
Diaporthe perniciosa Marchal & É.J. Marchal (anam: *Phomopsis mali*) [Ascomycetes: Diaporthales: Valsaceae	postharvest fruit decay		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008, Landcare NZFUNGI Database 2008)	N			N
Eudarluca caricis (Fr.) O.E. Erikss (anam: *Sphaerellopsis filum*) [Ascomycota:: Pleosporales: Phaeosphaeriaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	N			N
Eutypa lata (Pers.) Tul. &	Eutypa	Y (Farr *et al.*	Y (CPCI		Y (Landcare	N			N

Scientific name	Common name	WA	OR	ID	Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
C. Tul. [Ascomycota: Xylariales: Diatrypaceae]	dieback	2008)	2008, Farr *et al.* 2008)		NZFUNGI Database 2008, Farr *et al.* 2008)				
Fomes fomentarius (L.) J. Kickx f. [Basidiomycota: Polyporales: Polyporaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	N (Farr *et al.* 2008, PPIN 2008)	Y	plum (Farr *et al.* 2008	living and dead hardwoods (Farr *et al.* 1989)	N
Fomitopsis cajanderi (P. Karst.) Kotl. & Pouzar [Basidiomycota: Polyporales: Fomitopsidaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	apricot, peach, plum (Farr *et al.* 2008)	wood, usually of conifers (Farr *et al.* 2008)	N
Fomitopsis pinicola (Sw.) P. Karst. [Basidiomycota: Polyporales: Fomitopsidaceae]	brown crumbly rot	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	peach, plum (Farr *et al.* 2008)	wood, usually of conifers (Farr *et al.* 2008); trunks (Teng 1996); stumps and rotten wood (Zhuang 2005)	N
Fomitopsis rosea (Alb. & Schwein.) P. Karst. [Basidiomycota: Polyporales: Fomitopsidaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008, Weir 1923)	Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	peach, plum (Farr *et al.* 2008)	wood, usually of conifers (Farr *et al.* 2008); wood decay (Edman *et al.* 2006)	N
Fumago vagans Pers. [Ascomycotina: Incertae sedis]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	N (Farr *et al.* 2008)	N (Landcare NZFUNGI Database 2008, Farr *et al.* 2008), N (PPIN 2008)	Y	peach, plum (Farr *et al.* 2008)	leaf, stem and trunk (Schoulties 1980)	N
Fusarium poae (Peck) Wollenw. [Ascomycota: Hypocreales: Nectriaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)		Y (Farr *et al.* 2008, Landcare NZFUNGI Database 2008)	N			N

Scientific name	Common name				Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Ganoderma applanatum (Pers.) Pat. [Basidiomycota: Polyporales: Ganodermataceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Uncertain (Landcare NZFUNGI Database 2008), Y (PPIN 2008)	Y	apricot, peach, plum (Farr *et al.* 2008)	wood decay, enters trees primarily through wounds that expose secondary xylem of sapwood or heartwood (Ogawa *et al.*1995)	N
Ganoderma lucidum (Curtis) P. Karst. [Basidiomycota: Polyporales: Ganodermataceae]			Y (Farr *et al.* 2008)		Absent (Landcare NZFUNGI Database 2008), misdetermined and therefore presence recorded in error, N (PPIN 2008)	Y	peach, plum (Farr *et al.* 2008)	tree bole, buried wood causing butt rot and lethal root diseases (Farr *et al.* 2008)	N
Glomerella cingulata (Stoneman) Spauld. & H. Schrenk (anam: *Colletotrichum gloeosporioides*) [Ascomycota: Glomerellaceae]	anthracnose	Y (CPCI 2008, Farr *et al.* 2008)	Y (CPCI 2008, Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Landcare NZFUNGI Database 2008, Farr *et al.* 2008)	N			N
Heterobasidion annosum (Fr.) Bref. (anam: *Spiniger meineckellum*) [Basidiomycota Russulales: Bondarzewiaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Mistaken record (Buchanan & Ryvarden 2000), N (PPIN 2008)	Y	plum (Farr *et al.* 2008)	roots and heart wood (Pegler & Waterston 1968); stumps and bases of conifers (Farr *et al.* 2008)	N
Irpex lacteus (Fr.) Fr. [Basidiomycota: Polyporales: Steccherinaceae]	stem rot	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	apricot (Shaw 1973); peach, plum (Farr *et al.* 2008)	wood (Farr *et al.* 2008); stem rot (Smolyakova 2001); fallen trunk (Dai *et al.* 2004)	N
Laetiporus sulphureus		Y (Farr *et al.*	Y (Farr *et al.*	Y (Farr *et al.*	Absent (Landcare	Y	apricot,	wood, heart rot (Farr *et al.* 2008);	N

Scientific name	Common name	WA	OR	ID	Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
(Bull.) Murrill (anam: *Sporotrichum versisporum*) [Basidiomycota Polyporales: Polyporaceae]		2008)	2008)	2008)	NZFUNGI Database 2008), N (PPIN 2008)		peach, plum (Farr *et al.* 2008)	rotten wood (Zhuang 2005)	
Lambertella jasmini Seaver, Whetzel & Dumont [Ascomycota: Helotiales: Rutstroemiaceae]		Y (AQIS 2000)	Y (Farr *et al.* 2008)	Y (AQIS 2000)	N (Landcare NZFUNGI Database 2008, Farr *et al.* 2008, N (PPIN 2008)	Y	no host association found		N
Lambertella pruni Whetzel, Zeller & Dumont [Ascomycota: Helotiales: Rutstroemiaceae]	fruit rot		Y (Farr *et al.* 2008)		N (Landcare NZFUNGI Database 2008, Farr *et al.* 2008, PPIN 2008)	Y	apricot, plum (Farr *et al.* 2008)	fruit (Farr *et al.* 2008). A post-harvest rot that affects only damaged fruit, which would be culled during harvest and processing	N
Lenzites betulinus (L.) Fr. [Basidiomycota: Polyporales: Polyporaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Landcare NZFUNGI Database 2008, Farr *et al.* 2008)	N			N
Leucostoma persoonii (Nitschke) Höhn (anam: *Cytospora leucostoma*) [Ascomycota: Diaporthales: Valsaceae]	Leucostoma canker, peach canker, cytosporosis,	Y (CPCI 2008, Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008, Landcare NZFUNGI Database 2008)	N			N

Scientific name	Common name	WA	OR	ID	Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
Maireina marginata (McAlpine) W.B. Cooke [Basidiomycota: Agaricales, Tricholomataceae]	twig blight	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)		N (Farr *et al.* 2008, PPIN 2008)	Y	peach (Farr *et al.* 2008)	dead twigs of living plants (Farr *et al.* 1989)	N
Monilinia fructicola (G. Winter) Honey (anam: *Monilia fructicola*) [Ascomycota: Helotiales: Sclerotiniaceae]	American brown rot	Y (Farr *et al.* 2008, CPCI 2008)	Y (Farr *et al.* 2008, CPCI 2008)	Y (Farr *et al.* 2008, CPCI 2008)	Y (NZ MAF 2003, Landcare NZFUNGI Database 2008, Farr *et al.* 2008)	N			N
Monilinia fructigena Honey ex Whetzel (anam: *Monilia fructigena*) [Ascomycota: Helotiales: Sclerotiniaceae]	European brown rot	N (CPCI 2008, Farr *et al.* 2008)	N (CPCI 2008, Farr *et al.* 2008)	N (CPCI 2008, Farr *et al.* 2008)	Absent (Landcare NZ Fungi Database 2008), N (PPIN 2008)	N			N
Monilinia laxa (Aderh. & Ruhland) Honey (anam: *Monilia laxa*) [Ascomycota: Helotiales: Sclerotiniaceae]	brown rot	Y (Farr *et al.* 2008, CPCI 2008)	Y (Farr *et al.* 2008, CPCI 2008)	Y (Farr *et al.* 2008, CPCI 2008)	Y (Landcare NZFUNGI Database 2008, Farr *et al.* 2008)	N			N
Mucor oudemansii Vánová [Zygomycota: Mucorales: Mucoraceae]		Y (Farr *et al.* 2008) (as *M. racemosus* Fresen.)			Absent (Landcare NZ Fungi Database 2008), N (PPIN 2008)	Y	apricot, plum, nectarine (Farr *et al.* 2008)	a post-harvest rot that affects only damaged fruit, which would be culled during harvest and processing (Farr *et al*. 2008)	N
Mucor piriformis A. Fisch. [Zygomycota: Mucorales: Mucoraceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008, CPCI 2008)		Y (Landcare NZFUNGI Database 2008)	N			N
Mucor racemosus Fresen. [Zygomycota: Mucorales: Mucoraceae]		Y (Farr *et al.* 2008)			Absent (Landcare NZ Fungi Database 2008), Y	Y	apricot, plum, nectarine (Farr *et al.*	a post-harvest rot that affects only damaged fruit, which would be culled during harvest and	N

Scientific name	Common name				Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
					(PPIN 2008)		2008)	processing	
Mycosphaerella cerasella Aderh. (anam: *Passalora circumcissa, Cercospora circumscissa*) [Ascomycota: Mycosphaerellales: Mycosphaerellaceae	cercospore leaf spot; shot hole; leaf spot			Y (Crous & Braun 2003)	Absent (Landcare NZ Fungi Database 2008) (*Passalora circumcissa*), N (PPIN 2008)	Y	apricot, peach, plum (Farr et al. 2008)	leaf spot (Gadgil 2005); shallow circular spots may also form on the fruit (Little 1987)	Y
Mycosphaerella pyri (Auersw.) Boerema (anam: *Septoria pyricola*) [Ascomycota: Mycosphaerellales: Mycosphaerellaceae]	white spot of pear	Y (Farr *et al.* 2008)			N (Landcare NZ Fungi Database 2008, PPIN 2008)	Y	see discussion	leaf spot/flecks (Farr *et al.* 2008); fruit, leaves (Farr *et al.* 1989, Sivanesan 1990)	N
Neofusicoccum arbuti (Farr & Elliott) Crous, Slippers & Phillips [Anamorphic Botryosphaeriaceae] Syn. *Fusicoccum arbuti*	canker	Y (Farr *et al.* 2008)			N (Landcare NZ Fungi Database 2008, PPIN 2008)	Y	no host association found		N
Oxyporus corticola (Fr.) Ryvarden [Basidiomycota: Hymenochaetales: Schizoporaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	peach (Farr *et al.* 2008)	saprophytic wood decay fungus (Wikstrom 1975)	N
Oxyporus similis (Bres.) Ryvarden [Basidiomycota: Hymenochaetales: Schizoporaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	N (PPIN 2008)	Y	peach (Farr *et al.* 2008)	wood decay fungus (Adaskaveg & Ogawa 1990)	N

