



**Australian Government**

**Department of Agriculture, Fisheries and Forestry**

# Importation of Apples from New Zealand



**Revised Draft IRA Report  
Part A**

**February 2004**



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## GLOSSARY OF ABBREVIATIONS

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AAPGA	Australian Apple & Pear Growers Association (now Apple & Pear Australia Limited)
ABS	Australian Bureau of Statistics
AFFA	Agriculture, Fisheries and Forestry - Australia, now the Australian Government Department of Agriculture, Fisheries and Forestry
AIGN	Associated International Group of Nurseries
ALCM	Apple leafcurling midge
ALOP	Appropriate level of protection
APAL	Apple & Pear Australia Limited
AQIS	Australian Quarantine and Inspection Service
BA	Biosecurity Australia, an operating group within the Australian Government Department of Agriculture, Fisheries and Forestry
BHLR	Brownheaded leafroller
BPLB	Burnt pine longhorn beetle
c.	<i>Circa</i> , about
CA	Controlled atmosphere
CABI	CAB International, Wallingford, UK
cfu	Colony-forming unit; an individual cell or group of cells that is able to divide to produce an entire colony of cells
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DNA	Deoxyribo Nucleic Acid; the molecule responsible for the transference of genetic characteristics
ENZA	The brand 'ENZA' was introduced for export pipfruit by the New Zealand Apple & Pear Marketing Board in 1991
ERM	European red mite
FAO	Food and Agriculture Organization of the United Nations
GATT	General Agreement on Tariffs and Trade
GFF	Garden featherfoot
GBC	Grey-brown cutworm
GHLR	Greenheaded leafroller
HAL	Horticulture Australia

HortResearch	Horticulture and Food Research Institute of New Zealand Ltd
ICON	AQIS Import Conditions database
IFP	Integrated Fruit Production; a program undertaken by horticultural industries that requires good management practices in orchards and packing houses
IPM	Integrated Pest Management; integration of chemical means of pest control with other methods, notably biological control and habitat manipulation
IPPC	International Plant Protection Convention, as deposited in 1951 with FAO in Rome and as subsequently amended
IRA	Import risk analysis
ISPM	International Standards for Phytosanitary Measures
kPa	Kilopascal. One kilopascal = 1,000 Pa (pascal). A Pascal is a unit of pressure equal to one newton per square metre.
kt	Kilotonne = 1,000 metric tons
lux	A unit of illumination equal to 1 lumen per square meter; 0.0929 foot candle
MAFNZ	Ministry of Agriculture and Forestry, New Zealand; New Zealand's National Plant Protection Organization
MRL	Maximum residue levels
mt	Metric ton = unit of weight equivalent to 1,000 kilograms = 1 tonne
OFM	Oriental fruit moth
OIE	Office International des Epizooties
OP	Organic production
OPENZ	The Organic Products Exporters of New Zealand Inc.
OSS	Oystershell scale
NLR	Native leafroller
NPPO	National Plant Protection Organization
NZFT	New Zealand flower thrips
PBPM	Plant Biosecurity Policy Memorandum
PDI	Pest and Disease Information Database
PGNZI	Pipfruit Growers New Zealand Inc.
PM	Pest management
PPD	Partial probabilities of distribution

PRA	Pest risk analysis; the process of evaluating biological or other scientific evidence to determine whether a pest should be regulated and the strength of any phytosanitary measures to be taken against it
RAP	Risk analysis panel; replaced by the import risk analysis team (IRAT) in the <i>Import Risk Analysis Handbook</i> , 2003
REB	Registered Export Block; a defined section of a contiguous apple planting registered for export of apples to Australia
SNZ	Standards New Zealand
SPS	Sanitary and Phytosanitary
SPS Agreement	International Agreement on the Application of Sanitary and Phytosanitary Measures
t	Tonne (see metric ton)
USDA	United States Department of Agriculture
WTO	World Trade Organization

## GLOSSARY OF TERMS

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Abscission	The normal shedding from a plant of an organ that is mature or aged, e.g. a ripe fruit, an old leaf
Area	An officially defined country, part of a country or all or parts of several countries (ISPM 5)
Ascoma	An ascus-producing structure; a fruit-body containing asci
Ascospore	A sexual spore produced in an ascus
Ascus	The sac-like cell of the sexual state of a member of the Ascomycota in which the ascospores are produced
Bacteriophage	A virus that infects a bacterium
Conidiophore	A simple or branched, fertile hypha bearing conidiogenous cells from which conidia are produced
Conidium	A non-motile, usually deciduous, asexual spore
Control (of a pest)	Suppression, containment or eradication of a pest population (ISPM 5)
Cytoplasm	The part of a cell enclosed by the plasma membrane, except the nucleus
Diapause	Period of suspended development/growth occurring in some insects, in which metabolism is decreased
Dicotyledon	A flowering plant whose embryo has two (rarely more) cotyledons (seed leaves)
Endangered area	An area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss (ISPM 5)
Endophytic (of a pest)	Describes the endophytic (internal) colonisation (infection) of the core of an apple or the plant itself, and is generally associated with the development of disease symptoms
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (ISPM 5)
Entry potential	Likelihood of the entry of a pest
Epidemiology	The study of factors influencing the initiation, development and spread of infectious disease; the study of disease in populations of plants
Epiphytic (of a pest)	Describes the epiphytic colonisation (infestation) of the surface, calyx and stem-end of apple fruit, although the fruit and plant is unlikely to display disease symptoms

Establishment (of a pest)	The perpetuation, for the foreseeable future, of a pest within an area after entry (ISPM 5)
Establishment potential	Likelihood of the establishment of a pest
Exposure group	A category of susceptible host plants for which the likelihood of exposure, or the impact of a pest, are likely to be meaningfully different. Exposure groups in this analysis include: commercial fruit crops; nursery plants; household and garden plants, including weed species; and, wild (native and introduced) and amenity plants including susceptible plants growing on farmland
Fecundity	The fertility of an organism
Herbaceous	Not woody
Inoculum	Pathogen or its parts, capable of causing infection when transferred to a favourable location
Introduction (of a pest)	The entry of a pest, resulting in its establishment (ISPM 5)
Introduction potential (of a pest)	Likelihood of the introduction of a pest
Instar	A stage of insect larval development which is between two moults
Lepidopteran	A member of the Order comprising the butterflies and moths
Mature fruit	Commercial maturity is the start of the ripening process. The ripening process will then continue and provide a product that is consumer-acceptable. Maturity assessments include colour, starch index, soluble solids content, flesh firmness, acidity, and ethylene production rate
Mycelium	The vegetative body of a fungus, consisting of hyphae
Non-quarantine pest	Pest that is not a quarantine pest for an area (ISPM 5)
Official	Established, authorised or performed by a National Plant Protection Organization (ISPM 5)
Official control (of a regulated pest)	The active enforcement of mandatory phytosanitary regulations and the application of mandatory phytosanitary procedures with the objective of eradication or containment of quarantine pests or for the management of regulated non-quarantine pests (ISPM 5)
Organophosphate	A soluble fertiliser material consisting of organic phosphate esters (glucose, glycol, etc.)
Noctuid	A large family of dull-coloured, medium-sized moths
Parasitoid	An insect parasitic only in its immature stages, killing its host in the process of its development, and free living as an adult (ISPM 5)

Pathogenesis	Production and development of disease
Pathway	Any means that allows the entry or spread of a pest (ISPM 5)
Pedicel	The stalk of a flower
Perithecium	A subglobose or flask-like ascoma with an ostiole
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent, injurious to plants or plant products (ISPM 5)
Pest categorisation	The process for determining whether a pest has or has not the characteristics of a quarantine pest or those of a regulated non-quarantine pest (ISPM 5)
Pest Free Area	An area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained (ISPM 5)
Petiole	The stalk of a leaf
Phytosanitary measure	Any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (ISPM 5)
Polymorphic	Having more than two distinct morphological variants
Polyphagous	Feeding on a relatively large number of host plants from different plant families
PRA area	Area in relation to which a pest risk analysis is conducted (ISPM 5)
Practically free	Of a consignment, field, or place of production, without pests (or a specific pest) in numbers or quantities in excess of those that can be expected to result from, and be consistent with good cultural and handling practices employed in the production and marketing of the commodity (ISPM 5)
Propagule	A reproductive structure, e.g. a seed, a spore, part of the vegetative body capable of independent growth if detached from the parent
Pseudothecium	Perithecium-like fruiting body containing asci and ascospores dispersed rather than in an organised hymenium
Quarantine pest	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (ISPM 5)
Quiescent	Inactive, latent, or dormant, referring to a disease or pathological process

Regulated non-quarantine pest	A non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated with the territory of the importing contracting party (ISPM 5)
Saprophyte	An organism deriving its nourishment from dead organic matter
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (ISPM 5)
Spread potential (of a pest)	Likelihood of the spread of a pest
Stakeholders	Government agencies, individuals, community or industry groups or organisations, whether in Australia or overseas, including the proponent/applicant for a specific proposal, having an interest in the subject matter of an IRA
Streptomycin	An antibiotic used in the control of fire blight
Symptomless	Without any visible indication of disease by reaction of the host, e.g. canker, leaf spot, wilt
Utility points	The five key points at which apples are distributed or utilised and at which apple waste will be generated: orchard wholesalers; urban wholesalers; retailers; food services; and, consumers





## EXECUTIVE SUMMARY

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In response to an application made by New Zealand in January 1999 seeking access for their apples into Australia, Biosecurity Australia (BA) released a draft import risk analysis (IRA) for public comment in October 2000. After evaluating the stakeholder comments received on this draft and on the recommendation of a Senate Committee established to look into this IRA, BA established an import risk analysis panel in October 2001 to progress this IRA. The appointment of seven panel members was confirmed on 10 January 2002. The panel comprised the following people:

Dr Bill Roberts (Chairman) <sup>1</sup>	Australia's Chief Plant Protection Officer, Australian Government Department of Agriculture, Fisheries and Forestry.
Mr Bill Hatton	A specialist in fruit production with expertise in growing, packing and shipping.
Mr David Cartwright	A plant pathologist and Manager Plant Health, Department of Primary Industries and Resources, South Australia.
Dr Kent Williams	Principal Research Scientist, CSIRO Sustainable Ecosystems.
Mr Mike Kinsella <sup>2</sup>	A consultant horticulturalist and a former Director of Quarantine and Inspection Services, Victoria.
Mr Ian Armour	An owner and manager of an apple production business.
Dr Brian Stynes	A plant pathologist and General Manager, Plant Biosecurity, Biosecurity Australia.

The panel was initially known as a Risk Analysis Panel (RAP). However, its title was changed to an Import Risk Analysis Team (IRAT) coinciding with the release of Biosecurity Australia's *Import Risk Analysis Handbook* (2003). The IRAT established two provisional technical working groups to assist it in the pest categorisation of arthropod and pathogen pests.

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<sup>1</sup> Dr Bill Roberts took up a secondment with the Food and Agricultural Organization (FAO) in Rome for nine months. Mr David Cartwright was appointed acting chair during Dr Robert's secondment.

<sup>2</sup> On 22 January 2002, BA was informed that Mr Mike Kinsella had passed away. No replacement was sought for this position.

These groups had the following members:

*Provisional technical working group for Arthropods:*

Dr Kent Williams (Chair)

Mrs Margaret Williams	Entomologist, Department of Primary Industries, Water and Environment, Tasmania.
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Mr Bill Woods	Entomologist, Department of Agriculture, Western Australia.
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Mr David Williams	Entomologist, Department of Primary Industries, Victoria.
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*Provisional technical working group for Pathogens:*

Mr David Cartwright (Chair)

Mr Bill Washington	Plant Pathologist, Department of Primary Industries, Victoria.
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Dr Satendra Kumar	Quarantine Plant Pathologist, Department of Agriculture, Western Australia.
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Dr Trevor Wicks	Plant Pathologist, South Australian Research Institute.
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## CONSULTATION

The IRAT undertook a series of face-to-face meetings and teleconferences. Reports of these meetings were made available to stakeholders.

A two-day workshop was conducted in Melbourne in July 2002. Participants included Australian and New Zealand representatives from State governments, national governments, apple growers and related industries. They provided valuable input to Biosecurity Australia's staff and the IRAT, particularly in defining the proportions and distribution points for apples, waste generation at distribution points and exposure scenarios for susceptible host plants. The information provided at this workshop was incorporated into the methodology used to undertake the individual risk assessments.

Biosecurity Australia staff consulted extensively with their counterparts in the New Zealand Ministry of Agriculture and Forestry (MAFNZ) about research trials relevant to the risk assessment and the production and distribution methods of New Zealand apples. In addition, DAFF provided updates on the progress of the IRA to representatives from the Australian and New Zealand apple industries as part of its broader consultative process.

## AUSTRALIA'S CURRENT POLICY ON APPLES

The only fresh apples currently permitted into Australia are Fuji apples from Japan. Pre-inspection by the Australian Quarantine and Inspection Service (AQIS) inspectors is a requirement, and a phytosanitary certificate must accompany each shipment with details of

the source orchards, dates of packing, fumigation and cold disinfestation treatment amongst other details. Joint monitoring by AQIS and Japanese quarantine officers of the effectiveness of the treatments is required. However, as of February 2004, no trade has taken place.

## **IMPORT RISK ANALYSIS**

The technical component of an IRA for plants or plant products is termed a 'pest risk analysis', or PRA.

A PRA is carried out in three discrete stages:

- Stage 1: Initiation of the PRA;
- Stage 2: Pest Risk Assessment; and,
- Stage 3: Pest Risk Management.

## **INITIATION OF THIS IRA**

This PRA was initiated by a request from New Zealand in January 1999 for Australia to review its policy for the importation of mature apple fruit (*Malus × domestica* Borkhausen). It also builds on an analysis completed in December 1998 of the risks associated with the 'unrestricted' importation of New Zealand apples, as well as a further analysis, completed and circulated in draft form in October 2000.

## **PEST RISK ASSESSMENT**

### **Pest categorisation**

In all, 442 species associated with New Zealand apples were categorised according to their presence or absence in Australia, including regulatory status where applicable, their potential for being on the pathway (association with apple fruit), their potential for establishment or spread in Australia, and the potential consequences of establishment or spread. From these, 21 pests were identified as requiring additional consideration for the whole of Australia or for Western Australia, and were the focus of individual risk assessments. For the whole of Australia, these included one bacterium, one fungus and nine insects. Western Australia has a different pest status for apples compared with the rest of Australia, and for this State seven additional pests were considered, one fungus, five insects and one mite. In addition, for the whole of Australia, three species of insects contaminating apple fruit or pallets were also assessed.

### **Assessment of risk**

The risk assessment identified six insects, one bacterium and one fungus for the whole of Australia associated with the importation of apples from New Zealand that required management measures to reduce the risk to an acceptable level. In addition, one insect and one fungus required measures for importation into Western Australia because these pests, although present in the rest of Australia, are not present in Western Australia, where measures are in place to maintain area freedom.

## **PEST RISK MANAGEMENT**

The biosecurity measures and phytosanitary procedures proposed to manage the identified risks for the above quarantine pests are summarised below. These measures were considered by the IRAT to be the least trade restrictive, and to manage risks to a level within Australia's appropriate level of protection, which is very low.

Measures and phytosanitary procedures applied to all pests include:

- registration of export orchards, exporters and packing houses;
- packing, labelling and storage compliance;
- phytosanitary certification by MAFNZ;
- on-arrival verification procedures by AQIS for compliance with packaging requirements and import conditions; and,
- DAFF or MAFNZ may, by mutual agreement, audit the pathway of imported apple fruit at any time.

### **Pests for all of Australia**

#### **Fire blight**

- MAFNZ to provide assurance that apples are sourced from areas free of disease symptoms determined, for example, by surveillance;
- chlorine treatment of fruit; and,
- cold storage treatment of fruit.

#### **European canker**

- MAFNZ to provide assurance that apples are sourced from areas free of disease symptoms determined, for example, by surveillance.

#### **Apple leafcurling midge**

- phytosanitary action when apple leafcurling midge is intercepted during verification inspection in New Zealand and in Australia.

#### **Leafrollers (four species)**

- phytosanitary action when brownheaded or greenheaded leafrollers are intercepted during verification inspection in New Zealand and in Australia.

#### **Wheat bug**

- sourcing apples from areas with low pest prevalence and preventing contamination during handling and processing;
- pre-harvest inspection or surveillance by MAFNZ to determine pest prevalence;
- the application of effective treatment(s) to reduce the pest in and around orchards and packing houses where inspection and surveillance have detected high populations; and,
- phytosanitary action when wheat bug is intercepted during verification inspection in New Zealand and in Australia.

**Western Australia pests****Apple scab**

- MAFNZ to provide assurance that apples are sourced from areas free of disease symptoms determined, for example, by surveillance.

**Codling Moth**

- phytosanitary action when codling moth is intercepted during verification inspection in New Zealand and in Australia.

**QUARANTINE CONDITIONS**

This revised draft IRA Report outlines a set of conditions for the importation of apples from New Zealand. The quarantine conditions described in this report are based on the risk assessment and risk management conclusions from the IRA. The conditions are predicated on the minimum standards achieved by orchard (including IFP), packing house and transport management, as currently practiced in New Zealand.

Biosecurity Australia considers that the quarantine conditions (risk management measures together with phytosanitary procedures) proposed in this report are the least trade restrictive means of ensuring that Australia's ALOP would be met, and are commensurate with the identified risks. Biosecurity Australia invites technical comments on the economic and practical feasibility of the risk management measures. Proposals for equivalent measures that meet Australia's ALOP will be considered. Those seeking to propose alternative risk management measures should provide a submission for consideration; such proposals should include supporting scientific data that explain the way in which alternative measures would meet Australia's ALOP.

**CONCLUSION**

This revised draft IRA Report recommends that importation of fresh apples from New Zealand be permitted subject to certain conditions.

In accordance with the process for conducting IRAs, as outlined in the *Import Risk Analysis Handbook*, published in 2003 by the Australian Government Department of Agriculture, Fisheries and Forestry's Biosecurity Australia, comments are invited on this revised draft IRA Report. Submissions should reach Biosecurity Australia within 60 days of publication of this report. The final IRA Report will take into account any comments received on this revised draft, as well as any new information that may come to hand. The final IRA Report will be open to appeal for a period of 30 days after its release.



### INTRODUCTION

This section outlines:

- the legislative basis for Australia's biosecurity regime;
- Australia's international rights and obligations;
- Australia's Appropriate Level of Protection and risk management;
- import risk analysis; and,
- policy determination.

### AUSTRALIAN LEGISLATION

The *Quarantine Act 1908* and its subordinate legislation, including the *Quarantine Proclamation 1998*, are the legislative basis of human, animal and plant biosecurity in Australia.

Some key provisions are set out below.

#### **Quarantine Act: scope**

Subsection 4 (1) of the *Quarantine Act 1908* defines the scope of quarantine as follows.

*In this Act, quarantine includes, but is not limited to, measures:*

(a) *for, or in relation to:*

- (i) *the examination, exclusion, detention, observation, segregation, isolation, protection, treatment and regulation of vessels, installations, human beings, animals, plants or other goods or things; or*
- (ii) *the seizure and destruction of animals, plants, or other goods or things; or*
- (iii) *the destruction of premises comprising buildings or other structures when treatment of these premises is not practicable; and*

(b) *having as their object the prevention or control of the introduction, establishment or spread of diseases or pests that will or could cause significant damage to human beings, animals, plants, other aspects of the environment or economic activities.*

Section 5D of the *Quarantine Act 1908* covers the level of quarantine risk.