Scientific name	Common name	WA	OR	ID	Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
Panellus stipticus (Bull.) P. Karst. [Basidiomycota: Agaricales: Mycenaceae]			Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (McKenzie *et al.* 2000, Farr *et al.* 2008)	N			
Peniophora affinis (Burt) [Basidiomycota: Russulales: Peniophoraceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	peach (Farr *et al.* 2008)	wood decay fungus (Farr *et al.* 2008)	N
Phanerochaete velutina (DC.) P. Karst. [Basidiomycota: Polyporales Phanerochaetaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	peach (Farr *et al.* 2008)	wood rot fungus (Burdsall Jr 1985)	N
Phellinus pomaceus (Pers.) Maire [Basidiomycota: Hymenochaetales: Hymenochaetaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Regulated pest (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	plum (Farr *et al.* 2008)	trunks, branches (Teng 1996); leaves, roots (CPCI 2008); limbs and trunks (Farr *et al.* 2008)	N
Phoma pomorum Thüm. [Ascomycota: Pleosporales: Leptosphaeriaceae]	apple leaf spot	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)		Y (Farr *et al.* 2008, Landcare NZFUNGI Database 2008)	N			N
Phyllosticta circumscissa Cooke [Ascomycota: incert. sedis: Botryosphaeriaceae]	leaf spot	Y (Farr *et al.* 2008)			Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	apricot, peach, plum (Farr *et al.* 2008)	leaf spot (Farr *et al.* 2008)	N
Phyllosticta virginiana (Ellis & Halst.) Ellis & Everh. [Ascomycota: Botryosphaeriales: Botryosphaeriaceae]		Y (Farr *et al.* 2008)			N (Landcare NZFUNGI Database 2008, Farr *et al.* 2008, PPIN 2008)	Y	apricot (Farr *et al.* 2008)	leaf spot (Farr *et al.* 2008)	N

Scientific name	Common name				Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Phytophthora cactorum (Lebert & Cohn) J. Schröt. [Oomycota: Pythiales: Phythiaceae]	Phytophthora root and crown rots	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008, Landcare NZFUNGI Database 2008)	N			N
Phytophthora nicotianae Breda de Haan [Oomycota: Pythiales: Phythiaceae]	Phytophthora root and crown rots	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008, Landcare NZFUNGI Database 2008)	N			N
Plicaturopsis crispa (Pers.) D.A. Reid [Basidiomycota: Polyporales: Atheliaceae]			Y (Farr *et al.* 2008)		Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	plum (Farr *et al.* 2008)	wood, dead limbs, dead trunks, twigs and branches (Farr *et al.* 2008)	N
Podosphaera clandestina (Wallr.) Lév. [Ascomycota: Erysiphales: Eysiphaceae]	powdery mildew (Jones & Sutton 1996)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Landcare NZFUNGI Database 2008)	N			N
Podosphaera leucotricha (Ellis & Everh.) E.S. Salmon [Ascomycota: Erysiphales: Eysiphaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Landcare NZFUNGI Database 2008)	N			
Podosphaera pannosa (Wallr.) de Bary (anam: *Oidium leucoconium*) [Ascomycota: Erysiphales: Erysiphaceae]	powdery mildew/ rusty spot of peach	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	N			
Podosphaera tridactyla (Wallr.) de Bary (anam:		Y (CPCI 2008)			Y (CPCI 2008, Landcare	N			N

Scientific name	Common name				Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Oidium passerinii) [Ascomycota: Erysiphales: Eysiphaceae]					NZFUNGI Database 2008)				
Polyporus brumalis (Pers.) Fr. [Basidiomycota: Polyporales: Polyporaceae]		Y (Farr *et al.* 2008)		Y (Farr *et al.* 2008)	Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	plum (Farr *et al.* 2008)	on wood (Farr *et al.* 2008)	N
Postia tephroleuca (Fr.) Jülich [Basidiomycota: Polyporales: Fomitopsidaceae]			Y (AQIS 2000)		Y (Landcare NZFUNGI Database 2008)	N			N
Pycnoporus cinnabarinus (Jacq.) P. Karst. [Basidiomycota: Polyporales: Polyporaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	mistaken record (Buchanan & Ryvarden 2000)	Y	peach (Farr *et al.* 2008)	wood rot (Farr *et al.* 2008)	N
Pythium ultimum Trow [Oomycota: Pythiales: Pythiaceae]	damping-off	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)		Y (Landcare NZFUNGI Database 2008, Farr *et al.* 2008)	N			N
Rhizopus stolonifer (Ehrenb.) Vuill. [Zygomycota: Mucorales: Mucoraceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Landcare NZFUNGI Database 2008, Farr *et al.* 2008)	N			N
Rosellinia pulveracea (Ehrenb.) Fuckel [Ascomycota: Xylariales: Xylariaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	UNCERTAIN (Landcare NZFUNGI Database 2008), N	Y	plum (Farr *et al.* 2008)	wood (Farr *et al.* 2008)	N

Scientific name	Common name				Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
					(PPIN 2008)				
Schizophyllum commune Fr. [Basidiomycota: Agaricales: Schizophyllaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Landcare NZFUNGI Database 2008, Farr *et al.* 2008)	N			N
Schizothyrium pomi (Mont. & Fr.) Arx (anam: *Zygophiala jamaicensis*) [Ascomycota: Microthyriales: Schizothyriaceae]	flyspeck	Y (Farr *et al.* 2008)		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008; Landcare NZFUNGI Database 2008 as *Leptothyrium pomi*)	N			N
Sistotrema brinkmannii (Bres.) J. Erikss. [Basidiomycota: Polyporales: Sistotremataceae]			Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	UNCERTAIN (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	peach (Farr *et al.* 2008)	usually on wood, sometimes on plant debris and basidiomata (Farr *et al.* 2008)	N
Steccherinum ochraceum (Pers.) Gray [Basidiomycota: Polyporales: Steccherinaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Uncertain (Landcare NZFUNGI Database 2008)	Y	peach (*Farr et al.* 2008)	on wood, usually of hardwoods (Farr *et al.* 2008)	N
Stigmina carpophila (Lév.) M.B. Ellis [Dothideales: incertae sedis]	gumspot	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Landcare NZFUNGI Database 2008)	N			N
Taphrina communis (Sadeb.) Giesenh. [Ascomycota: Taphrinales: Taphrinaceae]	plum pockets	Y (Farr *et al.* 2008)			Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	apricot, plum (Farr *et al.* 2008)	leaves, stems and fruit. Symptoms on fruit are obvious, including distortion and enlargement, with spongy or hollow cankers, with or without pits (Ogawa *et al.* 1995)	Y

Scientific name	Common name	WA	OR	ID	Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
Taphrina deformans (Berk.) Tul. [Ascomycota: Taphrinales: Taphrinaceae]	peach leaf curl	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Landcare NZFUNGI Database 2008)	N			N
Taphrina pruni (Fuckel) Tul. [Ascomycota: Taphrinales: Taphrinaceae]	plum pockets (Jones & Sutton 1996)	Y (Farr *et al.* 2008)			Y (Landcare NZFUNGI Database 2008)	N			N
Taphrina pruni-subcordatae (Zeller) Mix [Ascomycota: Taphrinales: Taphrinaceae]			Y (Farr *et al.* 2008)		N (PPIN 2008)	Y	plum (Farr *et al.* 2008)	witches' broom and leaf curl (Heinis 1960)	N
Trametes hirsuta (Wulfen) Pilát [Basidiomycota: Polyporales: Polyporaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Landcare NZFUNGI Database 2008)	N			N
Trametes velutina (Pers.) G. Cunn. [Basidiomycota: Polyporales: Polyporaceae]		Y (Farr *et al.* 2008, as *pubescens*)	Y (Farr *et al.* 2008, as *pubescens*)	Y (Farr *et al.* 2008, as *pubescens*)	Y (Landcare NZFUNGI Database 2008)	N			N
Trametes versicolor (L.) Pilát [Basidiomycota: Polyporales: Polyporaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Landcare NZFUNGI Database 2008)	N			N
Trichaptum biforme (Fr.) Ryvarden [Basidiomycota: Polyporales: Polyporaceae]	white rot	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	peach (Farr *et al.* 2008)	wood decay fungus (Adaskaveg *et al.* 1993); wood (Fukasawa *et al.* 2005)	N

Scientific name	Common name				Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
Tyromyces chioneus (Fr.) P. Karst. [Basidiomycota: Polyporales: Polyporaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	N, previous record based on misidentification (Buchanan & Ryvarden 2000), N (PPIN 2008)	Y	peach (Farr *et al.* 2008)	wood (Farr *et al.* 2008)	N
Tyromyces galactinus (Berk.) Bondartsev ex Lowe [Basidiomycota: Polyporales: Polyporaceae]			Y (Farr *et al.* 2008)		Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	plum (Farr *et al.* 2008	wood (Farr *et al.* 2008); on hardwoods (Ogawa *et al.* 1995)	N
Valsaria insitiva (Tode) Ces. & De Not. (anam: *Cytospora cincta*) [Ascomycota: Diaporthales: Valsaceae]	perennial canker of peach; canker; dieback		Y (Farr *et al.* 2008)		Absent (Landcare NZFUNGI Database 2008), N (PPIN 2008)	Y	peach, plum (Farr *et al.* 2008)	twig necrosis and dieback (Farr *et al.* 2008); causes cankers on trunk, branch crotches, scaffold limbs and older branches. Branch or twig infections may produce leaf symptoms during growing season (Ogawa *et al.* 1995)	N
Venturia carpophila E.E. Fisher (anam: *Fusicladium carpophilum*) [Ascomycota: Dothideales: Venturiaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)		Y (Landcare NZFUNGI Database 2008)	N			N
Verticillium albo-atrum Reinke & Berthier 1879 [Ascomycetes: Hypocreales: Hypocreaceae]		Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	Y (Farr *et al.* 2008)	N			N
Verticillium dahliae Kleb.	Verticillium	Y (CPCI	Y (CPCI	Y (CPCI	Y (CPCI 2008,	N			N

Scientific name	Common name	WA	OR	ID	Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
1913 [Hypocreales: Hypocreaceae]	wilt	2008)	2008)	2008)	Landcare NZFUNGI Database 2008)				
Phytoplasmas									
peach X-disease phytoplasma [Bacteria: Firmicutes: Mollicutes: Acholeplasmatales: Acholeplasmataceae] Note: *Candidatus Phytoplasma pruni* is the suggested scientific name for this disease, but this is not yet formally recognised (Constable & Gibb 2007)	peach X-disease, Eastern peach X disease Western X-disease phytoplasma	Y (CPCI 2008)	Y (CPCI 2008)		N (Pearson *et al.* 2006, CPCI 2008, PPIN 2008)	Y	apricot, peach, plum (CPCI 2008); nectarine (Welliver 1999)	not known to be transmitted by seed or pollen (Welliver 1999); spread is by phloem-feeding vectors and by budding and grafting (Ogawa *et al.* 1995, Welliver 1999); transmitted by grafting, and mainly by the vectors *Scaphytopius acutus*, *Colladonus montanus* and *Praphlepsius irroratus* (Diekmann & Putter 1996)	N
Candidatus Phytoplasma prunorum Seemüller & Schneider, 2004 [Bacteria: Firmicutes: Mollicutes: Acholeplasmatales: Acholeplasmataceae]	apricot chlorotic leaf roll, European stonefruit yellows, plum leptonecrosis	Not recorded from the USA (CPCI 2008; Diekmann & Putter 1996; Seemüller & Schneider 2004)			N (Pearson *et al.* 2006, Diekmann & Putter 1996, PPIN 2008; Seemüller & Schneider 2004	N			N
Viruses and viroids									
Apple chlorotic leaf spot virus (Flexiviridae) ICTVdB code		probably (Lister 1987)	Y (CPCI 2008)	probably (Lister 1987)	Y (Pennycook 1989, Pearson *et al.* 2006)	N			N

Scientific name	Common name				Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
00.056.0.08.001									
Apple mosaic virus (Bromoviridae) ICTVdB code 00.010.0.02.003		Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	Y (Pearson *et al.* 2006, CPCI 2008)	N			N
Apple stem pitting virus (ungrouped) ICTVdB code 00.056.0.05.001		USA (CPCI 2008)			Y (Pearson *et al.* 2006, CPCI 2008)	N			N
Apricot ring pox		Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	N (Pearson *et al.* 2006, CPCI 2008, PPIN 2008)	Y	apricot (Ogawa *et al*. 1995)	leaves, fruit (Ogawa *et al.* 1995)	Y
[Peach] asteroid spot virus		Western USA (Ogawa *et al.* 1995)			N (Pearson *et al.* 2006, PPIN 2008)	Y	many stone fruits (Ogawa *et al.* 1995)	causes deformed fruit, leaf spots and discolouration. Transmissible by budding and grafting, seed transmission is not known (Ogawa *et al.* 1995)	N
Cherry mottle leaf virus ICTVdB code 00.056.0.08.004		Y (Ogawa *et al.* 1995)	Y (Ogawa *et al.* 1995)	Y (Ogawa *et al.* 1995)	N (Pearson *et al.* 2006, PPIN 2008)	Y	apricot, peach, plum (Ogawa *et al.* 1995)	leaves (Ogawa *et al.* 1995); transmitted by grafting and by peach bud mite, *Eriophyes inaequalis* (Davidson Jr *et al.* 1994), which is not recorded from NZ	N
Cherry rasp leaf nepovirus ICTVdB code 00.111.0.01.001		Y (CPCI 2008, EPPO/CABI 2008)	Y (CPCI 2008, EPPO/CABI 2008)	Y (CPCI 2008, EPPO/CABI 2008)	Unconfirmed (Pearson *et al*. 2006); Central Otago only (McLaren *et al.* 1999)	Y	peach (Ogawa *et al.* 1995, Diekmann & Putter 1996, CPCI 2008)	liable to carried internally by fruit in trade/transport (CPCI 2008)	Y
Cherry rusty mottle (American and European)		Y (*Ogawa et al.* 1995, CPCI 2008)	Y (*Ogawa et al.* 1995, CPCI 2008)	Y (*Ogawa et al.* 1995, CPCI 2008)	Y (CPCI 2008)	N			N
Peach latent mosaic	peach	Y (CPCI	Y (CPCI		as peach calico	Y	peach (major	no records of disease transmission	N

Scientific name	Common name	WA	OR	ID	Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
viroid (Avsunviroidae)	calico, peach blotch (Malfitano *et al.* 2003)	2008, Singh *et al.* 2003)	2008, Singh *et al.* 2003)		(McLaren *et al.* 1999, Pearson *et al.* 2006). Taxonomy uncertain, so proceed, N (PPIN 2008)		host), apricot, plum (minor) (Hadidi *et al.* 2003)	from fruit including seed (Poole *et al.* 2003); not transmitted by seed in peach (Barba *et al*. 2007)	
Peach mosaic virus (Flexiviridae)		California (Ogawa *et al.* 1995, CPCI 2008); no evidence of presence in PNW			N (CPCI 2008, Pearson *et al.* 2006, PPIN 2008)	Y	apricot, peach, plum, nectarine (Ogawa *et al.* 1995)	vectored by peach bud mite (*Eriophyes insidiosus*), which feeds within the buds. Fruit can be deformed and unmarketable (Ogawa *et al.* 1995). No evidence of seed transmission	N
Peach stubby twig virus/agent			Y (Ogawa *et al.* 1995)		N (Pearson *et al.* 2006, PPIN 2008)	Y	peach, nectarine (Ogawa et al. 1995)	causes chlorotic and deformed leaves, thick twigs, bud failure and small fruit. Transmitted by budding and grafting (Ogawa *et al.* 1995), but no evidence of seed transmission	N
Peach mule's ear Almond bud failure		Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008, Pennycook 1989, Pearson *et al.* 2006)	N			N
Peach wart virus		Y (Ogawa *et al.* 1995)	Y (Ogawa *et al.* 1995)	(Ogawa *et al.* 1995)	N (CPCI 2008, Pearson *et al.* 2006, PPIN 2008)	Y	peach (Ogawa *et al.* 1995, CPCI 2008))	transmitted by grafting and budding and not seedborne but can be experimentally transmitted to other *Prunus* cultivars (Ogawa *et al.* 1995)	N
Plum American line pattern virus (=American plum line pattern virus)		Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008)	Y (CPCI 2008, restricted); Y (Pennycook 1989,	Y	apricot, peach, plum, nectarine	affects leaves, fruit not known to carry the pest in trade (CPCI 2008); not seed-borne (EPPO/CABI 1997a)	N

Scientific name	Common name				Present in New Zealand	Continue	Associated with Prunus spp (ref)	Plant part association	Potential hazard
		WA	OR	ID					
(Bromoviridae) ICTVdB code 00.010.0.02.002					Pearson *et al.* 2006), N (PPIN 2008)		(Pennycook 1989)		
Plum pox virus (Potyviridae) ICTVdB code 00.057.0.01.054 (Prunus virus 7, Sarka virus, Sharka virus)		See assessment			See assessment	Y	See assessment		N
Prune dwarf virus (Bromoviridae) ICTVdB code 00.010.0.02.014					Y (CPCI 2008, Pearson *et al.* 2006)	N			N
Prune [*Prunus*] diamond canker agent		CA (Ogawa *et al*. 1995), no evidence of presence in PNW			N (Ogawa *et al.* 1995, Pearson *et al.* 2006, PPIN 2008)	N			N
Prunus necrotic ringspot virus (Bromoviridae) ICTVdB code 00.010.0.02.015		Y (Fulton 1985, CPCI 2008)	Y (Fulton 1985, CPCI 2008)	Y (Fulton 1985, CPCI 2008)	Y (Pennycook 1989, Pearson *et al.* 2006, CPCI 2008)	N			N
Tomato ringspot nepovirus (Comoviridae) ICTVdB code 00.018.0.03.029		Y (CPCI 2008)	Y (CPCI 2008)		few occurrences (CPCI 2008), Y (Pearson *et al.* 2006), N (PPIN 2008)	Y	peach (Stace-Smith 1987)	seedborne in several weed hosts (Ogawa *et al.* 1995), but seed transmission in *Prunus* spp. is not known. Natural spread of this virus in orchards and nurseries results directly from transmission by nematode vectors	N

[1] Pathogen classification generally follows that used by Mycobank. The classification given is: (Phylum: Order: Family)
[2]N: not listed in this geographical area by (or no entry in) this database/publication, not that the organism is necessarily stated to be absent.