*A reference in this Act to a level of quarantine risk is a reference to:*

(a) *the probability of:*

(i) *a disease or pest being introduced, established or spread in Australia or the Cocos Islands; and*

(ii) *the disease or pest causing harm to human beings, animals, plants, other aspects of the environment, or economic activities; and*

(b) *the probable extent of the harm.*

Section 5D of the *Quarantine Act 1908* includes harm to the environment as a component of the level of quarantine risk.

Environment is defined in Section 5 of the *Quarantine Act 1908*, in that it:

*includes all aspects of the surroundings of human beings, whether natural surroundings or surroundings created by human beings themselves, and whether affecting them as individuals or in social groupings.*

### **Quarantine Proclamation**

The *Quarantine Proclamation 1998* is made under the *Quarantine Act 1908*. It is the principal legal instrument used to control the importation to Australia of goods of quarantine (or biosecurity) interest. The Proclamation empowers a Director of Quarantine to grant a permit to import.

Section 70 of the *Quarantine Proclamation 1998* sets out the matters to be considered when deciding whether to grant a permit to import.

*Things a Director of Quarantine must take into account when deciding whether to grant a permit for importation into Australia*

- (1) *In deciding whether to grant a permit to import a thing into Australia or the Cocos Islands, or for the removal of a thing from the Protected Zone or the Torres Strait Special Quarantine Zone to the rest of Australia, a Director of Quarantine:*
  - (a) *must consider the level of quarantine risk if the permit were granted; and*
  - (b) *must consider whether, if the permit were granted, the imposition of conditions on it would be necessary to limit the level of quarantine risk to one that is acceptably low; and*
  - (ba) *for a permit to import a seed of a kind of plant that was produced by genetic manipulation—must take into account any risk assessment prepared, and any decision made, in relation to the seed under the Gene Technology Act; and*
  - (c) *may take into account anything else that he or she knows that is relevant.*

### **Development of Biosecurity Policy**

As can be seen from the above extracts, the legislation establishes the concept of the level of biosecurity (quarantine) risk as the basis of decision-making under Australian quarantine legislation.

Import risk analyses are a significant contribution to the information available to the Director of Animal and Plant Quarantine—the decision maker for the purposes of the *Quarantine Proclamation*. Import risk analysis is conducted within an administrative process—known as the IRA process (described in the *IRA Handbook*<sup>3</sup>).

The purpose of the IRA process is to deliver a policy recommendation to the Director of Animal and Plant Quarantine that is characterised by sound science and by transparency, fairness and consistency. The key elements of the IRA process are covered in ‘Import Risk Analysis’ below.

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<sup>3</sup> Agriculture, Fisheries and Forestry - Australia (2003) *Import Risk Analysis Handbook*, Canberra.



## AUSTRALIA'S INTERNATIONAL RIGHTS AND OBLIGATIONS

It is important that import risk analysis conforms with Australia's rights and obligations as a WTO Member country. These rights and obligations derive principally from the World Trade Organization's *Agreement on the Application of Sanitary and Phytosanitary Measures* (SPS Agreement), although other WTO agreements may also be relevant, and in the case of plants and plant products from the the International Plant Protection Convention (IPPC).

The SPS Agreement recognises the right of WTO Member countries to determine the level of sanitary and phytosanitary protection they deem appropriate, and to take the necessary measures to achieve that protection. Sanitary (human and animal health) and phytosanitary (plant health) measures typically apply to trade in or movement of animal- and plant-based goods within or between countries. The SPS Agreement applies to measures that may directly or indirectly affect international trade and that protect human, animal or plant life or health from pests and diseases or a Member's territory from a pest.

The SPS Agreement provides for the following:

- the right of WTO Member countries to determine the level of sanitary and phytosanitary protection (its appropriate level of protection, or ALOP) they deem appropriate;
- an importing Member has the sovereign right to take measures to achieve the level of protection it deems appropriate to protect human, animal or plant life or health within its territory;
- an SPS measure must be based on scientific principles and not be maintained without sufficient scientific evidence;
- an importing Member shall avoid arbitrary or unjustifiable distinctions in levels of protection, if such distinctions result in discrimination or a disguised restriction on international trade;
- an SPS measure must not be more trade restrictive than required to achieve an importing Member's ALOP, taking into account technical and economic feasibility;
- an SPS measure should be based on an international standard, guideline or recommendation where these exist, unless there is a scientific justification for a measure which results in a higher level of SPS protection to meet the importing Member's ALOP;
- an SPS measure conforming to an international standard, guideline or recommendation is deemed to be necessary to protect human, animal or plant life or health, and to be consistent with the SPS Agreement;
- where an international standard, guideline or recommendation does not exist or where, in order to meet an importing Member's ALOP, a measure needs to provide a higher level of protection than accorded by the relevant international standard, such a measure must be based on a risk assessment; the risk assessment must take into account available scientific evidence and relevant economic factors;
- where the relevant scientific evidence is insufficient, an importing Member may provisionally adopt SPS measures on the basis of available pertinent information. In such circumstances, Members shall seek to obtain the additional information necessary for a more objective assessment of risk and review the SPS measure accordingly within a reasonable period of time; and,
- an importing Member shall accept the measures of other countries as equivalent, if it is objectively demonstrated that the measures meet the importing Member's ALOP.

## AUSTRALIA'S APPROPRIATE LEVEL OF PROTECTION (ALOP)

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

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

ALOP can be illustrated using a 'risk estimation matrix' Table 1. The cells of this matrix describe the product of likelihood<sup>4</sup> and consequences—termed 'risk'. When interpreting the risk estimation matrix, it should be remembered that, although the descriptors for each axis are similar ('low', 'moderate', 'high', etc.), the vertical axis refers to *likelihood* and the horizontal axis refers to *consequences*.

**Table 1 Risk estimation matrix**

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

The band of cells in Table 1 marked 'very low risk' represents Australia's ALOP, or tolerance of loss.

## Risk Management and SPS Measures

Australia's plant and animal health status is maintained through the implementation of measures to facilitate the importation of products while protecting the health of people, animals and plants.

<sup>4</sup> The terms 'likelihood' and 'probability' are synonymous. 'Probability' is used in the *Quarantine Act 1908* while 'likelihood' is used in the WTO SPS Agreement. These terms are used interchangeably in this IRA Report.

Australia bases its national measures on international standards where they exist and where they deliver the appropriate level of protection from pests and diseases. However, where such standards do not achieve Australia's level of biosecurity protection, or relevant standards do not exist, Australia exercises its right under the SPS Agreement to take appropriate measures, justified on scientific grounds and supported by risk analysis.

Australia's approach to addressing requests for imports of animals, plants and their products, where there are biosecurity risks is, where appropriate, to draw on existing sanitary and phytosanitary measures for similar products with comparable risks. However, where measures for comparable biosecurity risks have not previously been established, further action would be required to assess the risks to Australia and determine the sanitary and phytosanitary measures needed to achieve Australia's ALOP.

## **IMPORT RISK ANALYSIS**

### **Description**

In animal and plant biosecurity, import risk analysis identifies the pests and diseases relevant to an import proposal, assesses the risks posed by them and, if those risks are unacceptable, specifies the measures that could be taken to reduce those risks to an acceptable level. These analyses are conducted via an administrative process (described in the IRA Handbook) that involves, among other things, notification to the WTO, consultation and appeal.

### **Undertaking IRAs**

Biosecurity Australia may undertake an IRA if:

- there is no relevant existing biosecurity measure for the good and pest/disease combination; or,
- a variation in established policy is desirable because pests or diseases, or the likelihood and/or consequences of entry, establishment or spread of the pests or diseases could differ significantly from those previously assessed.

### **Environment and human health**

When undertaking an import risk analysis, the Quarantine Act requires the Director of Animal and Plant Quarantine to ensure that environmental factors are considered in the decision making process. A Memorandum of Understanding (MOU) is in place between Biosecurity Australia and the Department of the Environment and Heritage to facilitate input of advice on environmental matters in import risk analyses.

Biosecurity Australia also consults with other Commonwealth agencies where they have responsibilities relevant to the subject matter of the IRA, e.g. Food Standards Australia New Zealand (FSANZ) and the Australian Government Department of Health and Ageing.

### **The IRA process in summary**

The process consists of the following major steps.

**Initiation:** This is the stage where the identified need for an IRA originates.

**Scheduling and Scoping:** At this stage, Biosecurity Australia considers all the factors that affect scheduling. Consultation with States, Territories and other Commonwealth agencies is involved. There is opportunity for appeal by stakeholders at this stage.

**Risk Analysis:** Here, the major scientific and technical work relating to risk assessment and risk management is performed. A panel with outside expertise may be engaged to provide advice. There is detailed consultation with stakeholders.

**Reporting:** Here, the results of the IRA are communicated formally. There is consultation with States and Territories. The Executive Manager of Biosecurity Australia then delivers the biosecurity policy recommendation arising from the IRA to the Director of Animal and Plant Quarantine. There is opportunity for appeal by stakeholders at this stage.

### **POLICY DETERMINATION**

The Director of Animal and Plant Quarantine makes the final policy determination. Biosecurity Australia then notifies the proponent/applicant, registered stakeholders and the WTO of the final policy determination. The Final IRA Report, the policy determination, the outcomes of any appeals and Biosecurity Australia's responses to issues raised, are provided to the proponent/applicant and registered stakeholders, and placed on the Biosecurity Australia website and on the public file. Information on the final policy determination is also published in *Biosecurity Australia News*. Biosecurity Australia notifies AQIS of the new policy and liaises with AQIS on implementation.

# PROPOSAL BY NEW ZEALAND TO EXPORT APPLES TO AUSTRALIA

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## BACKGROUND

### New Zealand's access applications

New Zealand had access to the Australian market for fresh apple fruit until 1921. In that year Australia banned apples from New Zealand entering Australia following the introduction and establishment of the disease, fire blight, in Auckland in 1919. In 1986 and again in 1989, New Zealand applied to regain access to Australian markets. However, both applications were rejected mainly because of unresolved issues relating to the risk of the disease entering Australia through trade in fresh fruit from fire blight affected orchards in New Zealand.

The Australian Quarantine and Inspection Service (AQIS) received a further application for access of fresh apples into Australia from New Zealand in December 1995. The application contained a pest list for New Zealand apples and details of New Zealand research work on fire blight. The application included the statement that *'the export of mature apples produced under New Zealand conditions (regardless of the fire blight (disease) status of the orchard) will not be a viable pathway for the introduction of E. amylovora into Australia'*. This claim was based on the scientific literature available at the time as well as additional research carried out in New Zealand. According to the New Zealand proposal, apples could be sourced from trees with active fire blight as long as they were mature and free of trash when packed. No other risk management measures were proposed by New Zealand in the original request.

### Australia's previous risk analyses

AQIS commenced a risk analysis for fire blight in 1996, following the International Standard for Phytosanitary Measures (ISPM) No 2: *Part 1 – Import Regulations: Guidelines for Pest Risk Analysis* (IPPC, 1996a). First an issues paper (AQIS, 1996) was released noting that the research quoted in the New Zealand proposal was based on orchards that had been inspected and found to be free of fire blight symptoms. Therefore AQIS considered that this research should not form the basis of any risk management measures to be developed based on the New Zealand submission. The issues paper also identified other pests of quarantine concern and provided background information on the disease fire blight. A paper from the Australian Bureau of Agricultural and Resource Economics (Bhati and Rees, 1996) on the probable costs of fire blight disease to the Australian industry was attached to the issues paper. Stakeholders were asked to provide relevant comments directly to AQIS within 60 days of release. At industry request, an extension of time was provided for comment so the final consultation period was approximately four months. Submissions were received from State departments of agriculture, industry and other parties. All submissions discussed the threat of fire blight but some submissions also highlighted other pests of quarantine concern. The submission from New Zealand's Ministry of Agriculture and Fisheries (MAFNZ) reasserted that apples were not a vector for fire blight and that alternative risk management measures did not therefore need to be considered in the Pest Risk Analysis.

A draft Pest Risk Analysis was released in April 1997 (AQIS, 1997). Comments were sought within 60 days. However, before the expiry of the comment period, it was reported that the

bacterium causing fire blight, *Erwinia amylovora*, was present on two shrubs in the Royal Botanic Gardens, Melbourne. The original two hosts were destroyed and extensive surveys were carried out but no further evidence of fire blight in Australia was found. A summary of the national survey program undertaken and the eradication action taken was released by AQIS on 9 March 1998 (AQIS, 1998b). AQIS announced in March 1998 that reconsideration of the New Zealand proposal was being undertaken and called for any further submissions on the draft Pest Risk Analysis by the end of April 1998.

The draft risk analysis of the New Zealand proposal had been largely completed and was being considered by stakeholders before a new modified risk analysis process developed in response to the Nairn review into quarantine was released (*Australian Quarantine—A shared responsibility—The Government Response*, 1997). The new process included provision for three consultations with stakeholders during the preparation of the Import Risk Analysis (IRA).

On 10 December 1998, AQIS released the draft IRA concerning the importation of apple fruit from New Zealand. During preparation of the draft IRA, AQIS reviewed the available scientific literature, sought opinion from stakeholders, considered all the material provided during the consultation process and followed the International Standards for Phytosanitary Measures, Guidelines for Pest Risk Analysis (ISPM 2) (IPPC, 1996a). The draft IRA determined that fresh apples would not be permitted entry to Australia under the conditions proposed by New Zealand and that this determination complied with Australia's international rights and obligations under the Agreement on the Application of Sanitary and Phytosanitary Measures.

### **Australia's current risk analysis**

New Zealand submitted a new application in January 1999, requesting a review of available risk management options for apples from New Zealand with a view to trade occurring under phytosanitary measures that were the least trade restrictive necessary to meet the level of protection deemed appropriate by Australia. In support of this request, the New Zealand Ministry of Agriculture and Forestry (MAFNZ) stated that the AQIS decision of December 1998 was 'very narrow in focus and did not address off-shore risk mitigation measures'. At this time data were provided in support of cold storage as an effective risk management option for fire blight.

In February 1999 AQIS advised stakeholders that it would conduct a further import risk analysis (IRA) for the importation of apples from New Zealand. AQIS obtained assistance from a range of scientific experts during the risk analysis, including three Australian scientists with acknowledged expertise in the disease, fire blight. AQIS also sought comments from 15 international scientists with specific expertise on fire blight.

### **Formation of Biosecurity Australia**

Changes to the internal structure of the Department of Agriculture, Fisheries and Forestry – Australia (AFFA) resulted in the formation of Biosecurity Australia on 6 October 2000. Biosecurity Australia became responsible, *inter alia*, for the import risk analysis function that was formerly the responsibility of AQIS.

Biosecurity Australia released the draft IRA on apples from New Zealand to stakeholders on 11 October 2000. It recommended the importation of New Zealand apples to Australia subject

to 11 phytosanitary measures including rigorous inspection and disinfection regimes both in orchards, in packing houses and in stores. It was available for public comment for 60 days.

### **Stakeholder comment**

Stakeholders submitted 141 submissions to the draft IRA. Biosecurity Australia compiled the comments and issued, on 20 November 2001, an inventory of the issues raised by stakeholders. Subsequently a Scientific Review Paper was produced on 4 July 2002 and distributed to stakeholders (available on the DAFF web site [www.daff.gov.au](http://www.daff.gov.au)). A two-day workshop was conducted in Melbourne in July 2002. Participants included Australian and New Zealand representatives from State governments, national governments, apple growers and related industries. They provided valuable input to Biosecurity Australia's staff and the IRAT, particularly in defining the proportions and distribution points for apples, waste generation at distribution points and exposure scenarios for susceptible host plants. The information provided at this workshop was incorporated into the methodology used to undertake the individual risk assessments.

### **Senate Committee inquiry and the government response**

On 2 November 2000, the Senate referred the proposed importation of fresh apple fruit from New Zealand to the Senate Committee on Rural and Regional Affairs and Transport Legislation to inquire into 'the administration and management by the Australian Quarantine Service and the Department of Agriculture Fisheries and Forestry Australia's Biosecurity Australia group of all aspects of the consideration and assessment of the proposed importation to Australia of fresh apple fruit from New Zealand'. The committee held 12 hearings covering all apple growing States of Australia. An interim report was released in July 2001 that made 15 recommendations as to procedures that could be adopted during the preparation of the IRA ([http://www.aph.gov.au/senate/committee/rtrat\\_ctte/apples/report/contents.htm](http://www.aph.gov.au/senate/committee/rtrat_ctte/apples/report/contents.htm)). The government response (Government Response to the Recommendations of the Senate Rural and Regional Affairs and Transport Legislative Committee's interim report, March 2003) can be found at [http://www.aph.gov.au/senate/committee/rtrat\\_ctte/nz\\_apples/gresponse.pdf](http://www.aph.gov.au/senate/committee/rtrat_ctte/nz_apples/gresponse.pdf).

## **IMPORT RISK ANALYSIS PANEL FORMATION**

Biosecurity Australia informed stakeholders on 8 October 2001 that a Risk Analysis Panel (RAP) would complete the import risk analysis (IRA) for New Zealand apples. This approach was adopted to utilise more efficiently the available scientific and other expertise and allow more comprehensive attention to stakeholders' concerns. The appointment of seven panel members was confirmed on 10 January 2002 and comprised the following people.

Dr Bill Roberts (Chairman) <sup>5</sup>	Australia's Chief Plant Protection Officer. Department of Agriculture, Fisheries and Forestry.
Mr Bill Hatton	A specialist in fruit production with expertise in growing, packing and shipping various fruit.

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<sup>5</sup> Dr Bill Roberts took up a secondment with the Food and Agricultural Organization (FAO) in Rome for nine months. During this time Mr David Cartwright was appointed acting chair.

Mr David Cartwright	A plant pathologist and Manager Plant Health, Department of Primary Industries and Resources, South Australia.
Dr Kent Williams	Principal Research Scientist, CSIRO Sustainable Ecosystems.
Mr Mike Kinsella <sup>6</sup>	A consultant horticulturist and a former Director of Quarantine and Inspection Services, Victoria.
Mr Ian Armour	An owner and manager of an apple production business.
Dr Brian Stynes	A plant pathologist and General Manager, Plant Biosecurity, Biosecurity Australia.

The panel was initially known as a Risk Analysis Panel (RAP). However, its title was changed to an Import Risk Analysis Team (IRAT) coinciding with the release of the Biosecurity Australia's *Import Risk Analysis Handbook* 2003. The IRAT established two provisional technical working groups to assist it in the pest categorisation of arthropod and pathogen pests. These groups had the following members:

*Provisional technical working group for Arthropods*

The members of this group included:

Dr Kent Williams (Chair)	
Mrs Margaret Williams	Entomologist, Department of Primary Industries, Water and Environment, Tasmania.
Mr Bill Woods	Entomologist, Department of Agriculture, Western Australia.
Mr David Williams	Entomologist, Department of Primary Industries, Victoria.

*Provisional technical working group for Pathogens*

The members of this group included:

Mr David Cartwright (Chair)	
Mr Bill Washington	Plant Pathologist, Department of Primary Industries, Victoria.
Dr Satendra Kumar	Quarantine Plant Pathologist, Department of Agriculture, Western Australia.
Dr Trevor Wicks	Plant Pathologist, South Australian Research Institute.

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<sup>6</sup> On 22 January 2002 BA was informed that Mr Mike Kinsella had passed away. No replacement was sought for this position.

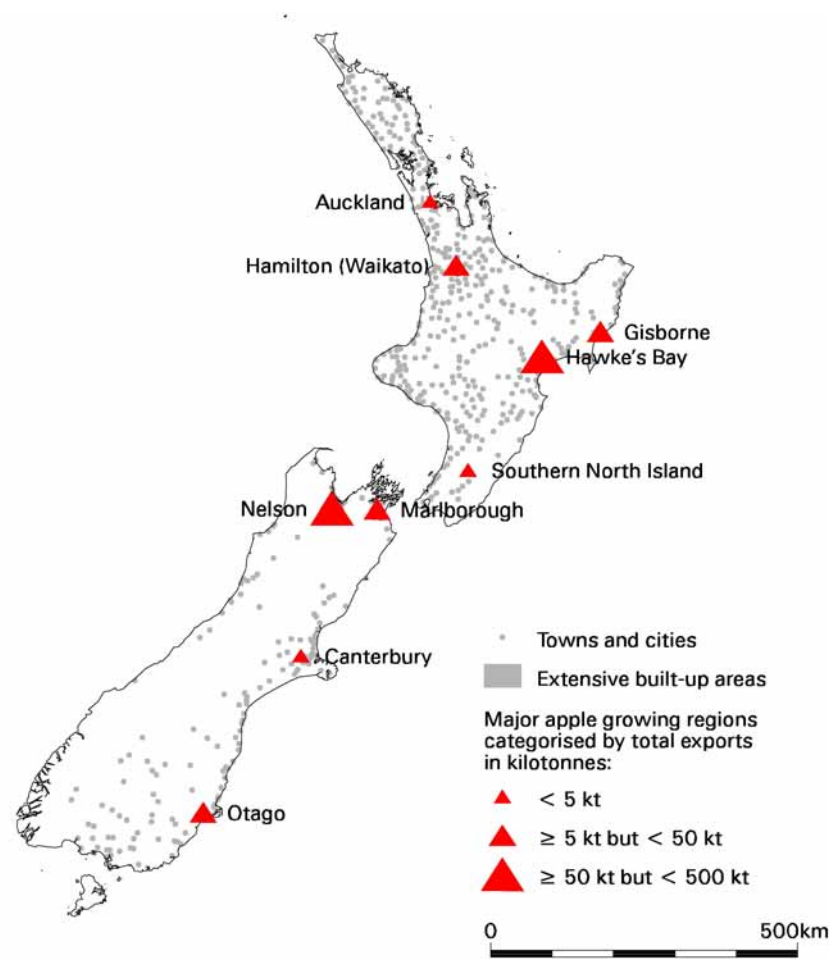


During the preparation of this revised draft IRA the Import Risk Analysis Team (IRAT) undertook a series of face to face meetings and teleconferences. Reports of these meetings were made available to stakeholders.

## THE APPLE INDUSTRY IN NEW ZEALAND

Apples are grown in both North and South Islands of New Zealand and a total of eight different apple-growing districts are involved. These are Auckland/Waikato, Gisborne, Hawke's Bay, Southern North Island, Marlborough, Nelson, Canterbury and Otago (Figure 1). Seventy-nine per cent of the national apple orchards are in the regions of Hawke's Bay and the Tasman (Nelson and Marlborough). Regions with a much smaller production are Canterbury and Otago.

**Figure 1 Major apple growing regions in New Zealand**



### CLIMATIC AND OTHER CONDITIONS NECESSARY FOR APPLE GROWING

The two main regions for apple growing of Hawke's Bay and Nelson are located in the rain shadows of mountain ranges and have a high percentage of cloudless days, long growing seasons and high light intensity (Table 2). The orchards at Hawke's Bay are located on flat ground and have fertile alluvial soils while orchards at Nelson are on low hills where heavier

clay soils predominate. Frost and hail are problems and at times cause considerable damage (<http://www.marketnewzealand.com/home/index/0,1455,SectionID%253D4557%2526ContentID%253D8627,00.html>; accessed 15/02/04, (Market New Zealand., 2004)). In summer, rainfall is low, so irrigation is usually necessary.

**Table 2 Meteorological records for the apple growing regions of New Zealand from 1971 to 2000**

	Rainfall (mm) per year	Wet days per year	Sunshine (hrs) per year	Mean annual temp. (°C)	Max. temp. (°C) per year	Min. temp. (°C) per year	Ground frost (days) per year	Wind (mean speed in km/h per year)	Gale days per year (gusts over 62 km/h)
<b>Auckland</b>	1,240	137	2,060	15.1	30.5	-2.5	10	17	2
<b>Canterbury</b>	648	85	2,100	12.1	41.6	-7.1	70	15	8
<b>Gisborne</b>	1,051	110	2,180	14.3	38.1	-5.3	33	15	1
<b>Hawke's Bay</b>	803	91	2,188	14.5	35.8	-3.9	29	14	4
<b>Marlborough</b>	655	76	2,409	12.9	36.0	-8.8	60	13	2
<b>Nelson</b>	970	94	2,409	12.6	36.3	-6.6	88	12	2
<b>Otago</b>	812	124	1,585	11.0	35.7	-8.0	58	15	3
<b>Southern North Island</b>	967	121	1,733	13.3	33.0	-6.0	38	17	1

Source: (NIWA, 2003).

## APPLE VARIETIES

A number of different varieties of apples are grown commercially in New Zealand but the 13 listed in Table 3 together with the regions in which they are grown are currently dominant.

**Table 3 The main varieties of apples grown in New Zealand**

VARIETIES	Auckland/ Waikato	Gisborne	Hawke's Bay	Masterton/ Wairarapa (Southern North Island)	Marlborough /Nelson	Canterbury /Otago
<b>Braeburn</b>	X	X	X	X	X	
<b>Cox's Orange Pippin</b>					X	X
<b>Fuji</b>	X	X	X	X		X

VARIETIES	Auckland/ Waikato	Gisborne	Hawke's Bay	Masterton/ Wairarapa (Southern North Island)	Marlborough /Nelson	Canterbury /Otago
Gala			X			X
Golden Delicious					X	
Granny Smith	X		X	X		
Pacific Beauty						X
Pacific Queen		X	X			
Pacific Rose	X		X	X	X	X
Pink Lady™			X			
Red Braeburn			X		X	
Red Delicious						X
Royal Gala	X	X	X	X	X	X

Source: (AppleMax, 2003).

## ORCHARD MANAGEMENT

There are two main types of orchard plantings in New Zealand, semi-intensive and intensive. A regime of semi-intensive management is normal and the average size of orchards is small, at around 12 ha per grower. In a semi-intensive orchard, trees are planted at distances of 3 × 5 m on the standard MM.106 rootstock for good soils or Merton 793 rootstock for poorer soils. The tree density used is 600 to 1,250 trees/ha and a wire trellis supports the trees. The majority of trees are pruned to a slender pyramidal shape to allow maximum light penetration to develop fruit colour. This shape uses the available vertical space efficiently and also minimises shading normally present with tall trees (Schupp *et al.*, 2003; Wilton, 2000).

Most tree plantings in the Hawke's Bay region (one of the two main apple growing regions) are semi-intensive, spaced at 5 × 4 m and use MM.106 as the main rootstock. Some newer plantings are on M.26, Mac9, Mark and M.9 rootstocks.

Organic apple growing is well established in New Zealand. Streptomycin application to control fire blight is not permitted and instead other control methods such as application of copper sprays or 'Blossom Bless' and removal of diseased branches are used (MAFNZ, email 17 October, 2003). Biological control agents such as predatory mites to control European red mite (*Panonychus ulmi*) and disease organisms, e.g. *Bacillus thuringiensis* and granulosus virus, to control other pests may be introduced. Techniques such as codling moth mating disruption and attract and kill traps are also used in organic pest management (Daly, 1994). Some chemicals, such as narrow target pyrethrins, are permitted to a limited extent (<http://www.bio-gro.co.nz/files/orchardguide.pdf>) as export standard fruit is difficult to produce without their use (Wearing and Larivière, 1994).

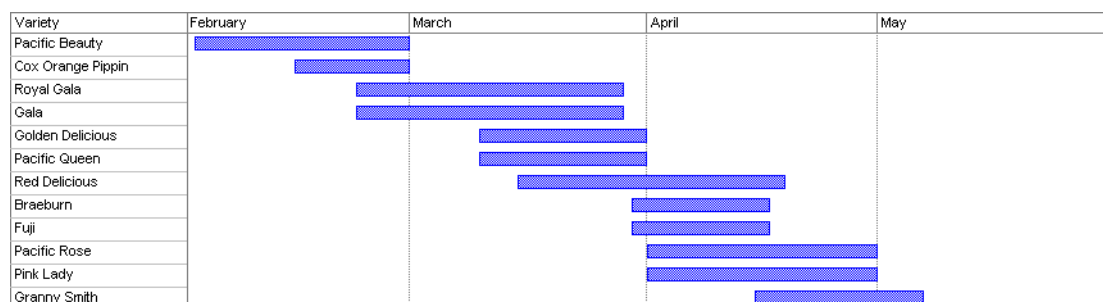
BIO-GRO New Zealand has developed a set of production standards for organic agriculture that are internationally recognised. The Organic Products Exporters of New Zealand Inc. (OPENZ), is a network of businesses, research institutions, consultancies and certifying agencies that provide an organic certification and verification service to organic producers and processors through Certenz, AgriQuality New Zealand's certification business (<http://www.organicnewzealand.org.nz/documents/organicexports2001-02.htm>; accessed August 2003).

## **INTEGRATED FRUIT PRODUCTION (IFP) AND INTEGRATED PEST MANAGEMENT (IPM) SYSTEMS**

The implementation of IFP began in 1996 and became a minimum export standard for New Zealand apples in 2000/01 (Avilla and Riedl, 2003). Between 85 to 90 per cent of growers now comply with IFP requirements and the only ones outside this system are certified or transitional organic producers (MAFNZ, email, 3/10/03)(NZPFI, 2003; MAFNZ, 2004). IFP involves an increased use of biological control agents, regular monitoring to assess pest and disease levels and threshold applications of insecticide. It has resulted in decreases in insecticide, fungicide and water use in orchards applying IFP. Risk assessment models are used to determine the optimum but minimum spray and irrigation regimes. More details are provided in the Horticulture and Food Research Institute of New Zealand Ltd (HortResearch, 2002; NZ Pipfruit-IFP Manual, 2001). The IPM component of IFP does not use broad-spectrum pesticides but uses a limited range of so called 'soft' chemicals, each targeted to a single pest. These formulations are considered benign to beneficial organisms such as predators and parasitoids. A list of these beneficial organisms acting as biological control agents is given at (Hortnet, 2003). A few of them are cultured and applied to orchards during the growing season. All materials applied to an orchard, even nutrients, are recorded in a diary that is an integral part of the audit system (NZPFI, 2003). These spray diaries must be examined by quality controllers before the apples can be packed so that spray responses to disease and pest events experienced by the orchard and maximum residue levels (MRL) in the fruit are compliant with the requirements of destination markets.

## **HARVESTING PROCEDURES**

The picking season extends from early February into May, although varieties differ in their harvesting times (Figure 2). The optimum date for harvesting each variety is determined by testing for maturity using colour, starch pattern, flesh firmness, soluble solids, tritatable acidity and ethylene production. Local laboratories operate in each district for this work (Fresh New Zealand, 2003).

**Figure 2 Harvesting times for apple varieties grown in New Zealand**

Sources: (Hodgies Fresh Fruit, 2002). (ENZAFOODS, 2004)

[http://www.enzafoods.co.nz/apple\\_story/various\\_varieties/](http://www.enzafoods.co.nz/apple_story/various_varieties/) accessed 4Feb. 2004).

Apples are picked by hand and rarely harvested mechanically because of an increased risk of bruising using this method. Pickers place the apples in harvesting bags or sacks. When the bags or sacks are full the apples are put into large, slatted, wooden bins placed on the ground in the orchard and are then transported to the packing house by a forklift truck. To reduce fruit damage, the base pallets of apples are often packed into specialised wooden structures to improve airflow between them.

All apple orchardists are required to apply for a MAFNZ Registered Mark under the amended Regulation 5 of the New Zealand Grown Fruit and Vegetable Regulations 1975 to facilitate the accurate tracing of the origin of all produce. Orchardists may have more than one Mark to enable them to differentiate between orchards or blocks within an orchard.

## PACKING HOUSE AND STORAGE PROCEDURES

All packing houses that pack export fruit must be registered with MAFNZ. Cool store operators and packers must apply for a Mark to use for export apples in order to identify and trace fruit (<http://www.maf.govt.nz/biosecurity/exports/plants/orchardist-registered-mark.htm>; accessed 13/02/04). MAFNZ maintains a register of packing houses, storage facilities and exporters that comply with the set standards for export apples to the USA as well as orchardists, operators and inspectors.

Details of procedures may differ slightly between packing houses, but the general procedure that was used by ENZA (formerly the Apple and Pear Marketing Board) before deregulation of the industry, is described below.

The fruit is delivered in bins to the packing house, where it is first permanently bar-coded and then inspected for quality, pests and diseases. Quality testing involves the monitoring of starch, flesh firmness, brix (sugar) levels, background colour, flavour and texture. These details are recorded and the records sent back to growers. The information is also provided to the packing house as it is relevant to packing and storage.

Packing procedures begin by first dumping the fruit into water for about five minutes to remove dust and any chemical residues. Water used in bin washers, bin dumps, rinses and to make up drench solutions must be certified as potable each year. As a minimum, the water in water dumps must be completely changed either: when it becomes discoloured and/or dirty; at the end of the production week; or, at the end of a production day closest to a cumulative

throughput of 600 field bins, whichever is the lesser period (MAFNZ email, 3/02/04). The fruit then float to the grading and packing lines. After pre-sorting to remove defective 'culls' the fruit may undergo another wash, and, if specified in export requirements, soap, detergents and cleaners, such as chlorine (at a rate of 15–20 ppm in the water dump (MAFNZ email, 3/02/04)), are added to the water. The use of chlorine is optional and varies considerably. Maintaining water dump concentrations of chlorine has been an ongoing issue and has meant more operators have focused on a spray rinse application of chlorine to ensure a more even and accurate application is achieved (MAFNZ email, 3/02/04). This washing process can take place on the risers at which time the fruit is sprayed with water under high pressure, usually at about 552–689 kPa (if the chlorine is used here the rate is 75–100 ppm (MAFNZ email, 3/02/04)), to remove trash and attached insects. Brushing follows to remove any debris still adhering and the fruit is dried.

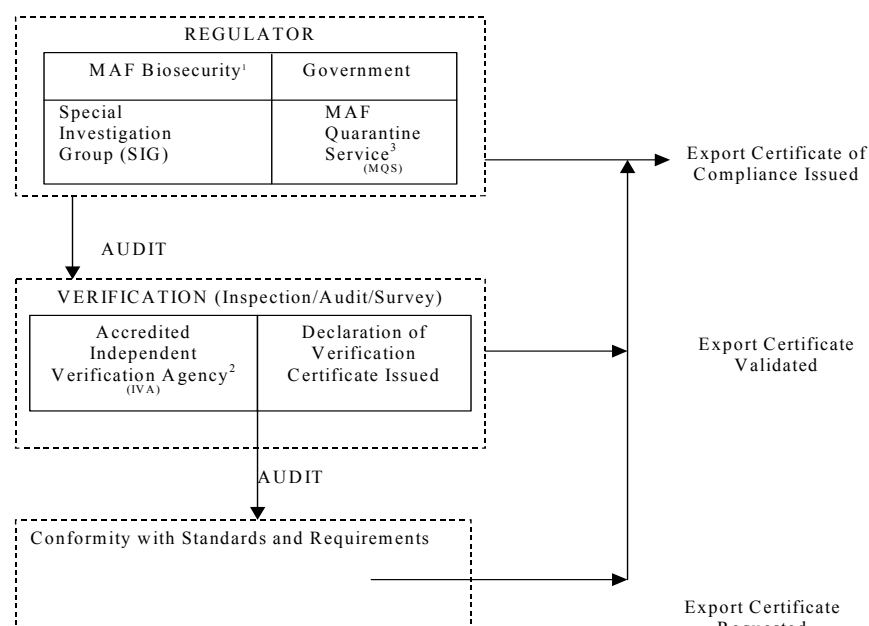
Fruit is then either sorted into export classes, sent for processing or further culled. The grading sizes are specified in detail for each variety in (Fresh New Zealand, 2003). Normally one sorter stands on each side of each table that is kept clean and uniformly lit. Lights on the sorting and packing tables are high CRI fluorescent bulbs illuminated at more than 1,000 lux. Each bulb is sleeved and each light fixture is c. 1 m above the table. The tables are flat with two adjacent belts and the cull shoot all on the same level. Fruit is graded on cosmetic blemishes, uniformity of colour, serious defects and insect damage or presence. The total defects cannot exceed more than six per cent or blemishes more than 1 cm<sup>2</sup> for the top grade apples. The sorters are supervised by the quality controllers who evaluate accuracy and productivity. Grading is sometimes carried out electronically where cameras control fruit colour and size to ensure conformity. In some sheds the cull line from each sorter leads to the quality controllers who examine the culls from each sorter. Sorting is followed by rinsing, drying, polishing and normally waxing. Freshly harvested apples have their own waxy coating that protects them from moisture loss and enhances firmness retention, but washing in the packing house removes about half of the original apple wax. It is replaced with either carnauba, from the Brazilian palm tree, *Copernicia cerifera*, or shellac, from the scale insect, *Kerria lacca*, before packing. Fruit that has been graded passes onto a packing belt where it is sized by weight, placed in trays and the trays placed in the appropriate cartons for export. Packing house stickers identify the farmer, orchard, harvest date, pack date and sugar level. Before leaving the packing house, apples for export may be subsequently randomly sampled and tested by the quality controllers who examine a certain number of boxes of fruit each hour to make sure that export standards are met. In order to assure uniformity of pack, pre-printed cartons and moulded paper trays are used. Polyliners are used for some varieties (Fresh New Zealand, 2003).

The boxes are then palletised and transported to the cold or controlled atmosphere (CA) storages where they are held at 0–2°C, before shipment as predetermined. Cold storages are located in all the growing districts and CA is used in New Zealand for fruit for the domestic market and to extend the marketing season for some export destinations. The packed boxes are stored in pallets of at least 35 boxes each and delivered to storages within 48 hours of harvest. Before entering storage, approximately one per cent of the boxes undergo a mandatory random check by storage quality control officers. Under the regime used by ENZA, if the fruit does not meet export standards or differs from the packing house quality control report, it is returned to the packing house or sent for processing (Kupferman, 1992). Detailed operating procedures for growing, sorting, packing and storing export apples are given in the Fresh New Zealand Manual (Fresh New Zealand, 2003).