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Appendix 3: Exclusions

The following species were originally considered due to their inclusion on various pest lists, but they have been removed from this analysis due to lack of evidence of their presence in Pacific Northwest

Eriophyes insidiosus (Keifer & Wilson) (Acari: Eriophyidae)
Tarsonemus smithi Ewing (Acari: Tarsonemidae)
Oligonychus mangiferus (Rahman and Punjab) (Acari: Tetranychidae)
Lorryia mali (Oudemans) (Acari: Tydeidae)
Tricholochmaea (=*Pyrrhalta*) *cavicollis* (LaConte) (Coleoptera: Chrysomelidae)
Amotus setulosus (Schönherr) (Coleoptera: Curculionidae)
Anametis granulata (Say) (Coleoptera: Curculionidae)
Cercopeus artemisiae (Pierce) (Coleoptera: Curculionidae)
Cleonidius canescens (LeConte) (Coleoptera: Curculionidae)
Conotrachelus anaglypticus (Say) (Coleoptera: Curculionidae)
Dyslobus luteus (Horn) (Coleoptera: Curculionidae)
Epicaerus imbricatus (Say) (Coleoptera: Curculionidae)
Omileus epicaeroides Horn (Coleoptera: Curculionidae)
Otiorhynchus ligneus (Olivier) (Coleoptera: Curculionidae)
Polydrusus impressifrons (Gyllenhal) (Coleoptera: Curculionidae)
Cotinis mutabilis Gory & Percheron (Coleoptera: Scarabaeidae)
Cotinis nitida (L.) (Coleoptera: Scarabaeidae)
Macrodactylus subspinosus (F.) (Coleoptera: Scarabaeidae)
Phytomyza persicae Frick (Diptera: Agromyzidae)
Atherigona orientalis Schiner (Diptera: Muscidae)
Anastrepha daciformis Bezzi (Diptera: Tephritidae)
Anastrepha fraterculus (Wiedemann) (Diptera: Tephritidae)
Anastrepha ludens (Loew) (Diptera: Tephritidae)
Anastrepha minensis Lima (Diptera: Tephritidae)
Anastrepha serpentina (Wiede.) (Diptera: Tephritidae)
Anastrepha striata Schiner (Diptera: Tephritidae)
Anastrepha suspensa (Loew) (Diptera: Tephritidae)
Anastrepha turicai Blanchard (Diptera: Tephritidae)
Bactrocera dorsalis (Hendel) (Diptera: Tephritidae)
Bactrocera duplicata (Bezzi) (Diptera: Tephritidae)
Bactrocera kraussi (Hardy) (Diptera: Tephritidae)
Bactrocera tryoni (Froggatt) (Diptera: Tephritidae)
Bactrocera zonata (Saunders) (Diptera: Tephritidae)
Dirioxa pornia (Walker) (Diptera: Tephritidae)
Rhagoletis cingulata (Loew) (Diptera: Tephritidae)
Rhagoletis suavis (Loew) (Diptera: Tephritidae)
Aleurodicus dispersus Russell (Hemiptera: Aleyrodidae)
Parabemisia myricae (Kuwana) (Hemiptera: Aleyrodidae)
Trialeurodes packardi (Morrill) (Hemiptera: Aleyrodidae)
Brachycaudus schwartzi (Börner) (Hemiptera: Aphididae)
Erasmoneura variabilis (Beamer) (Hemiptera: Cicadellidae)
Homalodisca insolita (Walker) (Hemiptera: Cicadellidae)
Norvellina seminuda (Say) (Hemiptera: Cicadellidae)
Paraphlepsius irroratus (Say) (Hemiptera: Cicadellidae)
Magicicada septendecim (L.) (Hemiptera: Cicadidae)
Eulecanium cerasorum (Cockerell) (Hemiptera: Coccidae)
Eulecanium kunoense (Kuwana) (Hemiptera: Coccidae)

Mesolecanium nigrofasciatum (Pergande) (Hemiptera: Coccidae)
Parthenolecanium pruinosum (Coquillett) (Hemiptera: Coccidae)
Protopulvinaria pyriformis (Cockerell) (Hemiptera: Coccidae)
Sphaerolecanium prunastri (Boyer de Fonscolombe) (Hemiptera: Coccidae)
Acanthocephala femorata (F.) (Hemiptera: Coreidae)
Aonidiella citrina (Coquillett) (Hemiptera: Diaspididae)
Clavaspis disclusa Ferris (Hemiptera: Diaspididae)
Epidiaspis leperii (Signoret) (Hemiptera: Diaspididae)
Melanaspis obscura (Comstock) (Hemiptera: Diaspididae)
Mercetaspis halli (Green) (Hemiptera: Diaspididae)
Neopinnaspis harperi McKenzie (Hemiptera: Diaspididae)
Parlatoria oleae (Colvee) (Hemiptera: Diaspididae)
Parlatoria theae Cockerell (Hemiptera: Diaspididae)
Pseudaonidia duplex (Cockerell) (Hemiptera: Diaspididae)
Euschistus servus (Say) (Hemiptera: Pentatomidae)
Phenacoccus gossypii Townsend & Cockerell (Hemiptera: Pseudococcidae)
Phenacoccus madeirensis Green (Hemiptera: Pseudococcidae)
Pseudococcus comstocki (Kuwana) (Hemiptera: Pseudococcidae)
Cacopsylla pruni (Scopoli) (Hemiptera: Psyllidae)
Choreutis pariana (Clerck) (Lepidoptera: Choreutidae)
Alsophila pometaria (Harris) (Lepidoptera: Geometridae)
Paleacrita vernata (Peck) (Lepidoptera: Geometridae)
Phyllonorycter crataegella (Clemens) (Lepidoptera: Gracillariidae)
Malacosoma americanum F. (Lepidoptera: Lasiocampidae)
Euproctis chrysorrhoea (L.) (Lepidoptera: Lymantriidae)
Spodoptera frugiperda (J.E. Smith) (Lepidoptera: Noctuiidae)
Euzophera semifuneralis (Walker) (Lepidoptera: Pyralidae)
Coleophora sacramenta (Heinrich) (Lepidoptera: Sesiidae)
Synanthedon pictipes (Grote and Robinson) (Lepidoptera: Sesiidae)
Acleris minuta (Robinson) (Lepidoptera: Tortricidae)
Argyrotaenia velutinana (Walker) (Lepidoptera: Tortricidae)
Microcentrum retinerve (Burmeister) (Orthoptera: Tettigioniidae)
Thrips hawaiiensis (Morgan) (Thysanoptera: Thripidae)
Thrips imaginis Bagnall (Thysanoptera: Thripidae)
Ganoderma brownii (Murrill) Gilb. 1961 (Basidiomycota: Polyporales: Ganodermataceae)
Gilbertella persicaria (E.D. Eddy) Hesselt. 1960 (Zygomycota: Mucorales: Gilbertella)
Issatchenkia scutulata (Phaff, M.W. Mill. & M. Miranda) Kurtzman, M.J. Smiley & C.J. Johnson 1980 (Ascomycota: Saccharomycetales: Saccharomycetaceae)
Kloeckera apiculata (Reess) Janke 1923 (Anamorphic fungi)
Phanerochaete arizonica Burds. & Gilb. 1974 (Basidiomycota: Polyporales Phanerochaetaceae)

Appendix 4: Vector analysis

The following species are present in the Pacific Northwest and associated with the fruit of stonefruit. They are also recorded from New Zealand, but are considered here because they are known vectors of various pathogens.

1. *Aculus fockeui*
2. *Aphis gossypii*
3. *Aphis spiraecola*
4. *Brachycaudus helichrysi*
5. *Macrosiphum euphorbiae*
6. *Myzus persicae*
7. *Pseudococcus longispinus*
8. *Frankliniella intonsa*
9. *Frankliniella occidentalis*
10. *Thrips tabaci*

1. *Aculus fockeui* Nalepa & Trouessart, 1891 (Acari: Eriophyidae)

Common name/s: plum rust mite, peach silver mite
Other scientific names: *Aculus cornutus* (synonymy Oldfield 1984), *Phyllocoptes cornutus*, *P. fockeui*, *Vasates cornutus*, *V. fockeui*

PNW status

Recorded from Washington (Oldfield 1984)

New Zealand status

Present (recorded by Manson 1984b), but regulated as a vector.

General geographical distribution

China, Japan, Lebanon, central and eastern Europe, Africa, Canada, the USA (including California).

Hosts

Prunus species CPCI (2008), peach, plum and nectarine (Manson 1984b, Beers *et al.* 1993)

Plant parts affected

Diapausing females overwinter in buds or in crevices of twigs and bark, other stages feed on leaves (Beers *et al.* 1993). Though no published association with fruit has been found, this species has been intercepted on fresh nectarines from the USA (Quancargo database, Consignment C2003/34762, as "*Arculus cornulus*").

Vectored organisms

Aculus fockeui is known to vector plum pox virus (Jeppson *et al.* 1975, Isac *et al.* 1998).

Hazard identification conclusion

Since plum pox virus is not present in the Pacific Northwest, *A. fockeui* is not considered to be a potential hazard at this time. Should PPV become established in the Pacific Northwest, measures should be taken against this species on imported stonefruit.

2. *Aphis gossypii* Glover, 1877 (Hemiptera: Aphididae)

Common name/s: cotton aphid, melon aphid
Other scientific names: *Aphis bauhiniae, A. circezandis, A. citri, A. citrulli, A. cucumeris, A. cucurbiti, A. lilicola, A. minuta, A. monardae, A. parvus, A. tectonae, Cerosipha gossypii, Doralina frangulae, D. gossypii, Doralis frangulae, D. gossypii, Toxoptera leonuri*

PNW status

Recorded from Washington, Oregon and Idaho (CPCI 2008)

New Zealand status

Present (recorded by Charles 1998, Teulon *et al.* 2004, PPIN 2008), but regulated as a vector

Hosts

Melon aphid is extremely polyphagous, and its hosts include apricot, peach (CPCI 2008) and plum (Blackman & Eastop 2000).