CA rooms may hold some 200,000 boxes under forced air-cooling. Fans circulate the air that can pass over the apples by way of the open handholds in the sides of the cartons. Fruit packed without polyliners is cooled within 24 hours. It takes twice as long to cool fruit with polyliners. Once cooled, the fruit is transferred to a holding area for shipment. Grower and packing house (i.e. carton and pallet card identification) numbers accompany the fruit from orchardist to the customers' warehouses and through the marketing channels to its destination where it can be checked. Organic apples require slightly different packing house procedures with more careful washing of fruit with the high-pressure apple washer and the use of an organic-only packing house (Kupferman, 1992).

MAFNZ approved officers certify the fruit is acceptable for export and attach a phytosanitary certificate. A new model was adopted for the certificates in November 2002. **(Figure 3)**.



**Figure 3 MAFNZ Plant Biosecurity model for Export Phytosanitary Certification****MAF PLANTS BIOSECURITY MODEL FOR EXPORT PHYTOSANITARY CERTIFICATION**

<sup>1</sup>. MAF Biosecurity is also responsible for developing and maintaining import standards covering New Zealand's zoo-sanitary and phytosanitary biosecurity interests.

<sup>2</sup>. Such as AgriQuality New Zealand Societe Generale de Surveillance (SGS).

<sup>3</sup>. MQS is primarily responsible for providing national technical inspection and clearance services for incoming overseas passengers, cargo, vessels, aircraft and mail as well as performing import phytosanitary inspections of plants and plant products. It is also responsible for the maintenance and control of forest, plant and animal quarantine and containment facilities.

**MAF Biosecurity** is responsible for:

- ascertaining and negotiating importing countries' phytosanitary requirements,
- developing export certification operational standards (in consultation with Industry),
- accrediting IVA's and operator's systems, staff and facilities
- managing audits of the certification process, and
- providing official phytosanitary assurances (certificates) for produce complying with the importing country's phytosanitary requirements.

**MQS** signs certificates verified by a MAF accredited IVA, inspects and certifies private, non-commercial export shipments.

**SIG** carries out audits of verification agencies and certification processes to ensure conformity to the export certification standards.

**IVAs** assess and verify that MAF accredited industry operator's inspection systems meet MAF certification standards, importing country phytosanitary requirements and provide a certificate verification service. IVAs also undertake product inspection, and surveys for pests.

**PMAC** is responsible for:

- In consultation with MAF Plants Biosecurity (Exports) developing export certification standards,
- Funding through levies the maintenance of an export certification system.

**Industry operators** (e.g. exporters) are responsible for meeting MAF export certification standards and importing countries' phytosanitary requirements.

Source: (MAFNZ, 2003d)

### INDUSTRY ORGANISATION AND MARKETING

New Zealand apple growers are represented by Pipfruit Growers New Zealand Incorporated (or PGNZI). Its subsidiary, New Zealand Pipfruit Limited is affiliated with the New Zealand Fruit Growers' Association and is funded by a commodity levy on growers.

There are now 28 approved exporters of apples from New Zealand to the USA, six approved inspection facilities, three in Hastings, two in Nelson and one in Havelock North. There were 28 approved storage facilities in 2003: one each in Blenheim, Dunedin, Havelock North, Roxburgh, Stoke, Te Puke and Whakatu; two each in Mount Maunganui and Nelson; seven in Hastings; and, ten in Motueka. Some companies are privately owned and provide a range of post harvesting facilities including running several types of controlled atmosphere and cool stores as well as organising the logistics and marketing of apples to export markets. Fresh New Zealand 2000 is a new company with very detailed instructions on operations for export produce (Fresh New Zealand, 2003);

<http://www.maf.govt.nz/biosecurity/exports/plants/certification/pipfruit/usda-exporters.htm>; accessed August 2003).

### EXPORTS

A high proportion of New Zealand's total apple production, 50–62 per cent, is exported. Apples comprise 15 to 20 per cent of all horticultural exports from New Zealand and in 2002, 59 countries imported New Zealand apples, an increase in destinations of 24 per cent from 2001. Europe, North America and Asia are the main destinations for exported New Zealand apples and supplies to Europe and North America can be made in their off-season. Because some varieties of apple can be stored for long periods with minimal spoilage, sales can continue on both domestic and world markets all year round. Exports of fully certified organic apples comprise nearly one million cartons per annum. The individual countries and regions to which New Zealand apples are sent are listed in Table 5 together with the value of apples, if more than NZD5 million, exported in 2002 to each country ([http://www.maf.govt.nz/mafnet/rural-nz/statistics-and-forecasts/sonzaf/2002/sonzaf-02-32.htm#P3411\\_190090](http://www.maf.govt.nz/mafnet/rural-nz/statistics-and-forecasts/sonzaf/2002/sonzaf-02-32.htm#P3411_190090); accessed August, 2003).

The main regions exporting apples in 1999 were Hawke's Bay (49 per cent) and Nelson (37 per cent). The percentage of exports from these regions has only slightly increased in 2002/03 rising to 52 per cent and 41 per cent respectively (MAFNZ email, 3/10/03). The main varieties have not altered in recent years. Braeburn (at about 40 per cent) and Royal Gala (at about 34 per cent) were the two top varieties chosen by retailers in North America in 2002 (World Apple Review 2003., 2003). The combined total percentage of these two main varieties of the total exported has increased slightly in 2002/03 from 74 to 87 per cent. Total carton equivalents exported in 1999 were 17.457 million (Table 4), an increase from the previous year. In 2003, the volume of total carton equivalents is estimated to be over 330 thousand tonnes (over 18 million cartons), again an increase (MAFNZ email, 3/10/03). The figures presented in Table 4 are the most current figures available from MAFNZ.

**Table 4 New Zealand apple varieties and apple exports for 1999 in ,000 carton\* equivalents**

	Hawke's Nelson Marlborough Otago Waikato Gisborne Southern Canterbury Auckland										
	Bay						N.I. <sup>a</sup>			TOTAL <sup>b</sup>	
Braeburn	3,603	2,499	333		208	187	142	129	47	10	7,159 (41.0)
Royal Gala	3,230	1,846	236		126	144	165	62	22	11	5,842 (33.5)
Fuji	697	429	99		75	8	21	27	5	3	1,363 (7.8)
Cox Orange	98	725	49		60	-	-	4	7	-	943 (5.4)
Granny Smith	244	309	5		41	18	-	12	-	19	649 (3.7)
Pacific Rose	203	80	34		19	3	7	18	1	-	363 (2.1)
Gala	145	126	12		3	687	6	4	-	2	300 (1.7)
Southern (Pacific) Rose	106	117	-		-	18	-	5	-	-	246 (1.4)
Red Delicious	77	30	5		113	94	-	4	few	-	229 (1.3)
Pink Lady	54	35	few		12	14	4	few	-	few	120 (0.4)
Other	108	115	9		-	2	3	2	few	few	240 (1.4)
TOTAL <sup>c</sup>	8,567	6,313	781		658	394	348	268	82	46	17,457 <sup>c</sup>
Percentage	(49.1)	(36.2)	(4.5)		(3.8)	(2.3)	(2.0)	(1.5)	(0.5)	(0.3)	

\*Cartons are 18 kg in weight.

<sup>a</sup> Southern North Island.

<sup>b</sup> Figures within brackets are percentages of the grand total and are subject to rounding error.

<sup>c</sup> 17,457,110 tray carton equivalents is approximately 314,228 metric tonnes of apples.

Source: (MAFNZ, 2000a).

Organic apple and pear exports reached over half a million cartons in the 2001 season, about 10 per cent of total pome fruit exports. The current organic varieties exported are Braeburn, Red Delicious, Granny Smith, Fuji, Fiesta, Gala, Royal Gala, Regal Gala, Galaxy and Moonlight. Apples are available in count sizes; 70, 80, 90, 100, 110, 120, 135, 150, 165 with

a net weight per carton of 18 kg. A standard 20 ft [6.1 m] reefer container (palletised) carries 476 cartons and a high cube 40 ft [12.2 m] reefer container (palletised) carries 1,176 cartons.

**Table 5 Countries and regions to which New Zealand apples are exported, value of exports and percentage of total exports**

Country/region	Value of exports NZD million	Percentage of total
UK	95	23
USA	77	19
Netherlands	32	8
Germany	26	6
Taiwan	17	4
Malaysia	14	3
China (Hong Kong)	11	2
Singapore	11	2
Middle East	8	1
other Asian countries	8	1

*Source: Horticulture Facts and Figures 2002 published by HortResearch (HortResearch, 2002).*

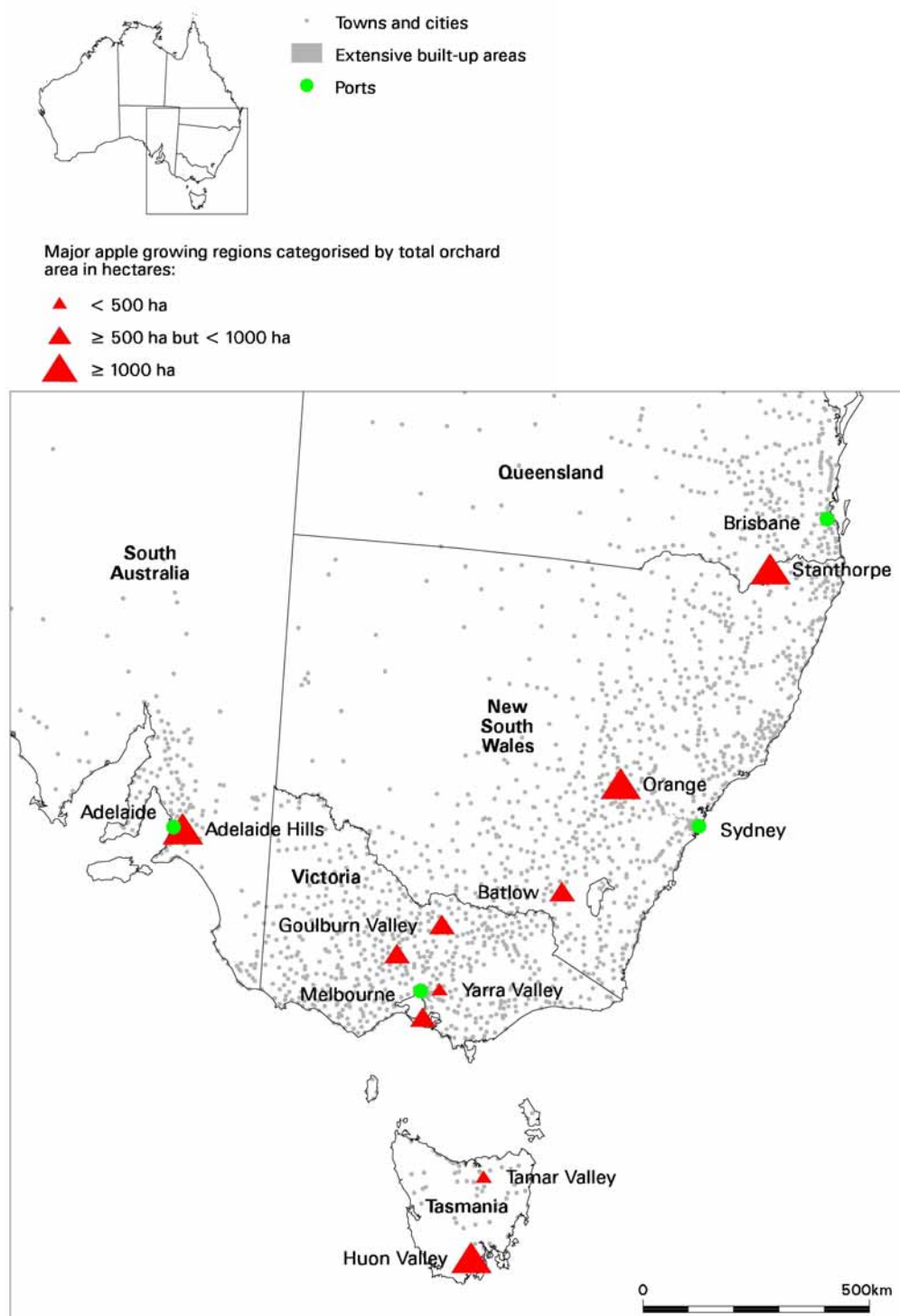
Fruit is taken directly from cold storage to the dock when needed for shipment and sent ‘break bulk’ (in individual cartons in the ship’s hold) on refrigerated ships. Some ships have CA generators on board and there are mobile CA units that can be carried on vessels carrying exports. Once the vessel arrives at its destination, the CA unit is airfreighted back to New Zealand. The journey to markets in Europe takes one month.

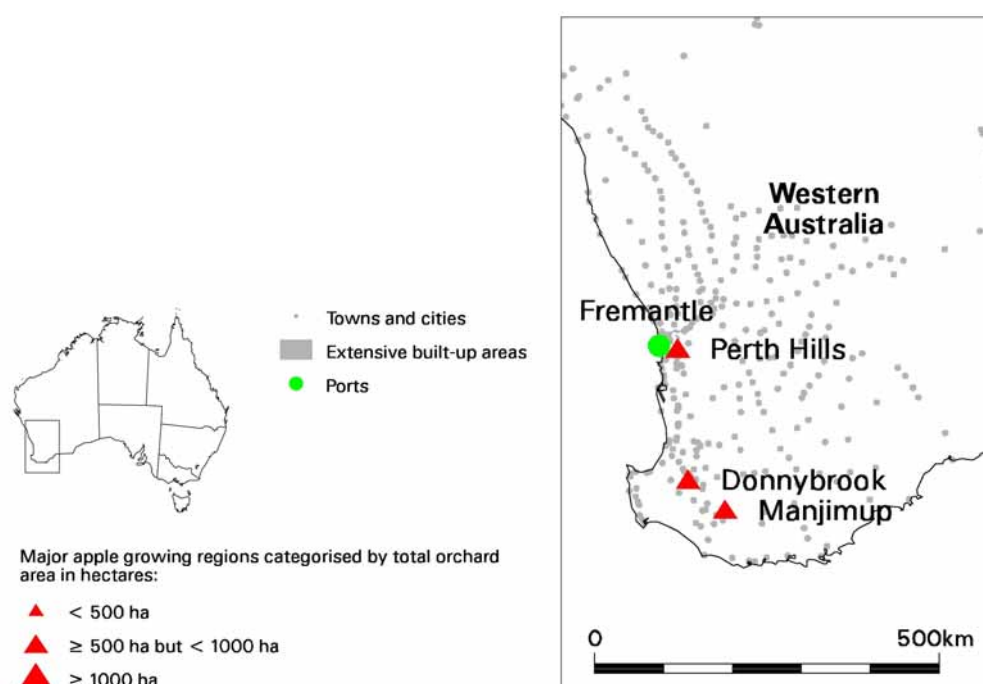
## **THE APPLE INDUSTRY IN AUSTRALIA**

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Apples are grown commercially in six States of Australia, New South Wales, Queensland, South Australia, Tasmania, Victoria and Western Australia and to a limited extent in the Australian Capital Territory. The main growing regions are Stanthorpe in southern Queensland, Orange and Batlow in New South Wales, the Goulburn Valley (Shepparton, Kyabram, Tatura and Cobram) and the Yarra Valley in Victoria, the Huon Valley, the Tamar Valley and Spreyton in Tasmania, the Adelaide Hills in South Australia (Figure 4), and the Perth Hills, Donnybrook and Manjimup in Western Australia (Figure 5).

**Figure 4 Apple growing regions in eastern Australia**



**Figure 5 Apple growing regions in Western Australia**

## CLIMATIC AND OTHER CONDITIONS NECESSARY FOR APPLE GROWING

The climatic variables for the main apple growing districts in Australia are given in Table 6.

**Table 6 Meteorological records for the main apple growing regions of Australia from 1971–2000**

	Annual rainfall (mm)	No. of wet days per year	Sunshine (hrs) per day	Mean temp. at 3 pm (°C)	Max. temp. at 3 pm (°C)	Min. temp. at 3 pm (°C)	Mean wind speed at 3 pm (km/hr per year)	Maximum wind gust (km/h) per year
Stanthorpe	784	111	n.c.	17.9	20.5	9.0	9.4	33.5
Orange	949	108	7.5	15.0	17.7	7.1	12.0	n.c.
Batlow (Tumbarumba)	986	109	n.c.	17.0	18.6	4.9	8.4	n.c.
Goulburn Valley (Tatura)	493	103	7.4	20	21.2	8.4	13.8	27.7
Bacchus Marsh	505	116	n.c.	n.c.	21.6	7.2	n.c.	n.c.
Huon Valley (Grove)	753	162	5.5	15.4	17.0	5.8	9.0	n.c.
Adelaide Hills	1,118	156	n.c.	16.3	17.8	8.6	15.3	n.c.

	Annual rainfall (mm)	No. of wet days per year	Sunshine (hrs) per day	Mean temp. at 3 pm (°C)	Max. temp. at 3 pm (°C)	Min. temp. at 3 pm (°C)	Mean wind speed at 3 pm (km/hr per year)	Maximum wind gust (km/h) per year
<b>(Stirling)</b>								
<b>Manjimup</b>	1,023	158	6.1	19.1	20.3	9.6	10.9	n.c.
<b>Donnybrook</b>	987.5	135	n.c.	22.0	23.0	9.6	16.0	n.c.
<b>Perth Hills (Kalamunda)</b>	1,069	114	n.c.	21.8	22.6	12.0	n.c.	n.c.

*n.c.* = not collected.

Source: © Copyright Commonwealth of Australia 2003, Commonwealth Bureau of Meteorology (CBM, 2003).

## APPLE VARIETIES

The major apple varieties (55 per cent of production) grown in Australia have traditionally been Red Delicious, Jonathon and Granny Smith. However, newer varieties such as Gala, Fuji, Pink Lady™ (variety name of Cripps Pink) and Sundowner™ (variety name of Cripps Red), now account for 34 per cent of total production. Plantings of Pink Lady™ are increasing, currently standing at nearly 20 per cent of all plantings and growing at the rate of two per cent a year. However, Granny Smith and Red Delicious still constitute about 50 per cent of production.

## INTEGRATED FRUIT PRODUCTION (IFP) AND INTEGRATED PEST MANAGEMENT (IPM) SYSTEMS

Integrated Fruit Production has been defined as the economical production of high quality fruit giving priority to adopting ecologically safer methods that reduce or eliminate undesirable effects on the environment and human health. This involves using agrochemicals that are narrowly focussed and applied only when necessary so that their use is minimised. It appears that most growers practice components of IFP but often would not have a formal IFP system with record keeping (Williams, 1999).

Over the past 15 years new orchard management techniques have reduced pesticide use, and whole farm planning is being increasingly adopted together with IPM and IFP programs that include biological control techniques. It is expected that IFP will be adopted by 2005. This includes consideration of remnant native vegetation and suitable siting of buildings, tracks, dams and windbreaks to minimise environmental impact. IPM techniques include the use of low volume sprays, higher density plantings, ground cover plants to provide nectar and pollen for parasitoids and predators and a reduction in chemical usage. IFP requires that pest management decisions be based on the results of monitoring populations and the use of specific rather than broad-spectrum pesticides. The Australian industry agreed to reduce pesticide use by 75 per cent by the year 2000 and, in 2002, it was reported that 80 per cent of growers nationally were using IPM. Williams (1999) gives the percentages of growers



adopting various IFP guidelines in a survey conducted in 1999. The number of sprays per year had been reduced by 30 per cent, the use of broad spectrum insecticides had been replaced by 'soft', more targeted chemicals including mating disruptants, the control of insects by pheromone-trapping had increased, and also predators and parasitoids were being encouraged (Williams, 1999).

## EXPORTS

In 2000, Australia exported 9.9 per cent (37,000 t) of its apple crop at a value of AUD30 million but this is only about 0.8 per cent of total world exports and a tenth that of exports from New Zealand. Fresh apple exports are focused on the premium markets of the UK and the rest of Europe, and the bulk markets of south-east Asia. The major export markets for Australian apples in the 1970s used to be the United Kingdom but are now concentrated in south-east Asia, including Malaysia, India, and Singapore with minor markets being Sri Lanka, Bangladesh, Indonesia, Philippines, China (Hong Kong), Taiwan, Fiji and Papua New Guinea (Table 7). Because of its fruit fly free status, only apples from Tasmania are permitted to be exported to Japan.

**Table 7 Exports of Australian apples for the 2001/02 financial year showing volume of exports to each country**

Destination	2001 (,000 tonnes)	2000/01 (value AUD) <sup>7</sup>	2002 (,000 tonnes)
USA	0	0	116
Malaysia	7,749	9,477	5,244
India	5,495	5,599	5,244
Singapore	3,920	4,718	2,848
UK <sup>8</sup>	3,369	9.507 <sup>2</sup>	2,234
Sri Lanka	2,975	3,442	3,639
Bangladesh	2,355	2,257	1,381
China (Hong Kong)	1,510	1,654	577
Taiwan	1,382	1,530	1,327
Indonesia	968	1,478	739
Japan	945	808	n.a.
Papua New Guinea	0	0	459
Others	3,189	4,464	2,137
<b>Total</b>	<b>33,857</b>	<b>44,934</b>	<b>25,920</b>

Source: (USDA, 2003a).

<sup>7</sup> Figures from the (Australian Horticultural Corporation., 2002).

<sup>8</sup> The value of exports to the United Kingdom in relation to weight is higher than for other countries because only high value varieties are exported to this country.

## **APPLE IMPORTS TO AUSTRALIA**

The only fresh apples currently permitted entry to Australia are Fuji apples from Japan. Preclearance by AQIS inspectors is a requirement and a phytosanitary certificate must accompany each shipment with details of source orchards, dates of packing, fumigation and cold disinfestation treatment among other details. Joint monitoring by AQIS and Japanese quarantine officers of the effectiveness of the treatments is required (AQIS, 2003). No trade has yet taken place.

## ORGANIC WASTE MANAGEMENT IN AUSTRALIA

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Organic waste is discussed throughout this IRA as it is important in the consideration of exposure of pests and pathogens to susceptible hosts. Discarded apples and apple cores or peel are most likely to be disposed of into landfill or used for composting. Bruising is a major reason for rejection of apples. It has been estimated that 40 per cent of bruising occurs in the field, 40 per cent during grading and 20 per cent during transportation (Funt *et al.*, 1999).

The main form of waste disposal in Australia is landfill, which accounts for over 95 per cent of solid waste disposal in some States and Territories (Australia State of the Environment Report., 2001).

Commercial and industrial wastes typically contribute 10–20 per cent of the total urban solid waste stream. The primary sources of commercial and industrial wastes are commercial establishments and non-biodegradable wastes from industrial and manufacturing processes. Solid waste from this sector has a very wide range of composition that arises from packaging, food and hospitality industries, and manufacturing (Australia State of the Environment Report., 2001).

In the Australian Capital Territory (ACT), food and kitchen garbage comprise 20 per cent by weight of the waste stream from commercial and industrial collections (The Next Step in the No Waste Strategy., 2000). A small fraction of commercial and industrial wastes are currently reused or recycled, the majority being either stockpiled or disposed of in landfill (Australia State of the Environment Report., 2001).

Approximately 40 per cent of all solid wastes are municipal or council wastes, much of it from domestic households (Australia State of the Environment Report., 2001). The national diversion rate of domestic waste from landfill is 19.8 per cent. Should all potentially recyclable materials be recovered from the waste stream, the highest possible diversion rate achievable would be 43.1 per cent. If green waste, which accounts for 20.2 per cent of the waste stream is included in collection systems the potential diversion increases to 63.3 per cent (National Recycling Audit and Garbage Bin Analysis, 1997).

The rate of domestic waste generated cannot be determined accurately because there is a discrepancy between waste generation and waste disposal. Waste data generally relates to quantities disposed of or collected for off-site recycling. Therefore, domestic wastes that are re-used on-site, such as garden wastes used in composting, are not quantified (Australia State of the Environment Report., 2001).

The average Australian household generates 15.7 kg of waste for collection each week. This consists of 11.9 kg of garbage, 3.1 kg of recyclables, 0.2 kg of contamination and 0.5 kg of green waste. The single largest component of the waste stream is organic material (green and food wastes), totalling 43.5 per cent (23.4 per cent food and 20.1 per cent green waste). (National Recycling Audit and Garbage Bin Analysis, 1997).

The information above indicates that about 50 per cent of waste going into landfills is solid organic waste from households and the food and hospitality industry. Removal of organic material from the waste stream would result in significant diversion of waste from landfill (National Recycling Audit and Garbage Bin Analysis, 1997). An example of a waste reduction strategy being implemented in Australia is the Australian Capital Territory's (ACT) *No Waste by 2010* strategy. In 1998/99 food and kitchen waste from domestic and

commercial and industrial sources accounted for 18 per cent of waste being disposed of in ACT landfills. Surveys on the composition of domestic waste in the ACT have shown that food and kitchen wastes comprise 52 per cent of the weight of garbage in domestic bins (The Next Step in the No Waste Strategy., 2000).

As local councils implement waste reduction programs, it is more likely that discarded apple cores, as part of food waste, will end up being collected in an organic collection service for reprocessing into a useable garden product (Household Organic Material Collection Trial., 2001), or else composted. The Chifley trial results showed that about 60 per cent of household organic material can be collected for reprocessing and thereby removed from the waste stream. In the ACT this would mean that about 17,035 of the 28,392 tonnes of food and kitchen waste being disposed of in landfills could be diverted from going into landfill (The Next Step in the No Waste Strategy., 2000).

## METHOD FOR IMPORT RISK ANALYSIS

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The technical component of an import risk analysis for plants or plant products is termed a ‘pest risk analysis’, or PRA.

A PRA is carried out in three discrete stages.

- Stage 1: Initiation of the PRA.
- Stage 2: Pest risk assessment.
- Stage 3: Pest risk management.

### STAGE 1: INITIATION OF THIS PRA

This PRA was initiated by a request from New Zealand in January 1999 for Australia to review its policy for the importation of mature apple fruit (*Malus × domestica* Borkhausen). It builds upon an analysis completed in December 1998 of the risks associated with the ‘unrestricted’ importation of New Zealand apples, and a further analysis, completed and circulated in draft form in October 2000.

### STAGE 2: PEST RISK ASSESSMENT

The process for pest risk assessment in this IRA can be broadly divided into four interrelated steps.

- Pest Categorisation.
- Assessment of the probability of entry, establishment or spread.
- Assessment of consequences.
- Combining the probability of entry, establishment or spread with consequence to estimate the risk.

The method used for these four steps is described in detail in the next section *Method for Pest Risk Assessment*.

### STAGE 3: PEST RISK MANAGEMENT

Risk management describes the process of identifying and implementing measures to mitigate risks so as to achieve Australia’s appropriate level of protection, or tolerance for loss, while ensuring that any negative effects on trade are minimised. Appropriate level of protection is considered a societal value judgement that reflects the maximal risk (or expected loss) from a disease incursion that Australia considers acceptable.

To implement risk management appropriately, it is necessary to understand the difference between ‘unrestricted’ and ‘restricted’ risk estimates. Unrestricted risk estimates are those derived in the absence of any risk management, or using only internationally accepted baseline risk management strategies. In contrast, restricted or mitigated risk estimates are those derived when ‘risk management’ is applied.

The result of the 'risk assessment' for New Zealand apples will be an unrestricted risk estimate for each of the identified pests of quarantine concern. This will be compared with Australia's appropriate level of protection, as the band of cells associated with a 'very low' risk in Table 1 in the Biosecurity Framework section. This step is termed 'risk evaluation'. An unrestricted risk that is either 'negligible' or 'very low' will meet Australia's appropriate level of protection and will be considered 'acceptable'. In this situation, risk management would not be justified. However, where an unrestricted risk is 'low', 'moderate', 'high' or 'extreme' risk management measures will be identified and applied and, for each of these, the 'restricted' risk will be re-calculated.

## METHOD FOR PEST RISK ASSESSMENT

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This section describes the following four steps that make up pest risk assessment.

- Pest categorisation.
- Assessment of the probability of entry, establishment or spread.
- Assessment of consequences.
- Combining the probability of entry, establishment or spread with consequence to estimate the risk.

### PEST CATEGORISATION

Pest categorisation is a process to examine, for each pest, whether the criteria in the definition of a quarantine pest are satisfied; that is, whether the pests identified should be considered as either ‘quarantine pests’, or not. The objective of pest categorisation is, therefore, to screen a large and frequently unmanageable list of potential quarantine pests, before doing the more in-depth examinations within the risk assessment proper.

The International Plant Protection Convention (IPPC, 2003) defines a quarantine pest as ‘*a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled*’.

An endangered area is ‘*an area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss*’.

### Elements in the categorisation of a pest

ISPM 11 Rev. 1 (IPPC, 2003) states that the categorisation of a pest as a quarantine pest includes the following primary elements.

- Identity of pest.
- Presence or absence in PRA area.
- Regulatory status.
- Potential for establishment and spread in PRA area.
- Potential for economic consequences in PRA area.

The explanations for these elements are provided in the ISPM 11 Rev.1 and are cited below.

### Identity of pest

The identity of the pest should be clearly defined to ensure that the assessment is being performed on a distinct organism, and that biological and other information used in the assessment is relevant to the organism in question. If this is not possible because the causal agent of particular symptoms has not yet been fully identified, then it should have been shown to produce consistent symptoms and to be transmissible.

The taxonomic unit for the pest is generally species. The use of a higher or lower taxonomic level should be supported by scientifically sound rationale. In the case of levels below the species, this should include evidence demonstrating that factors such as differences in

virulence, host range or vector relationships are significant enough to affect phytosanitary status.

In cases where a vector is involved, the vector may also be considered a pest to the extent that it is associated with the causal organism and is required for transmission of the pest.

### **Presence or absence in PRA area**

The pest should be absent from all or a defined part of the PRA area or under official control.

### **Regulatory status**

If the pest is present but not widely distributed in the PRA area, it should be under official control or expected to be under official control in the near future.

Official control of pests presenting an environmental risk may involve agencies other than the National Plant Protection Organisation (NPPO). However, it is recognised that ISPM No. 5 Glossary of phytosanitary terms, Supplement No. 1 on official control, in particular Section 5.7, applies.

### **Potential for establishment or spread in PRA area**

Evidence should be available to support the conclusion that the pest could become established or could spread in the PRA area. The PRA area should have ecological/climatic conditions, including those in protected conditions, suitable for the establishment and spread of the pest. Where relevant, host species (or near relatives), alternate hosts and vectors should be present in the PRA area.

### **Potential for consequences in PRA area**

There should be clear indications that the pest is likely to have an unacceptable economic impact (including environmental impact) in the PRA area.

Unacceptable economic impact is described in ISPM No. 5 Glossary of phytosanitary terms, Supplement No. 2: *Guidelines on the understanding of potential economic importance and related terms*.

### **Process used in this IRA**

Based on the above elements, the pest categorisation was carried out in six categorisation steps as described below.

- Step 1 Compilation of species lists.
- Step 2 Presence or absence within Australia.
- Step 3 Potential for being on pathway.
- Step 4 Potential for establishment or spread<sup>9</sup>.
- Step 5 Potential for consequences.

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<sup>9</sup> Note that IPPC (2003) uses 'establishment and spread' but the SPS Agreement uses 'establishment or spread' which is followed in this IRA.



- Step 6 Final categorisation.

### **Step 1 Compilation of species lists**

Species listed as being associated with apple fruit or apple orchards in New Zealand were derived from three sources. These included lists provided by New Zealand (MAFNZ, 1999a; MAFNZ, 2000b; MAFNZ, 2002b), literature research by Biosecurity Australia and comments provided by stakeholders on the draft IRA (Biosecurity Australia, 2000). Consolidated lists of 325 arthropod and mollusc species and 117 pathogens were compiled, and are provided in Part B of this document.

### **Step 2 Presence or absence within Australia**

Each species recorded in step 1 was assessed for presence within Australia by reviewing published records, checklists and catalogues, various pest and disease databases, and consulting relevant specialists. Species were classified as:

- ‘Yes’ if present in Australia;
- ‘Yes\*’<sup>10</sup> if present but not widely distributed and being officially controlled or where regional freedoms exist within Australia;
- ‘No’ if there was no evidence of its presence in Australia; or,
- ‘Uncertain’ if the organism is not identified to species level.

### **Step 3 Potential for being on the pathway**

Only species categorised as ‘No’, ‘Uncertain’ or ‘Yes\*’ in step 2 were assessed for their potential to be on the pathway.

The potential of a species for being on the pathway was categorised as ‘Likely’ or ‘Not likely’. Table 8 provides the criteria used to assess the potential of a species to be on the pathway.

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<sup>10</sup> Yes\* indicates that the species is present but not widely distributed and being officially controlled or where regional freedoms exist within Australia.

**Table 8 Criteria for categorisation of the potential of a species to be on the pathway**

Potential for being on pathway	Description of criteria	Arthropod examples	Pathogen examples
Likely	The species would be likely to be on the pathway if at least one life stage: (i) lives in or on mature apple fruit; or, (ii) has been intercepted on fresh fruit exported from New Zealand*.	Codling moth, apple leafcurling midge, leafroller larvae, burnt pine longhorn beetle	Fire blight, European canker, apple scab
Not likely	The species would be unlikely to be on the pathway if: (i) it is not found on mature apple fruit (but may be found on other parts of the apple plant); or, (ii) it has no life stage associated with apple transportation including packaging and pallet materials; or, (iii) it has not been intercepted on fresh fruit exported from New Zealand.	Bailey's apple rust mite, pine knot borer	Crown gall, Pythium root rot

*\*This is based on the records in the Pest and Disease Information (PDI) Database (Jan. 1986 to June 2003) (DAFF-PDI, 2003) maintained by DAFF (Plant Biosecurity).*

#### **Step 4 Potential for establishment or spread**

The potential for establishment or spread was assessed as 'Feasible' only for those species rated as 'Likely' in step 3, as explained in Table 9.

**Table 9 Criteria for categorisation of the potential of a species for establishment or spread in the PRA area**

Potential for establishment or spread	Description of criteria
Feasible	<p>All species rated as 'Likely' in step 3 will have the potential for establishment or spread in the PRA area. This is because:</p> <ul style="list-style-type: none"> <li>(i) New Zealand's climate varies from warm subtropical in the far north to cool temperate in the far south. Similar conditions exist in the PRA area—Australia—which has tropical, subtropical, temperate and cool temperate conditions;</li> <li>(ii) apples are grown in many parts of Australia and ecological conditions in these areas are similar to those of New Zealand, or environmental conditions are ameliorated by cultural practices; and,</li> <li>(iii) potential alternative hosts would also be present in Australia.</li> </ul>

### Step 5 Potential for consequences

The potential for consequences was assessed only for species with the rating of 'Likely' for potential for being on pathway and 'Feasible' for potential for establishment or spread. The potential for consequences was categorised as 'Significant' or 'Not significant'. The criteria for these categories are set out in Table 10.

**Table 10 Criteria for categorisation of the potential of a species for consequences**

Potential for consequences	Description of criteria	Arthropod examples	Pathogen example
Significant	The species would have potential for consequences in the PRA area if: (i) it has been reported as a pest; or, (ii) it is known to be polyphagous; or, (iii) it is known to be a vector of a disease.	Apple leafcurling midge, brownheaded leafroller	Fire blight
Not significant	The species would not exhibit potential for consequences in the PRA area if: (i) it has been reported only as a scavenger, or secondary feeder on fungi or bacteria; or, (ii) it is a potential biocontrol agent and is known to attack pest species only.	Fungus beetles, platygasterid parasitic wasp	

### Step 6 Final categorisation

The final outcome of pest categorisation is to determine if the species needs to be considered further. Thus the question ‘Consider species further?’ was answered as ‘Yes’, ‘Yes\*’<sup>11</sup> or ‘No’.

A species was not required to be considered further in the analysis if it was assessed as being present in Australia, or it was absent from Australia but was rated as ‘Not likely’ for its potential for being on the pathway, or ‘Not significant’ for its potential for consequences. It should be noted that, for some species that are not present in Australia, even if the answer to the question ‘Consider species further’ is ‘No’ in this import risk analysis, they may still be potential quarantine pests for Australia. This is because the species may be not likely to be on pathway for importation of New Zealand apples but could be a candidate for importation on other commodities.

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<sup>11</sup> ‘Yes\*’ indicates that the species is present but not widely distributed and being officially controlled or where regional freedoms exist within Australia.

## **ASSESSMENT OF THE PROBABILITY OF ENTRY, ESTABLISHMENT OR SPREAD**

Stages in the entry, establishment or spread of a pest are illustrated in Figure 6.

Under this terminology, the ‘probability of entry’ describes the probability that a quarantine pest will enter Australia as a result of trade in a given commodity, be distributed in a viable state to an endangered area, and subsequently be transferred to a suitable host. The probability of entry may be divided for administrative purposes into the following components:

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

*The probability of distribution:* the probability that the pest will be distributed (as a result of the processing, sale or disposal of the commodity) to the endangered area, and subsequently be transferred to a susceptible host<sup>12</sup>.

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

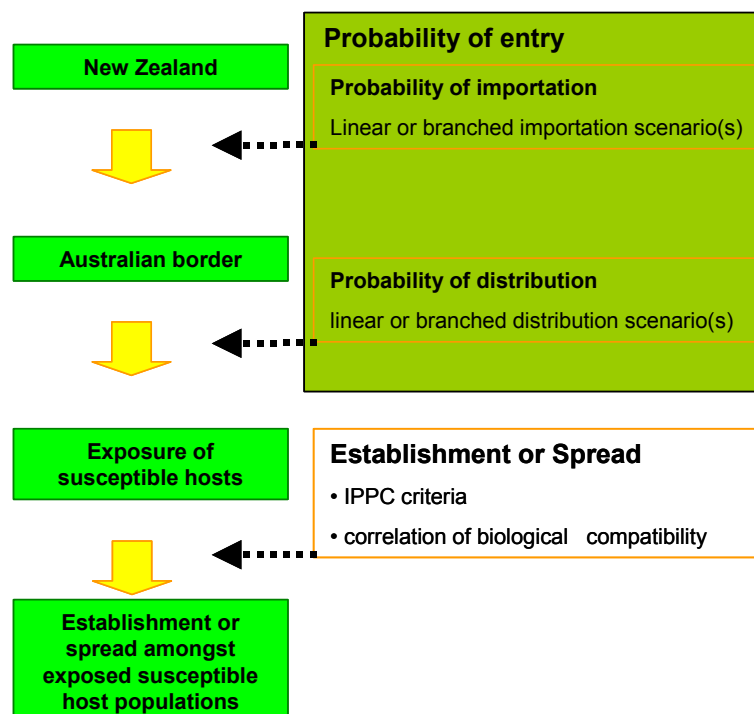
The probability of importation and the probability of distribution are obtained from pathway scenarios depicting necessary steps in the sourcing of the commodity for export, its processing, transport and storage, its utilisation in Australia, and the generation and disposal of waste. Scenarios for importation and distribution are described in detail in separate discussions (see Probability of Importation and Probability of Distribution).