Plant parts affected

A. gossypii will attack most parts of the plant if population density is high enough. Exceptions include direct feeding on mature reproductive structures (fruits, berries, nuts) and feeding on roots (CPCI 2008). However CPCI (2008) also states that plant parts liable to carry the pest in trade/transport include fruits, and that nymphs and adults are borne externally and visible under light microscope. *Aphis gossypii* has been intercepted at the border on a consignment of fresh plums from the USA (Quancargo database, Consignment C2005/182489 3), indicating its potential to be present on the fresh stonefruit pathway. Most interceptions of this species are on leaves, particularly taro, and other commodities include zucchini, dill, grapes, strawberry, watermelon, broccoli, rosella leaves, cow pea, pigeon pea, thyme, asparagus and orange (Quancargo database 2008).

Vectored viruses

The most important impact melon aphid has on world agriculture is through its ability to transmit plant viruses (CPCI 2008). It is known to transmit over 50 non-persistent and persistent viruses: Alfalfa mosaic virus, Arracacha Y potyvirus, Bean common mosaic virus, Beet western yellows virus, *Canavalia maritima* mosaic virus, Carnation mottle virus, Cauliflower mosaic virus, Celery mosaic virus, Chickpea distortion mosaic virus, Chinese yam necrotic mosaic virus, Citrus enation - woody gall virus, Citrus tristeza virus, *Commelina* mosaic virus, Cotton anthocyanosis virus, Cowpea (aphid-borne) mosaic virus, Cucumber mosaic virus, Dasheen mosaic virus, *Datura* distortion mosaic virus, *Dioscorea trifida* potyvirus, Garlic mosaic virus, Hippeastrum mosaic potyvirus, Iris mild mosaic virus, Johnsongrass mosaic virus, Lettuce mosaic virus, Lily symptomless virus, Muskmelon yellow stunt virus, *Narcissus* latent virus, Onion yellow dwarf virus, Papaya ringspot virus, Papaya ringspot virus W (=Watermelon mosaic virus 1), *Passiflora* ringspot virus, Passionfruit Sri Lankan mottle virus, Passionfruit woodiness potyvirus, Pea enation mosaic virus, Peanut mottle virus, Pepper Indian mottle virus, Pepper veinal mottle virus, Potato leafroll virus, Potato virus Y, Sri Lankan passionfruit mottle virus, Strawberry mottle virus, Strawberry pseudo mild yellow edge virus, Subterranean clover stunt virus, Sugarcane mosaic virus, Sunflower yellow blotch virus, Sweet potato feathery mottle virus, Swordbean distortion mosaic virus, Tobacco ringspot virus, *Trichosanthes* mottle virus, Tulip breaking virus, Turnip mosaic virus, Vanilla necrosis virus, Watermelon mosaic virus 2, Yam mosaic virus, Zucchini yellow mosaic virus (Sources: Brunt *et al*. 2007, CPCI 2008).

Hazard identification conclusion

None of the viruses vectored by *Aphis gossypii* are known to affect any *Prunus* species except plum pox virus (Brunt *et al*. 2007, CPCI 2008). Since plum pox virus is not present in the Pacific Northwest, *A. gossypii* is not considered to be a potential hazard at this time. Should PPV become established in the Pacific Northwest, measures should be taken against this species on imported stonefruit.

3. *Aphis spiraecola* Patch, 1914 (Hemiptera: Aphididae)

Common name/s: spirea aphid

Other scientific names: *Anuraphis erratica*, *Aphis bidentis*, *A. citricola*, *A. croomiae*, *A. deutziae*, *A. malvoides*, *A. mitsubae*, *A. nigricauda*, *A. pirifoliae*, *A. pseudopomi*, *A. virburnicolens*

PNW status

Recorded from Washington, Oregon and Idaho (CPCI 2008)

New Zealand status

Present (recorded by Teulon *et al.* 2004), but regulated as a vector

Hosts

This species is very polyphagous with hosts in over 20 families (Blackman & Eastop 2000). Stonefruit hosts include apricot and peach (CPCI 2008) and plum (Blackman & Eastop 2000).

Plant parts affected

Fruits/pods (CPCI 2008). CPCI (2008) states that "the movement of fruits and ornamental plants carries the risk of transporting this aphid to new geographic areas", but also states that fruits/pods are "not known to carry the pest in trade/transport", thus the commodity association is unclear. Blackman and Eastop (2000) only record the spirea aphid from leaves near stem apices and flower heads.

Vectored viruses

A. spiraecola transmits Araujia mosaic potyvirus, chilli veinal mottle virus, citrus tristeza virus, cucumber mosaic virus, papaya ringspot virus, Passiflora ringspot virus, peanut stunt cucumovirus, pepper veinal mottle virus, plum pox virus, potato Y virus, viburnum strain of alfalfa mosaic virus, water melon mosaic 2 virus and zucchini yellow mosaic virus (Sources: Brunt *et al*. 2007, Blackman & Eastop 2000).

Hazard identification conclusion

Although a number of the viruses vectored by *A. spiraecola* are not recorded from New Zealand, none are known to affect apricot, peach, plum or nectarine (Brunt *et al*. 2007). The only virus vectored by *A. spiraecola* known to affect stonefruit is plum pox virus (Brunt *et al*. 2007, CPCI 2008), and this is not present in the Pacific Northwest. Therefore *Aphis spiraecola* is not considered to be a potential hazard at this time. Should PPV become established in the Pacific Northwest, measures should be taken against this species on imported stonefruit.

4. *Brachycaudus helichrysi* (Kaltenbach, 1843) (Hemiptera: Aphididae)

Common name/s: leaf-curling plum aphid

Other scientific names: *Acaudus bipapillatus*, *Anuraphis abrotaniella*, *A. ammobii*, *A. brevisiphon*, *A. cardi*, *A. cardui*, *A. centauriella*, *A. cinerariae*, *A. cyani*, *A. fasciatus*, *A. filaginis*, *A. flavescens*, *A. glaucifolia*, *A. helichrysi*, *A.insititiella*, *A. marutae*, *A. menthaecola*, *A. mumecola*, *A. poae*, *A. pruni*, *A. pruniavium*, *A. sherardiae*, *Aphis adjecta*, *A. adscita*, *A. apposite*, *A. bartsiae*, *A. bellis*, *A. cardui*, *A. chrysanthemi*, *A. consumpta*, *A. convecta*, *A. conviva*, *A. detracta*, *A. diminuta*, *A. familiaris*, *A. helichrysi*, *A. incumbens*, *A. insessa*, *A. insititiae*, *A. leontopodii*, *A. marutae*, *A. myosotidis*, *A. nociva*, A. *persorbens*, *A. petasitidis*, *A. prunina*, *A. prunus*, *A. senecio*, *A. similis*, *A. socia*, *Brachycaudus cardi*, *B. tianshanicus*, *Siphocoryne cacaliae*

PNW status

Recorded from Washington (Baker 1920) and Idaho (CPCI 2008, Helton & Portman 1965)

New Zealand status

Present (recorded by Cameron *et al.* 1992, Charles 1998, Teulon *et al.* 2004, PPIN 2008) but regulated as a vector

Hosts

Brachycaudus helichrysi is extremely polyphagous (CPCI 2008). It has been recorded from plum and peach (Blackman & Eastop 2000).

Plant parts affected

Fruits/pods, growing points, leaves and whole plant (CPCI 2008). *B. helichrysi* has been intercepted on fruit (*Malus pumila*) from the USA (Townsend 1984), indicating that this species has the potential to be present on the fresh produce pathway.

Vectored viruses

Brachycaudus helichrysi is known to vector the following viruses: beet mild yellowing virus, beet western yellows virus, cucumber mosaic virus, dahlia mosaic virus, plum pox virus and potato V potyvirus (Brunt *et al*. 2007, CPCI 2008).

Hazard identification conclusion

None of the viruses vectored by *Brachycaudus helichrysi* are known to affect any *Prunus* species except plum pox virus (Brunt *et al*. 2007, CPCI 2008). Since plum pox virus is not present in the Pacific Northwest, *B. helichrysi* is not considered to be a potential hazard at this time. Should PPV become established in the Pacific Northwest, measures should be taken against this species on imported stonefruit.

5. *Macrosiphum euphorbiae* (Thomas, 1878) (Hemiptera: Aphididae)

Common name/s: potato aphid
Other scientific names: *Illinoia solanifolii*, *Macrosiphon euphorbiae*, *M.solanifolii*, *Macrosiphum amygdaloides*, *M. cyprissiae*, *M. euphorbiellum*, *M. koehleri*, *M. rosaeollae*, *M. solanifolii*, *M. tabaci*, *Nectarophora ascepiadis*, *N. heleniella*, *N. lycopersici*, *N. tabaci*, *Siphonophora asclepiadifolii*, *S. cucurbitae*, *S. euphorbiae*, *S. solanifolii*, *S. tulipae*

PNW status

Recorded from Washington, Oregon and Idaho (CPCI 2008)

New Zealand status

Present (recorded by Teulon *et al.* 2004, CPCI 2008, PPIN 12 March 2008), but regulated as a vector

Hosts

Primary hosts are *Rosa* species but potato aphid is highly polyphagous on secondary hosts, feeding on over 200 plant species (Blackman and Eastop 2000). Peach is a host (Stoetzel & Miller 1998). Nymphs and adults can potentially be dispersed on foliage, stems or fruits (especially with leaves attached) in trade; they are borne externally and are visible to naked eye (CPCI 2008).

Vectored viruses

M. euphorbiae is a vector of over 67 plant viruses, although transmission is usually non-persistent (CPCI 2008). The following viruses are recorded by Brunt *et al.* (1996) as vectored by *M. euphorbia*: *Alstroemeria* streak virus, bean leaf roll, bean yellow mosaic virus, Beet mild yellowing virus, beet western yellows virus, beet yellow net, beet yellow stunt closterovirus, beet yellows virus, bean common mosaic potyvirus (=Blackeye cowpea mosaic virus), broad bean wilt fabavirus, broad bean wilt virus, chrysantheum virus B, clover yellow vein potyvirus, Cocksfoot streak virus, cucumber mosaic virus, dahlia mosaic caulimovirus, Freesia mosaic potyvirus, Henbane mosaic potyvirus, Hop mosaic carlavirus, Iris fulva mosaic potyvirus, Iris mild mosaic potyvirus, Iris severe mosaic potyvirus, Lettuce mosaic virus, Pea enation mosaic, Pepper severe mosaic potyvirus, Potato leaf roll virus, Potato M carlavirus, Potato Y potyvirus, Subterranean clover red leaf luteovirus, Subterranean clover stunt nanavirus, Tulip breaking virus, Watermelon mosaic 1 potyvirus, Zucchini yellow mosaic virus.

Hazard identification conclusion

Although a number of these viruses are not recorded from New Zealand, none are known to affect apricot, peach, plum or nectarine (Brunt *et al*. 2007, CPCI 2008). Therefore *M. euphorbiae* is not considered to be a potential hazard in this analysis.

6. *Myzus persicae* (Sulzer, 1776) (Hemiptera: Aphididae)

Common name/s: green peach aphid
Other scientific names: *Aphis convolvuli*, *A. cynoglossi*, *A. derelicta*, *A. dianthi*, *A. dubia*, *A. egressa*, *A. malvae*, *A. persicae*, *A. persiciphila*, *A. persola*, *A. rapae*, *A. redundans*, *A. suffragans*, *A. tuberoscellae*, *A. vastator*, *A. vulgaris*, *Aulacorthum convolvuli*, *Myzodes persicae*, *M. tabaci*, *M. persicae*, *Myzus dianthi*, *M. malvae*, *M. nicotianae*, *M. pergandei*, *M. persicae* var. *sanguisorbella*, *M. persicae* var. *cerastii*, *Nectarosiphon persicae*, *Phorodon cynoglossi*, *P. persicae*, *Rhopalosiphum betae*, *R. calthae*, *R. dianthi*, *R. lactucellum*, *R. persicae*, *R. solani*, *R. tuberosellae*, *R. tulipae*, *Siphonophora achyrantes*, *S. nasturtii*

PNW status

Recorded from Washington, Oregon and Idaho (CPCI 2008)

New Zealand status

Present (recorded by Charles 1998; Teulon *et al.* 2004, PPIN 2008) but regulated as a vector

Hosts

The primary host of green peach aphid is peach, including nectarine; secondary hosts are in over 40 different families (Blackman & Eastop 2000) and include apricot and other stonefruit (CPCI 2008). Plant parts affected are growing points, inflorescence, leaves, stems and whole plant (CPCI 2008), but the species has been recorded feeding directly on young nectarine fruit (Beers *et al*. 1993).

Vectored viruses

Green peach aphid is the most important aphid virus vector. It has been shown to transmit well over 100 plant virus diseases, in about 30 different families, including many major crops (CPCI 2008). Viruses transmitted by green peach aphid include: alfalfa mosaic alfamovirus, amaranthus leaf mottle potyvirus, Amazon lily mosaic virus, Anthoxanthum mosaic virus, Araujia mosaic potyvirus, Arracacha Y potyvirus, artichoke latent potyvirus, asparagus 1 potyvirus, barley yellow dwarf luteovirus, bean common mosaic potyvirus, bean leaf roll luteovirus, bean yellow mosaic potyvirus, bean yellow vein banding umbravirus, beet mild yellowing luteovirus, beet mosaic potyvirus, beet western yellows luteovirus, beet western yellows ST9-associated RNA virus, beet yellow stunt closterovirus, beet yellows closterovirus, Bidens mosaic potyvirus, Canavalia maritima mosaic virus, carnation etched ring caulimovirus, carnation latent carlavirus, carrot mosaic virus, Carrot thin leaf potyvirus, Cassia yellow spot potyvirus, cauliflower mosaic caulimovirus, celery mosaic potyvirus, chickpea distortion mosaic potyvirus, chickpea filiform virus, chilli veinal mottle virus, chinese yam necrotic mosaic virus, chrysanthemum B carlavirus, clover yellow vein potyvirus, cocksfoot streak virus, cole latent virus, coriander feathery red vein nucleorhabdovirus, cowpea Moroccan aphid-borne mosaic potyvirus, cowpea rugose mosaic potyvirus, cucumber mosaic cucumovirus, dahlia mosaic caulimovirus, dandelion latent carlavirus, dandelion yellow mosaic sequivirus, daphne S virus, dasheen mosaic potyvirus, Datura distortion mosaic potyvirus, Datura mosaic virus, Desmodium mosaic potyvirus, Dioscorea green banding mosaic potyvirus, eggplant severe mottle virus, elderberry carlavirus, endive necrotic mosaic virus, fig virus, Habenaria mosaic virus, Helenium S carlavirus, henbane mosaic potyvirus, Hippeastrum mosaic potyvirus, Hop mosaic carlavirus, Horseradish latent caulimovirus, Hyacinth mosaic potyvirus, Iris fulva mosaic potyvirus, Iris mild mosaic potyvirus, Iris severe mosaic potyvirus, Lamium mild mottle fabavirus, Launaea mosaic virus, Lettuce mosaic potyvirus, Lettuce speckles mottle umbravirus, Maclura mosaic macluravirus, Malva vein clearing potyvirus, Marigold mottle potyvirus, Melothria mottle virus, Narcissus latent macluravirus, Nasturtium mosaic virus, Papaya ringspot potyvirus, Parsley green mottle virus, Parsnip mosaic potyvirus, Passionfruit Sri Lankan mottle virus, Passionfruit woodiness potyvirus, Patchouli mosaic potyvirus, Pea enation mosaic enamovirus, Pea mosaic potyvirus, Peanut mottle potyvirus, Peanut stunt cucumovirus, Pepper Indian mottle potyvirus, Pepper mottle potyvirus, Pepper severe mosaic potyvirus, Pepper veinal mottle potyvirus, Physalis mild chlorosis virus, Physalis vein blotch virus, plum pox potyvirus, Potato A potyvirus, Potato aucuba mosaic potexvirus, Potato M carlavirus, Potato S carlavirus, Potato V potyvirus, Potato Y potyvirus, Red clover vein mosaic carlavirus, Sowbane mosaic sobemovirus, Soybean mosaic potyvirus, Subterranean clover stunt nanavirus, Sweet potato feathery mottle potyvirus, Tamarillo mosaic potyvirus, Teasel mosaic virus, Tobacco etch potyvirus, Tobacco mottle umbravirus, Tobacco necrotic dwarf luteovirus, Tobacco ringspot nepovirus, Tobacco vein-distorting virus, Tobacco yellow net virus, Tobacco yellow vein virus, Tobacco yellow vein assistor virus, Tomato aspermy cucumovirus, Tradescantia-Zebrina potyvirus, Trichosanthes mottle virus, Tropaeolum 2 potyvirus, Tulip breaking potyvirus, Turnip mosaic potyvirus, Vallota mosaic potyvirus, Vanilla mosaic potyvirus, Vanilla necrosis potyvirus, Watermelon mosaic 1 potyvirus, Watermelon mosaic 2 potyvirus, Welsh onion yellow stripe potyvirus, Zucchini yellow mosaic potyvirus (Source: Brunt *et al*. 2007).

Hazard identification conclusion

Only two of these viruses are recorded from *Prunus* species: plum pox virus and Sowbane mosaic sobemovirus. Plum pox virus is not present in the Pacific Northwest. No records have been found of Sowbane mosaic sobemovirus in the Pacific Northwest (Brunt *et al*. 2007, CPCI 2008, ICTVdb 2004). Therefore *Myzus persicae* is not considered to be a potential hazard at this time. Should PPV or Sowbane mosaic sobemovirus become established in the Pacific Northwest, measures should be taken against this species on imported stonefruit.

7. *Pseudococcus longispinus* (Targioni Tozzetti, 1867) (Hemiptera: Pseudococcidae)

Common name/s: longtailed mealybug
Other scientific names: *Boisduvalia lauri*, *Coccus adonidum*, *C. laurinus*, *Dactylopius adonidum*, *D. longifilis*, *D. longispinus*, *D. pteridis*, *Oudablis lauri*, *Pseudococcus adonidum*, *P. laurinus*

PNW status

Recorded from Washington (CPCI 2008, ScaleNet 2008)

New Zealand status

Present (recorded by Cox 1987, ScaleNet 2008)

Hosts

P. longispinus is a highly polyphagous species that has been recorded from over 100 host plants belonging to 78 plant families, most commonly from the families Leguminosae, Moraceae, Araceae, Myrtaceae and Palmae. The host plant list contains numerous crops and ornamentals of economic importance, including peach and plum (CPCI 2008).

Vectored organisms

Longtailed mealybug is known to vector the following organisms: grapevine leafroll-associated virus, grapevine A virus, cacao swollen shoot badnavirus (mampong strain only) and grapevine stem pitting associated closterovirus (CPCI 2008). In the Solomon Islands and other islands in the south-west Pacific region, *P. longispinus* is also a vector of the smaller of two bacilliform viruses causing 'bobone' disease in some cultivars of taro (*Colocasia esculenta*) and *Xanthosoma* sp. (Gollifer *et al.* 1977).

Hazard identification conclusion

Although a number of these organisms are not recorded from New Zealand (Pearson *et al.* 2006), none are known to affect Rosaceae (Brunt *et al*. 2007, Gollifer *et al.* 1977). Therefore *Pseudococcus longispinus* is not considered to be a potential hazard in this analysis.

8. *Frankliniella intonsa* (Trybom, 1895) (Thysanoptera: Thripidae)

Common name/s: Taiwan flower thrips, Intonsa flower thrips
Other scientific names: *Frankliniella breviceps*, *F. brevistylis*, *F. formosae* f. *tricolour*, *F. formosae*, *F. intonsa* f. *norashensis*, *F. intonsa* var. *maritima*, *F. intonsa* var. *rufula*, *F. vicina*, *Physopus brevistylis*, *P. vulgatissimus*, *P. vulgatissimus* var. *adusta*, *P. vulgatissimus* var. *albicornis*, *P. vulgatissimus* var. *fulvicornis*, *P. vulgatissimus* var. *nigropilosa*, *Thrips intonsa*

PNW status

Recorded from Washington (CPCI 2008)

New Zealand status

Present (recorded by Teulon and Nielsen 2005, restricted; PPIN 2008)

Hosts

Major hosts include peach (CPCI 2008)

Vectored organisms

Frankliniella intonsa is known to vector tomato chlorotic spot virus, tomato spotted wilt virus (Persley *et al*. 2006) and groundnut ring spot tospovirus (with low transmission efficiency, CPCI 2008).