The ‘probability of establishment or spread’ encompasses biological factors associated with the likelihood that a pest will successfully propagate on or in that host, and disperse from there to other populations of susceptible hosts. The probability of establishment or spread is obtained from an examination of biologic factors associated with compatibility of the host and environment, and the availability of necessary mechanisms for dispersal. These factors are summarised in the ISPM 11 Rev.1, and will be described in detail in a separate discussion (see Probability of Establishment or Spread).

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<sup>12</sup> Biosecurity Australia denotes ‘transfer’ in this context to describe the exposure of a suitable site on a suitable host to a sufficient dose of a pest to initiate infection.

**Figure 6 Stages in the entry, establishment or spread of a pest**



## **Evaluating and reporting likelihood**

Many of the steps relevant to the importation and utilisation of apple fruit, and the disposal of fruit waste can be evaluated as probabilities or likelihoods. This section discusses the approach taken in this import risk analysis.

## **The quantitative likelihood model**

A quantitative likelihood model was used in this import risk analysis to represent pathways relevant to the importation and utilisation of apple fruit, the disposal of fruit waste, and the possible exposure of susceptible host plants in Australia.

The quantitative model provided the following four important technical facilities:

- a framework upon which to base the logical structure of each assessment;
- evaluation of the effect of the ‘volume of trade’ during a specified period;
- accommodation of ‘uncertainty’ or ‘natural variation’ in the likelihood estimate assigned to individual steps in pathways; and
- use of ‘sensitivity analysis’ to identify critical steps in each scenario, and thus focus information needs and (where relevant) risk management.

**A framework upon which to base the logical structure of each assessment**

Assessments in this import risk analysis were carried out according to carefully described importation and distribution scenarios and a rigorous evaluation of consequences. This logical structure allowed the various elements to be combined transparently and consistently.

**Evaluation of the effect of the ‘volume of trade’ during an extended period**

It is to be expected that the longer the period of time there is trade in a commodity, the likelihood of at least one introduction of a pest or disease will increase. Because the volume of trade in an extended period affects likelihood, it will also affect risk and, by extension, will be important to the concept of appropriate level of protection (ALOP), the benchmark against which risk is compared.

**Accommodation of uncertainty or natural variation in the likelihood estimate assigned to individual steps in pathways**

One of the requirements of an assessment in which elements are quantified is that any uncertainty or natural variation in individual estimates should be incorporated. This is important because quantitative assessments may otherwise appear to convey a degree of ‘precision’ that is not present in either the underlying science, or in the model parameter being estimated.

**The use of ‘sensitivity analysis’ to identify critical steps in each scenario, and thus focus information needs and (where relevant) risk management**

Sensitivity analysis is a procedure that can be performed using the output from a quantitative assessment. In this context, sensitivity analysis ranks the model variables (in this case, either step likelihoods, or other variables such as test sensitivity that are used to calculate step likelihoods) according to their correlation with the output.

Estimates for variables that were strongly correlated with the model output were as robust as possible. In some situations, it was important to identify such variables and, where they could not be estimated with assurance, to re-model using extreme values or probability distributions above and below those that are believed to be most realistic. These manual re-analyses are termed ‘sensitivity simulations’, and provided a means by which to determine whether a lack of precise knowledge might lead to misrepresentation of the final risk.

**Representing qualitative expert judgements and quantitative data**

The probability assigned to each step in the quantitative model was estimated and subsequently represented using one of two interchangeable approaches:

- a simple Uniform probability distribution representing a *qualitative* expert judgement of probability, or likelihood, interpreted as a range of probabilities; or,
- a more precise probability distribution representing *quantitative* data or other scientific evidence on a probability, or on estimates of other numeric quantities such as counts and volumes.

## Representing qualitative expert judgments

Quantitative data was not always available to support estimation of many of the probabilities assigned to the pathway steps considered in this analysis. Likelihoods assigned to these steps were subsequently based on expert judgements, and modelled using the qualitative likelihoods described in Biosecurity Australia's *Guidelines for Import Risk Analysis* (2001)<sup>13</sup> (See Table 11).

The 0–1 probability interval was divided into six likelihoods (Table 11) to ensure consistency in usage and interpretation, and to provide a framework under which the likelihoods can be logically and transparently combined. Events considered almost certain to occur were assigned a likelihood of 1.

**Table 11 Nomenclature for qualitative likelihoods, corresponding semi-quantitative probability intervals and their probability distributions**

Likelihood	Descriptive definition	Probability interval	Midpoint	Probability distribution
High	The event would be very likely to occur	$0.7 \rightarrow 1$	0.85	$L \sim \text{Uniform}(0.7, 1)^{14}$
Moderate	The event would occur with an even probability	$0.3 \rightarrow 0.7$	0.5	$L \sim \text{Uniform}(0.3, 0.7)$
Low	The event would be unlikely to occur	$0.05 \rightarrow 0.3$	0.175	$L \sim \text{Uniform}(0.05, 0.3)$
Very low	The event would be very unlikely to occur	$0.001 \rightarrow 0.05$	0.0255	$L \sim \text{Uniform}(0.001, 0.05)$
Extremely low	The event would be extremely unlikely to occur	$10^{-6} \rightarrow 0.001$	0.0005005	$L \sim \text{Uniform}(10^{-6}, 0.001)$
Negligible	The event would almost certainly not occur	$0 \rightarrow 10^{-6}$	0.0000005	$L \sim \text{Uniform}(0, 10^{-6})$

The boundaries adopted for qualitative likelihoods are those described in the Biosecurity Australia *Guidelines for Import Risk Analysis*. In choosing these boundaries, it was important to provide a system that could be adopted by those experts whose task it was to review scientific evidence and estimate likelihoods. It was also important to ensure that the categories were neither overly precise nor constrictive; nor so broad as to lose the precision that may have been present in the original body of scientific evidence. Accepting these requirements, it was *not* critical that the categories were of equal width, or that they were assigned according to a predefined arithmetic or logarithmic scale. Overall, the emphasis was on useability and, once defined, a system that would enable experts to use the corresponding terms and

<sup>13</sup> Available at: <http://www.affa.gov.au/>

<sup>14</sup> This abbreviated syntax for likelihood (L) should be read as '*L is distributed uniformly between 0.7 and 1*'.



definitions (Table 11) consistently, and for stakeholders to be clear on the meaning of the likelihood terms used.

Likelihoods described under this nomenclature were subsequently combined using a spreadsheet-based simulation model. The model was constructed in Microsoft Excel<sup>15</sup> and run using the spreadsheet add-on software @Risk<sup>16</sup>. This was achieved by representing each of the six semi-quantitative likelihood categories as a 'Uniform probability distribution' (abbreviated 'Uniform distribution'). A Uniform distribution (also called a Rectangular probability distribution) is one that has a maximum and minimum value, but for which each value in the continuous spectrum of values between these limits occurs with the same probability.

The parameters of each of these six Uniform distributions (their maximum and minimum values) were obtained from the boundaries of the corresponding probability category, as shown in Table 11.

An example of a Uniform distribution for a 'very low' likelihood (L) with minimum value of 0.001 and a maximum value of 0.05 is shown in Figure 7. Using the notation explained above, this distribution can be written in shorthand as  $L \sim \text{Uniform}(0.001, 0.05)$ .

Thus, a likelihood described by an expert presented with the descriptors and probability ranges shown above as 'very low', will be represented using a Uniform probability distribution with parameters, minimum = 0.001 and maximum = 0.05.

This would imply that the true likelihood might fall anywhere in the range 0.001 to 0.05, but that no particular value in this range is considered by the analyst to be more likely than any other.

Where qualitative likelihoods were to be combined, the rules shown in Table 12 were used. The rules in the matrix are, by definition, arbitrary and were derived by combining the 'midpoints' of the corresponding semi-quantitative probability intervals (Table 11) as specified in the *Guidelines for Import Risk Analysis*.

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<sup>15</sup> © 2003, Microsoft Corporation, USA.

<sup>16</sup> © 2003, Palisade Corporation, USA.

**Table 12 A matrix of ‘rules’ for combining descriptive likelihoods**

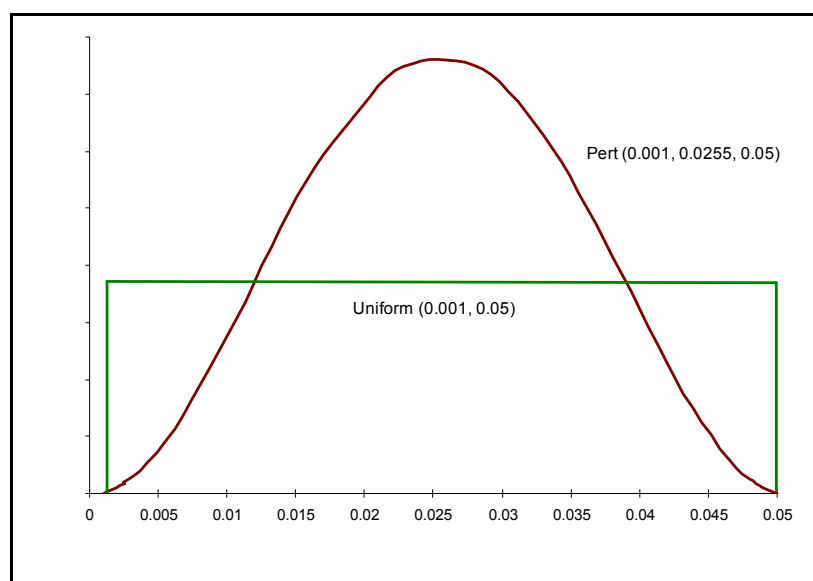
	High	Moderate	Low	V. low	E. low	Negligible
High	High	Moderate	Low	V. Low	E. Low	Negligible
Moderate		Low	Low	V. Low	E. Low	Negligible
Low			V. low	V. Low	E. Low	Negligible
V. low				E. Low	E. Low	Negligible
E. low					Negligible	Negligible
Negligible						Negligible

### Representing quantitative data

Quantitative data on a probability, or on estimates of other numeric quantities such as import volume, was modelled either as a point estimate or, more commonly, as a probability distribution. The shape and parameters of this distribution depend on the nature of the variable being modelled and the completeness of available data. The Pert distribution (a special case of the Beta distribution) was used in the case of volume of apples likely to be imported.

The Pert distribution has three parameters, its minimum, most likely and maximum values. The advantage of the Pert distribution over the very simple Uniform distributions described above is that it allows values that are considered more likely to occur to be modelled as such. The distribution may resemble the familiar ‘bell curve’ although, unlike the Normal distribution upon which the bell curve is based, it need not be symmetrical and can be limited or constrained to any designated maximum and minimum values.

An example of a Pert distribution for a likelihood (L) with a minimum value of 0.001, a most likely value of 0.0255 and a maximum value of 0.05 is shown in Figure 7. Using the notation explained above, this distribution can be written in shorthand as  $L \sim \text{Pert}(0.001, 0.0255, 0.05)$ .

**Figure 7 Uniform and Pert probability distributions****Probability of entry****Probability of importation****Steps in the importation scenario**

The ‘biological pathway’, or ordered sequence of steps undertaken in sourcing, processing and exporting a commodity up to the point where it is released from quarantine by the importing country, is termed its ‘importation scenario’. The initiating step for the importation scenario for apple fruit is the sourcing of apples from orchards in New Zealand, whereas the end-point is ‘the arrival in Australia’ of infected or infested fruit or packaging materials. In this context, ‘arrival in Australia’ is taken to mean the release of imported apples from the port of entry—whether this is an airport or a shipping port.

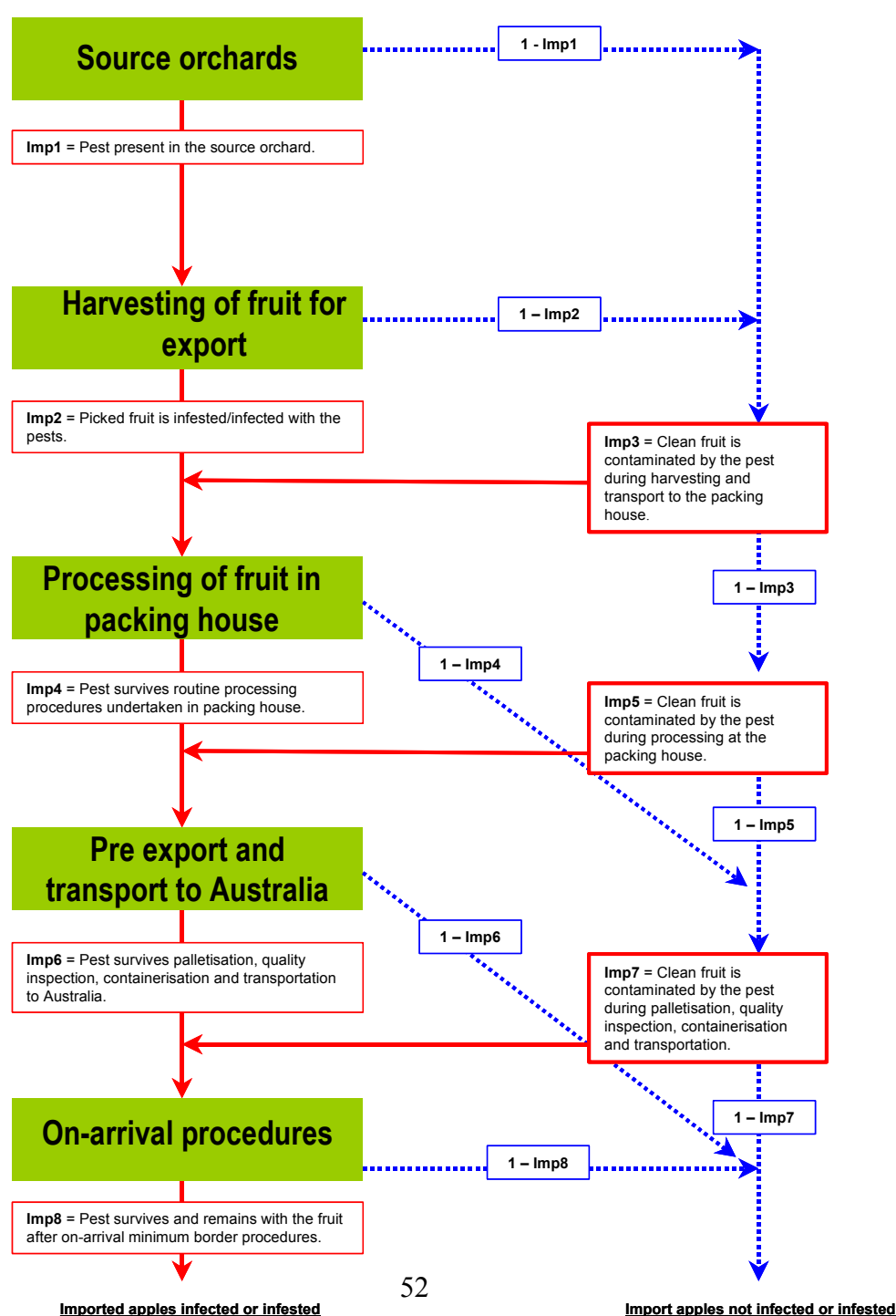
Biosecurity Australia held a two-day workshop with stakeholders to identify the various steps and processes associated with importation of New Zealand apples into Australia and distribution within Australia. A schematic representation of the simplified importation scenario for apple fruit is presented in Figure 8. Probabilities assigned to steps in the importation scenario (labelled Imp1–Imp8 in Figure 8) were evaluated and reported quantitatively, or using the terms and definitions in Table 11. In each case the likelihood at each step represents the probability that infection or infestation will not be detected or removed at that step, or that the pest will not be destroyed.

Importation steps are summarised below. Note that, because the pathways include the opportunity for contamination of clean fruit, the importation scenario is not a simple sequence following Imp1 to Imp8.

- Importation step 1 (Imp1): pest is present in the source orchard.
- Importation step 2 (Imp2): picked fruit is infected or infested.
- Importation step 3 (Imp3): clean fruit is contaminated during picking or transport to the packing house.

- Importation step 4 (Imp4): pest survives routine processing procedures in the packing house.
- Importation step 5 (Imp5): clean fruit is contaminated during processing in the packing house.
- Importation step 6 (Imp6): pest survives palletisation, quality inspection, containerisation and transportation to Australia.
- Importation step 7 (Imp7): clean fruit is contaminated during palletisation, quality inspection, containerisation and transportation.
- Importation step 8 (Imp8): pest survives and remains with the fruit after on-arrival minimum border procedures.

**Figure 8 Importation scenario for apple fruit from New Zealand**



The following section on importation steps broadly describes the guidelines followed in allocating likelihoods for the eight Imp steps. Details considered in deciding these likelihoods are given in the individual risk assessments for the different pests.

### ***Importation step 1 (Imp1)***

The likelihood assigned to the first importation step represented the prevalence of orchards in New Zealand that are infected or infested with a given pest. Prevalence was weighted by the relative volume of export quality apples produced by each orchard, so that, for example, the infection or infestation of smaller orchards is not given an importance higher than appropriate to this analysis.

The prevalence of infected or infested orchards was determined largely by four groups of factors, climate and environment, orchard management, varietal susceptibility and pest epidemiology. In most cases, these groups of factors interrelated and, as a result, there are areas within New Zealand within which the prevalence of infection or infestation is higher, and areas within which prevalence is lower or, in some cases, in which the pest is known to be absent. Information available on these aspects was considered in determining the likelihood for this step.

### ***Importation step 2 (Imp2)***

The likelihood assigned to the second importation step represented the various factors that determine the prevalence of infection or infestation amongst picked apples. Because this likelihood was inherently complex, it was approached in each pest risk assessment systematically by considering the following questions where information was available.

- *How likely is infestation or infection of apple fruit at the time of picking?*
- *How likely is infestation or infection on an individual block within an infected or infested orchard?*
- *How likely is infection or infestation on each tree on an infected or infested block?*
- *How likely is the pest to be on or in apple fruit selected from an infected or infested tree?*

### ***Importation step 3 (Imp3)***

The likelihood assigned to the third importation step represented factors relevant to the ability of each pest to persist in or on bins, other containers, or equipment used to transport apples to the packing house.

Some pathogens may lead to the production of infective materials, such as ooze or damaged flesh, that can be rubbed off on the surface of bins, persist in a stable form, and subsequently infect the next batch of apples. Alternatively, the ability of some arthropods to move freely amongst apples or within the environment may influence their likelihood to persist in inadequately cleaned bins, or to contaminate clean bins in the field.