Hazard identification conclusion

Tomato chlorotic spot virus and groundnut ring spot tospovirus have not been recorded from New Zealand (Pearson *et a*l. 2006), but they are not known to affect apricot, peach, plum or nectarine (Brunt *et al*. 2007). Therefore *Frankliniella intonsa* is not considered to be a potential hazard in this analysis.

9. *Frankliniella occidentalis* (Pergande, 1895) (Thysanoptera: Thripidae)

Common name/s: western flower thrips
Other scientific names: *Euthrips helianthi*, *E. occidentalis*, *E. tritici*, *Frankliniella californica*, *F. canadensis*, *F. chrysanthemi*, *F. claripennis*, *F. conspicua*, *F. dahliae*, *F. dianthi*, *F. helianthi*, *F. moultoni*, *F. nubila*, *F. occidentalis* f. *brunnescens*, *F. occidentalis* f.

dubia, *F. syringae*, *F. trehernei*, *F. tritici maculata*, *Frankliniella tritici* var. *moultoni*, *F. umbrosa*, *F. venusta*

PNW status

Recorded from Washington, Oregon and Idaho (CPCI 2008)

New Zealand status

Present (recorded by Teulon & Nielsen 2005, CPCI 2008), but regulated as a vector

Hosts

F. occidentalis is a highly polyphagous species with at least 250 plant species from more than 65 families being listed as 'hosts', including apricot, peach, plum and nectarine (CPCI 2008). All life stages are liable to be carried on fruits in trade or transport, and the small size makes them difficult to detect except under a light microscope (CPCI 2008). This species is intercepted relatively frequently (more than 20 times between February 2003 and October 2006) at the border on apricot, peach and nectarine consignments from the USA (Quancargo database).

Vectored organisms

The most serious effect of feeding by western flower thrips is the transmission of tospoviruses. Seven viruses are known to be transmitted: tobacco streak virus, Impatiens necrotic spot tospovirus, tomato spotted wilt virus, groundnut ringspot virus (Brunt *et al*. 2007, CPCI 2008), Chrysanthemum stem necrosis virus, tomato chlorotic spot virus and Pelargonium flower break virus (CPCI 2008). Of these, only Impatiens necrotic spot tospovirus, tobacco streak virus and tomato spotted wilt virus are recorded from New Zealand (Pearson *et al.* 2006, CPCI 2008).

Hazard identification conclusion

None of the viruses vectored by western flower thrips are known to affect any *Prunus* species (Brunt *et al*. 2007, CPCI 2008) and it is not considered to be a potential hazard in this analysis.

10. *Thrips tabaci* Lindeman, 1889 (Thysanoptera: Thripidae)

Common name/s: onion thrips, potato thrips
Other scientific names: *Heliothrips tabaci*, *Limothrips allii*, *Thrips allii*, *T. bremnerii*, *T. dianthi*, *T. hololeucus*

PNW status

Recorded from Washington, Oregon and Idaho (CPCI 2008)

New Zealand status

Present (recorded by Mound & Walker 1982), but regulated as a vector

Hosts

The major hosts of *Thrips tabaci* are species of *Allium* (onions, garlic, leek, etc.) (CPCI 2008). Minor hosts include apricots, peaches, plums and nectarines. *T. tabaci* larvae are also predatory on small arthropods, mite eggs and small mites (probably spider mites, for example the two-spotted spider mite on cotton) (Wilson *et al.* 1996).

Plant parts affected

T. tabaci are found infesting growing points, flowers and leaves (CPCI 2008). This species has been intercepted on shipments of nectarines from the USA (Quancargo database, Consignments C2007/244106, C2004/79331), cherries from the USA (Quancargo database,

Consignment C2004/85122) and peaches/nectarines from the USA (Quancargo database, Consignment C2006/156904).
Vectored organisms: Iris yellow spot virus, Maize chlorotic mottle virus, *Prunus* necrotic ringspot virus, Sowbane mosaic virus, Tobacco streak virus, Tomato spotted wilt virus (Jones 2005) and Tobacco ringspot virus (Brunt *et al*. 2007).
Only two of these viruses are recorded from *Prunus* species: *Prunus* necrotic ringspot virus and Sowbane mosaic virus (Brunt *et al*. 2007). *Prunus* necrotic ringspot virus is present in New Zealand (Pearson *et al*. 2006), and Sowbane mosaic sobemovirus has not been recorded in the Pacific Northwest (Brunt *et al*. 2007, CPCI 2008, ICTVdb 2004).

Hazard identification conclusion

Two of the viruses known to be vectored by *T. tabaci* are recorded from *Prunus* species: *Prunus* necrotic ringspot virus and Sowbane mosaic virus (Brunt *et al*. 2007). *Prunus* necrotic ringspot virus is present in New Zealand (Pearson *et al*. 2006), and Sowbane mosaic sobemovirus has not been recorded in the PNW (Brunt *et al*. 2007, CPCI 2008, ICTVdb 2004). Therefore *Thrips tabaci* is not considered to be a potential hazard in this analysis.

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Appendix 5: Pest control programmes for apricots, peaches and nectarines and plums in the Pacific Northwest

WSU (2007) outlines control programmes for the following pests on each of the following crops:

1. Pest control programme for peaches and nectarines

- STAGE 0 (Dormant): Coryneum blight (shothole); Peach leaf curl
- STAGE 1 (Delayed-Dormant): Cutworms, European red mite (overwintering eggs), Green peach aphid, San Jose scale, Lecanium scale
- STAGES 2–5 (Prebloom): Brown rot (blossom blight), Coryneum blight (shothole), Cutworms, Lecanium scale, Lygus bugs, stink bugs, Oriental fruit moth, Peach silver mite, Peach twig borer, Ambrosia beetle, Western flower thrips
- STAGES 6–7 (Blossom): Brown rot (blossom blight), Leafrollers
- PETAL-FALL (100% petal fall): Brown rot (blossom blight), Coryneum blight (shothole), Powdery mildew, Leafrollers, Lygus bugs, stink bugs, Oriental fruit moth, Peach twig borer, Green peach aphid, Western flower thrips
- SHUCK FALL: Brown rot, Coryneum blight (Shothole), Leafrollers, Powdery mildew
- SUMMER: Brown rot (fruit rot), Powdery mildew, Cutworms, Earwigs, Grasshoppers, Mormon crickets, McDaniel spider mite, twospotted spider mite, European red mite, Oriental fruit moth, Leafrollers, Peach silver mite, Peachtree borer, Peach twig borer, San Jose scale, Shothole borer, ambrosia beetle
- PREHARVEST AND HARVEST: Brown rot, Powdery mildew, Oriental fruit moth, peach twig borer
- POSTHARVEST: Coryneum blight (shothole), Peach leaf curl, bacterial gummosis, Coryneum blight, Peach silver mite, Shothole borer, Spider mites

2. Pest control programme for apricots

- STAGE 0 (Dormant): Coryneum blight (shothole)
- STAGE 1 (Delayed-Dormant): Cutworms, European red mite (overwintering eggs), San Jose scale, Lecanium scale
- STAGES 2–5 (Prebloom): Brown rot (blossom blight), Coryneum blight (shothole), Cutworms, Grape mealybug, Aphids, Lecanium scale, Lygus bugs, stink bugs, Oriental fruit moth, Peach silver mite, Peach twig borer, Western flower thrips
- STAGES 6–7 (Blossom): Brown rot (blossom blight), Leafrollers
- PETAL-FALL (100% petal fall): Brown rot (blossom blight), Coryneum blight (shothole), Powdery mildew (Perfection spot), Grape mealybug, Aphids, Leafrollers, Lygus bugs, Oriental fruit moth, Peach twig borer
- SHUCK FALL: Brown rot, Coryneum blight (Shothole), Powdery mildew (Perfection spot), Leafrollers
- SUMMER: Brown rot (fruit rot), Powdery mildew, Cutworms, Earwigs, Grasshoppers, Mormon crickets, Oriental fruit moth, Pandemis leafroller, obliquebanded Leafroller, Peach silver mite, Peachtree borer, Peach twig borer, San Jose scale, Shothole borer
- PREHARVEST AND HARVEST: Brown rot, Powdery mildew, Oriental fruit moth, peach twig borer
- POSTHARVEST: Coryneum blight (shothole), bacterial gummosis, Coryneum blight, Shothole borer

3. Pest control programme for prunes and plums

- STAGE 1 (Delayed-Dormant): Cutworms, European red mite (overwintering eggs), San Jose scale, Lecanium scale
- STAGES 2–5 (Prebloom): Cutworms, Grape mealybug, Mealy plum aphid,leaf curl plum aphid, Lecanium scale, Lygus bugs, stink bugs, Pandemis leafroller, obliquebanded leafroller, Peach twig borer, Plum rust mite
- STAGES 6–7 (Blossom): Brown rot (blossom blight)
- PETAL-FALL (100% petal fall): Brown rot (blossom blight), Grape mealybug, mealy plum aphid, leaf curl plum aphid, Pandemis leafroller, obliquebanded leafroller, Peach twig borer, Plum rust mite, White apple leafhopper
- SHUCK FALL: Brown rot
- LATE SPRING AND SUMMER: Brown rot (fruit rot), Earwigs, Grasshoppers, Mormon crickets, McDaniel spider mite, twospotted spider mite, European red mite, Grape mealybug, Pandemis leafroller, Obliquebanded leafroller, Peachtree borer, Peach twig borer, Plum rust mite, San Jose scale, Lecanium scale, Shothole borer, White apple leafhopper
- POSTHARVEST: bacterial gummosis, Shothole borer, Plum aphids

Reference

WSU (2007) *2007 Crop Protection Guide for Tree Fruits in Washington*. Washington State University Extension, EB0419.

Appendix 6: USA state and territory abbreviations

Alabama AL
Alaska AK
Arizona AZ
Arkansas AR
California CA
Colorado CO
Connecticut CT
Delaware DE
District of Columbia DC
Florida FL
Georgia GA
Idaho ID
Illinois IL
Indiana IN
Iowa IA
Kansas KS
Kentucky KY
Louisiana LA
Maine ME
Maryland MD
Massachusetts MA
Michigan MI
Minnesota MN
Mississippi MS
Missouri MO
Montana MT
Nebraska NE
Nevada NV
New Hampshire NH
New Jersey NJ
New Mexico NM
New York NY
North Carolina NC
North Dakota ND
Ohio OH
Oklahoma OK
Oregon OR
Pennsylvania PA
Rhode Island RI
South Carolina SC
South Dakota SD
Tennessee TN
Texas TX
Utah UT
Vermont VT
Virginia VA
Washington WA
West Virginia WV
Wisconsin WI
Wyoming WY

Appendix 7: Pre-arrival phytosanitary measures for high impact fruit flies associated with cherries in the United States of America – States of Idaho, Oregon and Washington

Treatment specification

Orchard pest management programme

In order to ensure cherry fruit fly populations are maintained at low levels the management of those orchards registered for export to New Zealand must be carried out in accordance with the Pacific Northwest cherry pest management program.

Methyl bromide fumigation

The following treatment must be performed prior to the arrival of cherries in New Zealand. The treatment will be undertaken in accordance with agreed procedures.

Fruit pulp temperature	Fumigant concentration	Exposure period
22 °C and above	32 g/m³	2 hours
17 – 22 °C	40 g/m³	2 hours
12 – 17 °C	48 g/m³	2 hours
6 – 12 °C	64 g/m³	2 hours

NOTE: full details of the fruit fly treatment must be included in the "Disinfestation and/or Disinfection Treatment" area of the phytosanitary certificate. Details of the treatment duration, fumigant type and concentration, and fruit pulp temperature must be recorded.

Treatment monitoring

All treatments shall be monitored in accordance with agreed procedures. All cartons of cherry fruit shall be traceable to a unique treatment batch, packhouse and orchard.

Product security

Security of cherry fruit between the time of harvest and treatment must be maintained. Following treatment, the security of all treatment batches must be maintained in accordance with agreed procedures.

Appendix 8: A systems approach for Peach twig borer (PTwB) for Australia

The systems approach for Peach twig borer [*Anarsia lineatella* (PTwB)] will consist of orchard monitoring and treatment; fruit cutting in the orchard; fruit cutting in the packing facility; and the regulatory inspection.

I. Growers who plan to export apricots, nectarines, peaches, plums, or their hybrids to Australia must participate in the Systems Approach Program in accordance with the terms established.

II. For the purposes of the systems approach work plan, orchard is defined as "a continuous planting of a single commodity that is not separated by a physical barrier (for example: ranch road, canal or highway)".

III. Mandatory spray program

a. Mandatory dormant/delayed dormant and bloom spray aimed at PTwB
b. Dormant or delayed dormant sprays must be applied before first bloom
c. Bloom sprays are to be applied up to one inch leaf growth

IV. Field trapping, degree-day accumulation, and treatment

a. Trap type: Use traps with long lasting pheromone lures (a minimum of 6 weeks) to monitor PTwB.

b. Timing of trap placement: Traps must be placed in the orchards before the emergence of the first PTwB generation and no later than March 20, San Joaquin Valley, and April 1, Sacramento Valley. For the Pacific Northwest States, traps must be in place no later than May 1.

c. PTwB Trap Density: Determine the number of traps needed in the orchard by the following chart:

PTwB Trapping Density			
Number of Acres	Number of Traps	Number of Acres	Number of Traps
0 to 10	2	51 to 60	6
11 to 15	3	61 to 70	7
16 to 40	4	71 to 100	8
41 to 50	5	> 100	Add 1 trap per 20 acres

d. Trap placement: Hang traps 6 to 8 feet high, 1 to 3 feet inside the canopy in the north quadrant of the tree, in the shade, and at least 5 trees in from the edge of the orchard.

e. Trap monitoring and maintenance: Check traps twice a week until the biofix is established; thereafter, check traps weekly.

A. Remove trapped insects from the trap bottom after counting and record the trap catch on a monitoring form.
B. Replace trap bottoms monthly or sooner if they become covered with debris.
C. Follow manufacturer's recommendations for replacing pheromone dispensers.
D. Pheromone must be changed according to the manufacturer's label.
Do not place other types of pheromone (e.g. codling moth) into the PTwB trap.

f. Phenology (degree day or DD) model

A. “Biofix” for this option is described as (2) or more PTwB moths trapped within a 7-day period. The biofix is used to control PTwB with pesticide sprays that are timed with the PTwB phenology model.

B. The log book of minimum/maximum temperatures or thermograph. records/charts or electronic recorded data must be available for review upon request by USDA and County (California) or State (Pacific Northwest) officials.

g. Treatments: Treatments should be applied 400DD to 500 DD from the beginning of the flight in each generation. If the fruit has begun to color, however, treat at 300 DD.

If no moths are caught in the pheromone traps during the whole season, if shoot strikes are less than 3 per tree, and if no larvae are found during the orchard survey, no in-season pesticide sprays have to be applied.

h. Records: Trap inspection records shall be available for review during the season upon request of USDA, State, or County Agricultural Commissioner personnel. Such records must be updated until ALL fruit from the orchard has been harvested.

i. In order to certify fruit for export to Australia, trap inspection records and PTwB pesticide spraying records must be available in the packing facility during the development of the export season and will be reviewed prior to phytosanitary certification.

V. Orchard shoot strike survey and fruit cutting:

Carry out a field inspection, including a shoot strike survey, and pre-harvest cutting for each one of the lots of peaches, nectarines, apricots, plums, or hybrids of the four species that will be exported to Australia.

a. The shoot strike survey and fruit cutting must be done no more than 5 days prior to harvest and before harvesting any fruit from the orchard.

b. The number of trees to be surveyed will vary by orchard size as follows:

Number of Trees to be Surveyed for Orchard Fruit Cutting			
Number of Acres	Trees Surveyed	Number of Acres	Trees Surveyed
0 to 40	60	61 to 65	79
41 to 45	64	66 to 70	83
46 to 50	68	71 to 75	86
51 to 55	71	76 to 80	90
56 to 60	75	> 80	Over 80, add 1 tree per 2 acres

c. In each case, the trees will be checked for shoot strikes, and five (5) fruit from each tree surveyed will be cut and examined for PTwB. The fruit must be taken from the top portion of the tree (Samples taken from the lower and middle portion of the tree are not acceptable.)

d. If more than an average of 2 shoot strikes per tree and/or one live PTwB larva are found during the orchard shoot strike survey and fruit cutting, the grower lot will be suspended from export to Australia for the remainder of the season.

e. The Pest Control Advisor must be present or readily available.

VI. On Line (Packing Facility) Cull Cutting

a. The packing facility must have at least two State or county trained “technical” employees responsible for fruit cutting during the packing process.

b. Technical employees shall cut and examine 300 cull fruit per day from each lot intended for export to Australia. The fruit that is cut should be representative of the entire harvested lot.

c. Culls for cutting cannot be held longer than five (5) days.

d. If no fruit for an entire pack date is shipped to Australia, cull cutting does not need to be completed.

e. Once cull cutting has been started in a lot, all 300 fruit must be cut no matter how many live larvae are being found unless the packing facility chooses to remove the lot from the program for the season (e.g. numerous finds of larvae other than PTwB).

f. The county or State regulatory officials will monitor the cull cutting activity.

g. All live larvae found must be presented to a State or County regulatory official and identified by the State or County, recorded on the “Packing Facility Inspection Log” prior to presenting the lot for export certification for Australia. All live larvae found must be clearly identified as to which lot they were found in and must be kept for a minimum of 48 hours.

h. The technical employees shall complete the log for each lot. The county or State inspectors must sign the log by cutting date and review prior to each phytosanitary certification.

i. The packing facility must keep available a notebook for recording (separate from the Packing Facility Inspection Log) for any official regulatory visits.

j. If one live PTwB larva is found during the packing facility cull cutting, the grower lot will be suspended from export to Australia for the remainder of the season.

VII. Leaf and Stem Tolerance

a. An average of two whole leaves per box will be the maximum allowable leaf tolerance. For apricots, packed fruit must have no more than an average of 3 stems per box smaller than ½ inch in length and 2 stems larger than ½ inch in length.

VIII. Packing and Storage

a. All approved lots eligible for export to Australia must be segregated from all other fruit at all times.

b. All approved lots eligible for export to Australia must be stored in a properly marked designated area(s).

c. All boxes must be stamped with the corresponding lot number and pack date.

IX. Regulatory Inspection

Two percent of the boxes will be randomly selected for inspection and 100 percent of the fruit in the selected boxes will be inspected. Five percent of the fruit in the selected boxes plus any fruit showing signs of possible insect infestation will be cut to look for internal feeders.

If one live PTwB larva is found at regulatory inspection, the grower lot will be suspended from export to Australia for the remainder of the season.

X. Inspection at Australian port of entry

One interception of a live PTwB larva at Australian port of entry will suspend the grower lot from export to Australia for the remainder of the season.

Sources

University of California Integrated Pest Management Guidelines for Peach Twig Borer in Stone Fruit. UC IPM Online. Webpage: http://www.ipm.ucdavis.edu/PMG/r602300611.html

Washington State University Tree Fruit Research and Extension Center: Orchard Pest Management Online. Webpage: http://jenny.tfrec.wsu.edu/opm/