### ***Importation step 4 (Imp4)***

The likelihood assigned to the fourth importation step represented the ability of a pest to survive in or on apples after routine processing, packing and cold storage before transport. For many pests, this likelihood was dictated largely by whether the surface of fruit was infected or

infested, or whether the pest lived inside the fruit. External pests are likely to be more vulnerable to physical (e.g. washing and brushing) and chemical (e.g. dips and waxing) treatments.

Because this likelihood is inherently complex, it was approached in each pest risk assessment systematically by considering the following where relevant information was available.

- *How likely is the pest's survival after post-harvest treatments and temporary cold storage?*
- *How likely is the pest's survival after flotation dump?*
- *How likely is the pest's survival after high-volume/high-pressure washing?*
- *How likely is the pest's survival after brushing?*
- *How likely is the pest's survival, or the persistence of infected or infested fruit, after sorting and grading?*
- *How likely is the pest's survival after fruit waxing?*
- *How likely is the pest's survival after cold storage of fruit before transport?*

### ***Importation step 5 (Imp5)***

The likelihood assigned to the fifth importation step represented factors associated with the ability of a pest to persist within the environment of the packing house and thus to contaminate clean fruit. These factors largely reflected the characteristics of the pest—in particular, its tolerance of the physical, chemical and thermal processes used in the packing house and its ability to move amongst apples. Other considered factors reflected the quality management practices within packing houses, the most important being adherence to rigorous hygiene practices at steps such as water baths or brushing where contamination may be most likely to occur.

### ***Importation step 6 (Imp6)***

The likelihood assigned to the sixth importation step represented factors relevant to the ability of each pest to survive routine practices used during palletisation, quality inspection, containerisation and refrigerated transport to Australia. These factors included the physical characteristics of each pest, its resilience to a range of temperatures, aspects of its life cycle, and the nature of its infection or infestation of apple fruit.

### ***Importation step 7 (Imp7)***

The likelihood assigned to the seventh importation step represented factors relevant to the ability of a pest to contaminate fruit during palletisation, quality inspection, containerisation and refrigerated transport to Australia. These factors reflected the tolerance of each pest to the physical and thermal processes, and its ability to move amongst apples or amongst cartons or bins.

### ***Importation step 8 (Imp8)***

The final step in the importation scenario represents the likelihood that the pest will survive and remain with fruit after on-arrival minimum border procedures.

The factors considered here related only to the minimum border procedures used by relevant government agencies. There is some AQIS inspection, such as verification of the commodity as described in the shipping documents, verifying external and internal contamination of containers and their packaging. Possible AQIS on-arrival inspection for quarantine pests associated with apples is not considered in the assessment of unrestricted risk. Wood packaging and dunnage such as pallets from New Zealand are subject to a full unpack and quarantine inspection and treatment if necessary at an appropriate quarantine approved premises, or are subject to a pre-shipment or on-arrival treatment (AQIS, 2000).

### ***Projected volume of trade in New Zealand apples***

The amount of apple fruit that might be imported from New Zealand if importation was to proceed for a prescribed period without phytosanitary restrictions is an important factor in estimating the probability of importation. The period that was chosen for the purpose of this analysis was 12 months. This applies only to the time of importation and does not mean that examination of issues associated with the development of a pest incursion, or with the longer-term impact of a pest, was restricted to 12 months.

Because there is no existing trade in apple fruit from New Zealand, the volume of apples that might be imported during 12 months was difficult to estimate. The difficulty was compounded by the fact that trade in apple fruit will not necessarily be limited to a single clearly defined market. For example, apples might be imported in packed cartons for table consumption, but might also be imported in bulk bins for repacking or for processing into fruit juices or other products. The size of these markets would be dictated by many interrelated factors, including the supply of and demand for apples within Australia and the cost of shipment, and by any price differential between production of apples in Australia and New Zealand.

In this IRA, the experts assumed a market penetration of 20 per cent of the domestic fresh market if New Zealand apples were allowed in. Based on this, the most likely number of individual apples that may come into Australia was calculated as follows.

Total Australia Production for 2002 (Australian Bureau of Statistics, 2003)	=	325,500 Tonnes
Amount utilised for processing	=	40%
	=	130,200 Tonnes
Exports for 2002	=	25,920 Tonnes
Balance domestic fresh fruit	=	169,380 Tonnes
	=	9,410,000 cartons (18 kg each)
20 % of domestic fresh fruit	=	1,882,000 cartons
20% of domestic fresh fruit as individual fruits (assuming an average count per carton of 100)	=	188,200,000 apple fruit
	=	Approximately 200 million apples

This information was entered into the simulation model as a Pert distribution  $L \sim \text{Pert}(100000000, 200000000, 400000000)$ . Where certain pests were of concern to Western Australia (WA) only, the volume of apples likely to be imported into WA was estimated as one-tenth of the above figures, based on the proportion of the Australian population in WA (1.9 million) compared with 19.4 million in whole of Australia.

### Calculating the probability of importation

The calculations focussed on the proportion of imported fruit that may be infected or infested with each pest. From this, and from an analysis of the projected volume of trade in New Zealand apples (see below), the expected number of apples that might be infected or infested with each pest was calculated.

The probability of importation was an estimate derived from a spreadsheet-based simulation of the probabilities at each step in the importation scenario. The calculation was based on the probability that an individual imported apple will be infected/infested. If it can be assumed that the infection status of an individual apple is largely independent of other apples, then this will approximate the proportion of imported apples that is infected/infested<sup>17</sup>. From this, and from an analysis of the projected volume of trade in New Zealand apples (see above), the expected number of apples that might be infected/infested with each pest was calculated. An individual apple fruit was chosen as the 'unit' for the analysis because calculation of the 'proportion', 'volume' and 'number' of imported apples that might be infected/infested will be most accurate if based on likelihoods ascribed to the same unit of analysis.

Calculation of number of infected or infested apples that might be imported during 12 months,  $\text{No. imported}_{\text{infected}}$ , is tabulated in Table 13. This table shows that the probability of importation was derived from probabilities attributed to ten individual pathways that lead to the importation of infected or infested fruit. These pathways, numbered 1 to 10, were obtained from an analysis of the importation scenario in Figure 8.

The overall probability that an imported apple was infected/infested was the sum of the probabilities associated with each individual pathway. This calculation makes the simplifying assumption that relatively few fruit will be rejected or removed through detection of the pest or the lesions it produces on apple fruit.

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<sup>17</sup> Individual imported apples would not always be infested or infected independently (for example, apples derived from a single tree or block). However, because the volume of imported apples is, without restrictions, likely to be very large, the probability of infection or infestation in one apple will provide a reasonable approximation for the proportion of infected or infested apples.



**Table 13 The number of infected or infested apples that might be imported during 12 months**

Likelihood	Description and calculation
<b>No. imported<sub>infected</sub></b>	<b>The number of infected or infested apples that might be imported during 12 months</b> $= \text{Annual volume} \times P_{\text{Importation (apple)}}$
<b>Annual volume</b>	<b>The number of apples that might be imported into Australia during 12 months</b> 100,000,000 = Minimum 200,000,000 = Most likely 400,000,000 = Maximum
<b><math>P_{\text{Importation (apple)}}</math></b>	<b>The probability that an individual imported apple will be infected or infested</b> $= \text{Path1} + \text{Path2} + \text{Path3} \dots \text{Path10}$
Path1	The probability that an apple fruit will follow pathway 1 $= \text{Imp1} \times \text{Imp2} \times \text{Imp4} \times \text{Imp6} \times \text{Imp8}$
Path2	The probability that an apple fruit will follow pathway 2 $= (1-\text{Imp1}) \times \text{Imp3} \times \text{Imp4} \times \text{Imp6} \times \text{Imp8}$
Path3	The probability that an apple fruit will follow pathway 3 $= (1-\text{Imp1}) \times (1-\text{Imp3}) \times \text{Imp5} \times \text{Imp6} \times \text{Imp8}$
Path4	The probability that an apple fruit will follow pathway 4 $= (1-\text{Imp1}) \times (1-\text{Imp3}) \times (1-\text{Imp5}) \times \text{Imp7} \times \text{Imp8}$
Path5	The probability that an apple fruit will follow pathway 5 $= (1-\text{Imp1}) \times \text{Imp3} \times (1-\text{Imp4}) \times \text{Imp7} \times \text{Imp8}$
Path6	The probability that an apple fruit will follow pathway 6 $= \text{Imp1} \times (1-\text{Imp2}) \times \text{Imp3} \times \text{Imp4} \times \text{Imp6} \times \text{Imp8}$
Path7	The probability that an apple fruit will follow pathway 7 $= \text{Imp1} \times (1-\text{Imp2}) \times (1-\text{Imp3}) \times \text{Imp5} \times \text{Imp6} \times \text{Imp8}$
Path8	The probability that an apple fruit will follow pathway 8 $= \text{Imp1} \times (1-\text{Imp2}) \times \text{Imp3} \times (1-\text{Imp4}) \times \text{Imp7} \times \text{Imp8}$
Path9	The probability that an apple fruit will follow pathway 9 $= \text{Imp1} \times (1-\text{Imp2}) \times (1-\text{Imp3}) \times (1-\text{Imp5}) \times \text{Imp7} \times \text{Imp8}$
Path10	The probability that an apple fruit will follow pathway 10 $= \text{Imp1} \times \text{Imp2} \times (1-\text{Imp4}) \times \text{Imp7} \times \text{Imp8}$

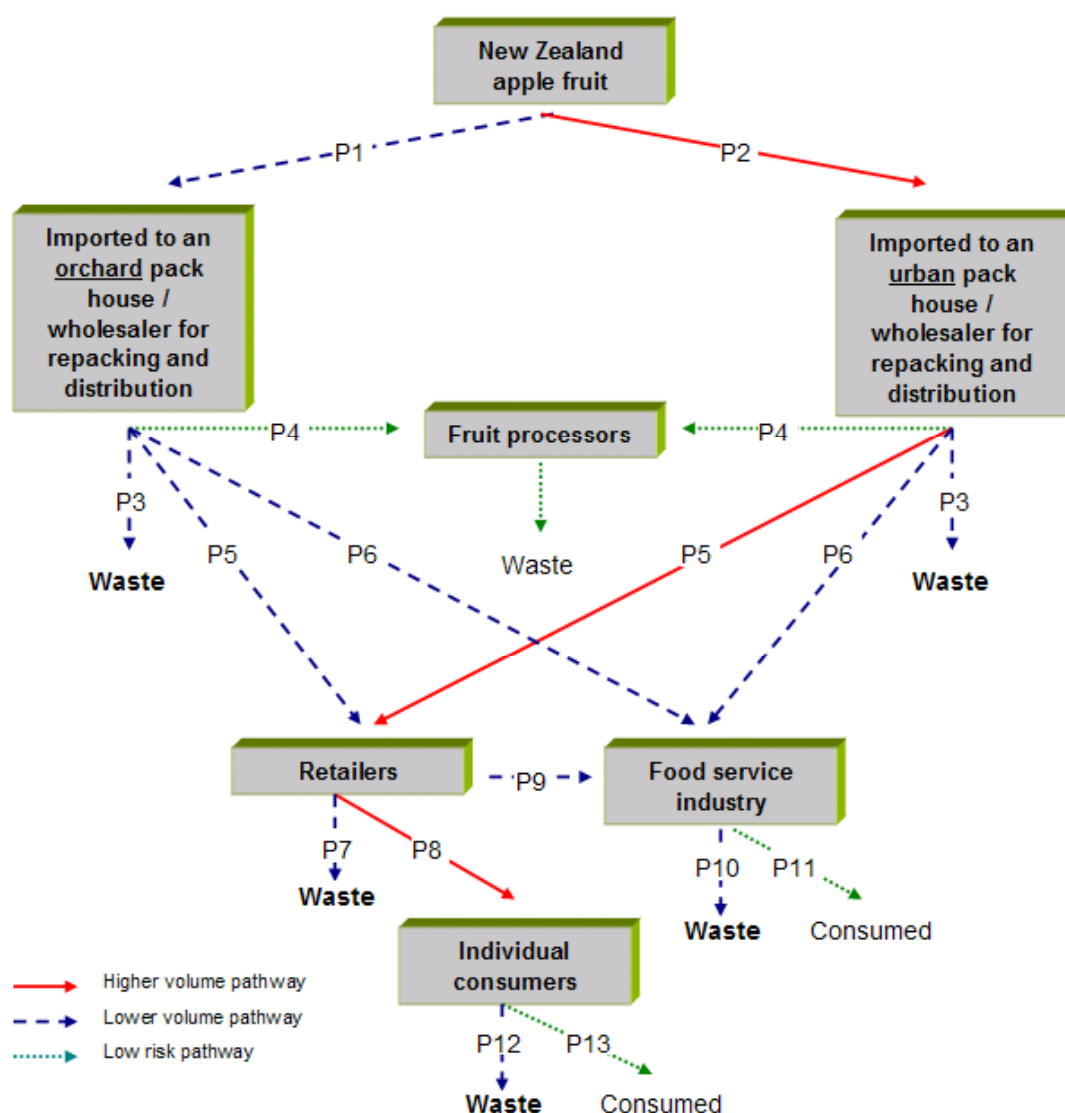
## **Probability of distribution**

### **Utilisation of apple fruit in Australia and generation of waste**

The purpose of this part of the risk analysis is to identify and quantify as far as is practical the likely pattern of distribution and utilisation of imported apple fruit, and the generation and disposal of apple waste. The pathways of distribution, utilisation and waste generation incorporating the outcomes of the workshop with stakeholders are shown in Figure 9. There are five key points (termed '*utility points*') at which apples are distributed or utilised and at which apple waste will be generated. These include two pathways from importers/wholesalers (which have been delineated because of the proximity of orchard-based premises to high-density commercially grown fruit), to retailers, then to the food service industries and finally to individual consumers. Although included in the diagram, fruit processors were considered an end point for imported fruit because neither fruit products, nor the processed and concentrated waste generated during the manufacture of fruit juices and other products are considered a significant phytosanitary risk.

The proportion of imported apples that may be channelled through each of these utility points and the proportion that might subsequently be discarded whole or in part as apple waste are calculated below.

The characteristics of fruit distribution and vendor practices, and of waste disposal at the various utility points, are discussed in general terms in the text below. The implications of each for the likelihood of exposure are explored in detail in the individual pest risk assessments.

**Figure 9 Utilisation of apple fruit in Australia and generation of waste**

Definitions for the proportions shown in Figure 9 are given below.

- P1 = The proportion of imported fruit that might be imported directly to an orchard packing house for repacking
- P2 = The proportion of fruit that might be imported directly to urban wholesalers for repacking
- =  $1 - P1$
- P3 = The proportion of fruit that may spoil during repacking and storage
- P4 = The proportion of imported fruit that might be channelled by wholesalers (orchard-based or urban) to fruit processors

- = 0 (considered a low volume pathway of rare occurrence and neither fruit products, nor the processed and concentrated waste generated during the manufacture of fruit juices and other products are considered a phytosanitary risk)
- P5 = The proportion of imported fruit that might be channelled from wholesalers (orchard-based or urban) to retailers
- =  $1-(P3+P6)$
- P6 = The proportion of imported fruit that might be channelled from wholesalers (orchard-based or urban) to the food service industry
- P7 = The proportion of fruit purchased by retailers that might spoil and be discarded before sale
- P8 = The proportion of fruit purchased by retailers that might be channelled to individual consumers
- =  $1-(P7 + P9)$
- P9 = The proportion of fruit purchased by retailers that might be channelled to the food service industry
- P10 = The proportion of fruit purchased by the food service industry that might spoil and be discarded, or be discarded by the consumer
- P11 = The proportion of fruit purchased by the food service industry that might be consumed or utilised
- =  $1-P10$
- P12 = The proportion of fruit purchased by consumers that might be discarded whole or in part as waste
- P13 = The proportion of fruit purchased by consumers that might be consumed without generation of any waste
- =  $1-P12$

Ratings allocated to the above proportions are summarised in Table 14. These proportions for use of apple fruit and generation of waste at utility points were discussed with stakeholders at the two-day workshop in Melbourne in July 2002. These discussions were considered by the RAP before it made its decision on ratings. The proportion P12 was considered high in this analysis because most consumers discard at least some part of each purchased apple. The last column in Table 14 shows the calculation of the proportions of imported apple fruit discarded at each utility point.

**Table 14 Summary: utilisation of apple fruit in Australia and generation of waste**

Utility point	Proportion of imported apple fruit utilised	Proportion of apple fruit discarded as waste by each utility point	Proportion of imported apple fruit discarded as waste
Orchard-based re-packers and wholesalers	P1 = Very low	P3 = Extremely low	$P1 \times P3$
Urban re-packers and wholesalers	$P2 = (1 - P1)$	P3 = Extremely low	$P2 \times P3$
Retailers	$P5 = 1 - (P3 + P6)$	P7 = Very low	$P5 \times P7$
Food service industry	$P6$ (very low) + $P9$ (very low)	$P10$ = Very low	$(P5 \times P9 + P6) \times P10$
Consumers	$P8 = 1 - (P7 + P9)$	$P12$ = High	$P5 \times P8 \times P12$

### Exposure groups

The term ‘exposure group’ denotes a category of susceptible host plants in Australia, and may be based on species, geographic location or the manner in which it is managed. The purpose of an exposure group is to delineate certain collections of susceptible host plants for which the likelihood of exposure<sup>18</sup>, or the impact of a pest, are likely to be meaningfully different. This enabled a more precise and transparent assessment of overall risk.

Exposure groups identified in this analysis include:

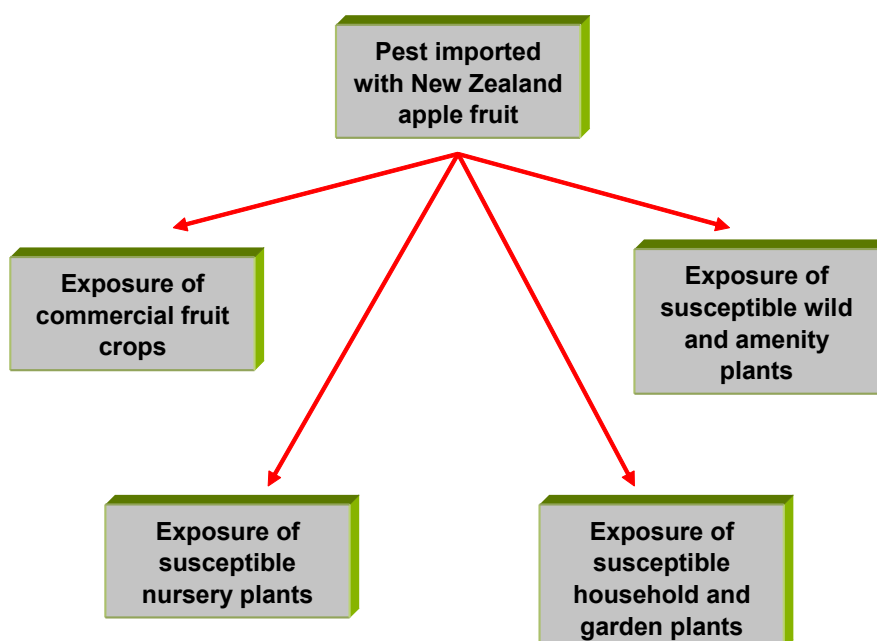
- susceptible commercial fruit crops;
- susceptible nursery plants;
- susceptible household and garden plants, including weed species; and,
- susceptible wild (native and introduced) and amenity plants including susceptible plants growing on farmland.

These are abbreviated as commercial fruit crops, nursery plants, household & garden plants and wild & amenity plants in various tables and figures that follow.

The direct exposure of each group of susceptible plants is illustrated in Figure 10. It is important that each group might also be exposed to a pest introduced with New Zealand apples as a result of that pest’s establishment or spread in Australia. This is termed ‘secondary exposure’ and is discussed elsewhere in this document (see Probability of Establishment or Spread).

<sup>18</sup> Likelihood of exposure is the likelihood that a pest will be distributed to an endangered area, and subsequently transferred to a susceptible host. Biosecurity Australia takes ‘transfer’ in this context to describe the exposure of a suitable site on a suitable host to a sufficient dose of a pest to initiate infection.

**Figure 10 Exposure groups for pests of New Zealand apples**



### Calculating the probability of distribution

The probability of *importation* was an estimate of the ‘number of fruit that might be infected or infested’ if apples were imported from New Zealand for 12 months without phytosanitary restrictions. The probability of *distribution* is estimated individually for each of the exposure groups identified above, and is based on the number of exposure opportunities associated with the importation of that number of infected fruit.

*The manner in which the partial probability of distribution (PPD) for each exposure group is calculated in the simulation model is explained below using a hypothetical example. It is to be noted that the calculation is based primarily on the number of infected/infested fruit likely to be imported into Australia, estimated at the end of the importation pathway. When a proportion described as ‘very low’, ‘high’, etc. is used in an equation, the simulation model refers to the probability range allocated to that likelihood in Table 11 and uses a randomly simulated midpoint value.*

Step 1, from the total number of infected/infested apples likely to be imported (Table 13) and the proportion of imported apples discarded as waste by a utility point (column 4 of Table 14), the number of infected/infested apples discarded by that utility point is calculated.

**Example:** Say for a particular pest, the number of infected/infested apples that might be imported (importation pathway, Table 13) = 10,000,000.

If we consider the utility point urban wholesaler, the proportion of imported apples discarded as waste by this utility point, from column 4 in Table 14 =  $(1-P1) \times P3$ .

Then the number of infected/infested apples discarded as waste by Urban wholesaler =  $10,000,000 \times (1-P1) \times P3$ .

Taking the ratings for P1 and P3 as 'Very low' and 'Extremely low' from Table 14, and using the midpoints for these likelihoods from Table 11, the number of infested/infested apples discarded as waste by Urban wholesaler =  $10,000,00 \times (1-0.0255) \times 0.0005005$   
 = 4877.

Step 2, the number of infected/infested apples discarded as waste likely to be near susceptible host plants of that exposure group is calculated by multiplying the figure from the first step above with the proportion of the utility point likely to be near susceptible host plants in that exposure group. For the latter, a pest specific rating is inserted into the model.

**Example:** Say the proximity of urban wholesalers to the exposure group, susceptible nursery plants, has been rated as 'very low' for a particular pest.

Then, the number of infected/infested fruit discarded by the urban wholesaler in proximity of susceptible nursery plants =  $4877 \times 0.0255$   
 = 124.

Let this number of fruit = n.

The proportions of different utility points likely to be close to different exposure groups are provided as a table in individual risk assessments. These tables for different pests appear closely similar but vary slightly because the susceptible host plants in each exposure group are different for different pests. The proportions were determined by the host specificity of each pest, the distribution and density of each utility point in Australia and by each pest's mobility within the environment.

Step 3, an estimate of the probability that exposure would result from a single infected apple discarded near a particular exposure group is considered. Here again a pest-specific rating is inserted into the model.

Let this probability = p.

**Example:** Say the probability of exposure of a susceptible nursery plant from a single infected/infested apple distributed in proximity of that host plant by an urban wholesaler is rated as 'negligible'. Then, p = negligible.

Again taking the midpoint from Table 11, p = 0.0000005.

The probability that exposure of susceptible host plants in a given exposure group would result from a single infected apple discarded near them, is dependent on the biology and epidemiology of each pest. In particular, this probability will be affected by the pest's requirement for particular climatic or environmental conditions, or the presence of particular mechanical or biological vectors. The estimates of exposure by a single infected/infested fruit discarded as waste near susceptible host plants for various combinations of utility points and exposure groups are also given as a table in individual risk assessments.

Step 4, knowing the probability of exposure from a single fruit, p, (step 3 above), and the number of infected/infested apples that get distributed near susceptible host plants in the particular exposure group by a utility point, n, (step 2 above), the probability of exposure resulting from n infected/infested apples is estimated by the model using the standard equation  $1-(1-p)^n$ .

This equation can be written in a general format as:

$$1-(1-\text{Exp}_{\text{Exposure group from Utility point waste}})^{\text{Waste units from Utility point near Exposure group}}$$

The equation in words for the current example is:

$$1 - (1 - \text{Exp}_{\text{nursery plants from urban wholesaler waste}}) \text{Waste units from urban wholesaler near nursery plants}$$

$$= 1 - (1 - 0.0000005)^{124}$$

= 0.000062, which falls within the 'Extremely low' range according to Table 11.

Hence, in this case, with 10,000,000 infected/infested fruit coming in, the simulation model may give the result that the likelihood of exposure of nursery plants resulting from urban wholesaler waste is 'Extremely low'.

Step 5, the Partial Probability of Distribution (PPD) to that exposure group is calculated by combining the exposure probability through each utility point using the following equation.

$$\text{PPD Exposure group} = 1 - (1 - \text{Exp}_{\text{Exposure group from Orchard wholesalers}}) \times (1 - \text{Exp}_{\text{Exposure group from Urban wholesalers}}) \times (1 - \text{Exp}_{\text{Exposure group from Retailers}}) \times (1 - \text{Exp}_{\text{Exposure group from Food service}}) \times (1 - \text{Exp}_{\text{Exposure group from Consumers}})$$

The manner in which the above calculations are performed for each exposure group in the simulation model, is summarised in Table 15 and Table 16.

Because the partial probability of distribution for each exposure group has already taken into consideration the outcome of the importation pathway, this probability is also the partial probability of entry for that exposure group for later calculations. That is, it will be combined with the partial probability of establishment or spread (PPES) to give the partial probability of entry, establishment or spread (PEES) for that exposure group. The four PEES values for the four exposure groups are then combined into one (see the section on Annual probability of entry, establishment or spread and Table 17 later).

**Table 15 Number of infected fruit wasted at a utility point**

No. imported infected	The number of infected or infested apples that might be imported during 12 months without phytosanitary restrictions = Table 13
<b>For each of the five utility points: orchard wholesalers; urban wholesalers; retailers; food service; and consumers</b>	
Wasted Utility point	The proportion of imported apples that are channelled to, and subsequently discarded by, utility point = Table 14
No. wasted Utility point	The number of imported infected or infested apples that might be channelled to, and subsequently discarded by, utility point = No. imported infected x Wasted utility point



**Table 16 Partial probability of distribution (PPD) resulting in exposure of susceptible host plants within the exposure groups**

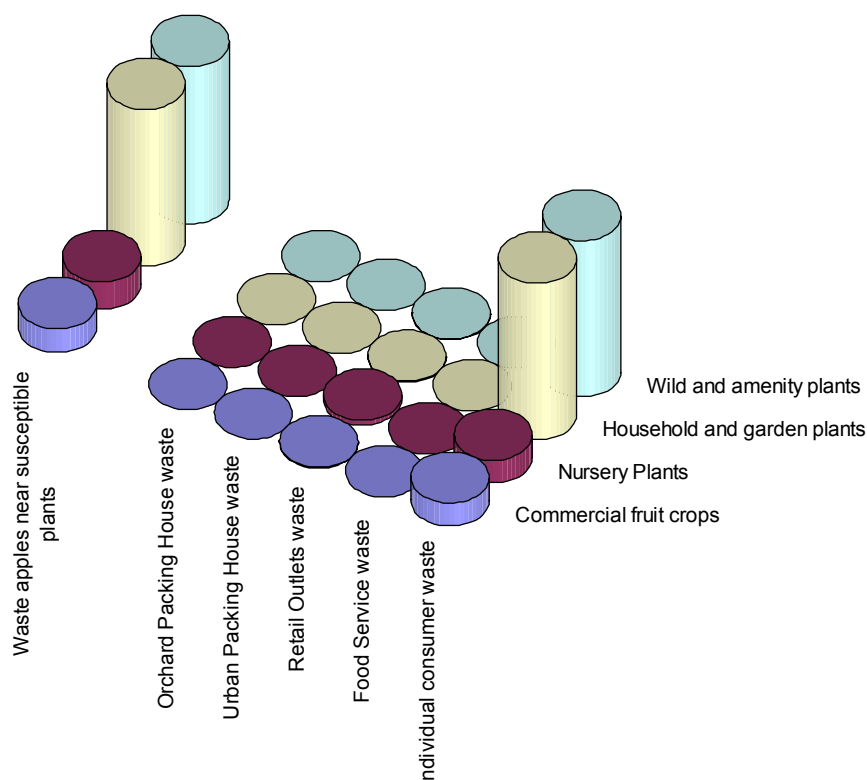
Likelihood	Description and calculation
<b>For each of the four exposure groups:</b> <b>commercial fruit crops; nursery plants; household &amp; garden plants; and wild &amp; amenity plants</b>	
<b>PPD</b> Exposure group	<b>Probability that a pest that enters Australia with imported New Zealand apples will gain direct exposure to the exposure group</b> $= 1 - (1 - \text{Exp}_{\text{Exposure group from orchard wholesalers}}) \times (1 - \text{Exp}_{\text{Exposure group from urban wholesalers}}) \times (1 - \text{Exp}_{\text{Exposure group from retailers}}) \times (1 - \text{Exp}_{\text{Exposure group from food service}}) \times (1 - \text{Exp}_{\text{Exposure group from consumers}})$
<b>For each of the four exposure groups:</b> <b>commercial fruit crops; nursery plants; household or garden plants; and wild or amenity plants,</b> <b>and</b> <b>for each of the five utility points:</b> <b>orchard wholesalers; urban wholesalers; retailers; food service; and consumers</b>	
<b>Exp</b> Exposure group from utility point	<b>Probability that a pest will gain exposure to susceptible plants in the exposure group as a result of waste generated by utility point and discarded near host plants</b> $= 1 - (1 - \text{Exp}_{\text{Exposure group from utility point waste}})^{\text{Waste units from utility point near exposure group}}$
Exp Exposure group from utility point waste	Probability that exposure of susceptible hosts within the exposure group would result from utility point discarding a single infected apple = pest specific estimate
Waste units from utility point near exposure group	Number of whole or part apples that might be discarded by utility point near susceptible host plants within the exposure group = No. wasted Utility point x Proximity Utility point near exposure group
Proximity Utility point near exposure group	Proportion of utility point situated near an exposure group = pest specific estimate

The probability of distribution calculations in the current simulation model are based on exposure of hosts from infected/infested fruit discarded as waste near susceptible host plants. That is, it is assumed that host exposure would take place only from infected/infested fruit discarded as waste. This may not always be true. There may be rare occasions that could lead to host exposure from an infected/infested fruit before it goes into the waste pathway. For example, an insect may fly out during transport of apples or when pallets or boxes are opened at wholesalers or retailers, and find a susceptible host. Similarly, a worker or a customer in a supermarket may touch a fruit infected/infested with bacteria before the fruit goes into the waste dump and then touch a susceptible nursery plant in the same store. Alternatively, an individual may take an infected/infested fruit from a utility point to some distant location so that the fruit does not go in the normal waste pathway. These situations are considered extremely rare. The scenario of a pest escaping from the utility point could apply more to flying arthropods than to other pests. Therefore, that fact, where relevant, was taken into consideration in allocating likelihoods to determine the number of waste units that come near

susceptible host plants. That is the possibility of an insect flying out early in the distribution pathway has been accommodated in the waste calculation.

To assist readers to interpret the results, a figure showing the relative amounts of waste apples discarded near susceptible host plants in the four exposure groups by the utility points is provided for each pest in individual risk assessments. A sample of this figure is shown in (Figure 11). It is important to note that these values vary for different pests owing to the variability in the host plants' susceptibility to the pest within each exposure group.

**Figure 11 Sample figure showing the pictorial representation of the relative amounts of infested/infected apple waste discarded by utility points near exposure groups, for the pest in question**



### **Probability of establishment or spread**

The probability of establishment or spread examines factors relevant to the successful colonisation of a susceptible host, and to the subsequent establishment or spread within the larger population of susceptible hosts. It is important that establishment or spread begins with the assumption that a sufficient or sustainable number of pests have been transferred to a suitable site on a susceptible host plant (as described in the Probability of Distribution).

A single estimate of the probability of establishment or spread for feeding into the simulation model was obtained by assessing probability of establishment and probability of spread

separately according to the guidelines described below, and combining the respective likelihoods using the rules shown in Table 12.

## **IPPC criteria for establishment or spread**

The assessment of establishment or spread followed the guidelines in ISPM 11 Rev 1, summarised below.

### **Partial probability of establishment**

The partial probability of establishment for each exposure group is derived from a comparative assessment of those factors in the source country and ‘PRA area’ considered pertinent to the ability of a pest to survive and propagate.

These factors include:

- Availability of suitable hosts, alternate hosts and vectors in the PRA area

Whether hosts and alternate hosts are present and how abundant or widely distributed they may be; whether hosts and alternate hosts occur within sufficient geographic proximity to allow the pest to complete its life cycle; whether there are other plant species, which could prove to be suitable hosts in the absence of the usual host species; whether a vector, if needed for dispersal of the pest, is already present in the PRA area or is likely to be introduced; and whether another vector species occurs in the PRA area.

- Suitability of environment

Factors in the environment (e.g. suitability of climate, soil, pest and host competition) that are critical to the development of the pest, its host and if applicable its vector, and to their ability to survive periods of climatic stress and complete their life cycles, should be identified. It should be noted that the environment is likely to have different effects on the pest, its host and its vector. This needs to be recognised in determining whether the interaction between these organisms in the area of origin is maintained in the PRA area to the benefit or detriment of the pest. The probability of establishment in a protected environment, e.g. in glasshouses, should also be considered.

Climatic modelling systems may be used to compare climatic data on the known distribution of a pest with that in the PRA area.

- Cultural practices and control measures

Where applicable, practices used during the cultivation/production of the host crops should be compared to determine whether there are differences in such practices between the PRA area and the origin of the pest that may influence its ability to establish.

Pest control programs or natural enemies already in the PRA area, which reduce the probability of establishment may be considered. Pests for which control is not feasible should be considered to present a greater risk than those for which treatment is easily accomplished. The availability (or lack) of suitable methods for eradication should also be considered.

- Other characteristics of the pest affecting the probability of establishment

Reproductive strategy of the pests and method of pest survival—characteristics, which enable the pest to reproduce effectively in the new environment, such as parthenogenesis/self-crossing, duration of the life cycle, number of generations per year, resting stage etc., should be identified.

Genetic adaptability—whether the species is polymorphic and the degree to which the pest has demonstrated the ability to adapt to conditions like those in the PRA area should be considered, e.g., host specific races or races adapted to a wider range of habitats or to new hosts. This genotypic (and phenotypic) variability facilitates a pest’s ability to withstand environmental fluctuations, to adapt to a wider range of habitats, to develop pesticide resistance and to overcome host resistance.

Minimum population needed for establishment—if possible, the threshold population that is required for establishment should be estimated.

### **Partial probability of spread**

The partial probability of spread for each exposure group is derived from a comparative assessment of those factors in the source country and ‘PRA area’ considered pertinent to the expansion of the geographical distribution of a pest.

These factors include:

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

### **Annual probability of entry, establishment or spread**

The annual probability of entry, establishment or spread is obtained from the ‘partial’ probabilities of entry, establishment or spread obtained for each exposure group.

The importation step provides an estimate for the ‘number’ of infected or infested fruit that might be imported from New Zealand during a year of unrestricted trade. The distribution step then looks at the annual likelihood that susceptible plants in each exposure group will be exposed to the pest, given the distribution and consumption of the estimated number of infected or infested apples in Australia and the generation and disposal of infected or infested apple waste.

Calculation of the annual probability of entry, establishment or spread is explained in Table 17. The calculations consider the probability that entry, establishment or spread might occur by ‘at least one’ of the available routes—i.e. as a result of the exposure of ‘at least one’ group of susceptible hosts. In probability terms, the likelihood of ‘at least one’ option occurring is equivalent to the complement of (or ‘one minus’) the likelihood that *none* of the options will occur. Thus the focus of the sub-calculations in Table 17 is the probability that each group of susceptible hosts will *not* be exposed and that establishment or spread will *not* occur.

The calculations shown in Table 17 are carried out using the spreadsheet-based simulation model (see Evaluating and Reporting Likelihood). Because at least some of the inputs to these calculations will be probability distributions rather than point estimates, the outcome of each calculation will be a probability distribution. Interpretation of this probability distribution will be based on its correlation with Biosecurity Australia’s six likelihood categories (see Evaluating and Reporting Likelihood). Where the distribution spans more than a single range,

the effects of using different percentiles (e.g. 50<sup>th</sup> and 95<sup>th</sup> percentile) were evaluated for each pest. The 50<sup>th</sup> percentile was chosen as the likelihood to be used because it provides a more robust measure of central tendency for skewed (asymmetrical) distributions.

**Table 17 The probability of entry, establishment or spread**

Likelihood	Description and calculation
<b>PEES</b>	<b>The probability of entry, establishment or spread</b> $= 1 - (1 - \text{PEES}_{\text{Commercial}}) \times (1 - \text{PEES}_{\text{Nursery}}) \times (1 - \text{PEES}_{\text{Household}}) \times (1 - \text{PEES}_{\text{Wild}})$
<b>For each of the four exposure groups:</b> <b>commercial fruit crops; nursery plants; household or garden plants; and wild or amenity plants</b>	
$\text{PEES}_{\text{Exposure group}}$	The partial probability of entry, establishment or spread for exposure group $= \text{PPD}_{\text{Exposure group}} \times \text{PPES}_{\text{Exposure group}}$
$\text{PPD}_{\text{Exposure group}}$	The partial probability of distribution for exposure group $= \text{Table 16}$
$\text{PPES}_{\text{Exposure group}}$	The partial probability of establishment or spread for exposure group $= \text{pest-specific estimate}$

## ASSESSMENT OF CONSEQUENCES

### Direct and indirect criteria

Criteria for assessing the consequences associated with a pest are outlined in the relevant Acts and agreements, and in the standards prepared by the international organisations.

In particular:

- the *Quarantine Act 1908* requires decision-makers to take into account the likelihood of harm being caused (to humans, animals, plants, other aspects of the environment, or economic activities) and the probable extent of the harm (Section 5D);
- the *SPS Agreement* states that  
*Members shall take into account as relevant economic factors; the potential damage in terms of loss of production or sales in the event of entry, establishment or spread of a pest or disease; the costs of control or eradication in the territory of the importing Member; and the relative cost-effectiveness of alternative approaches to limiting risks; and,*
- IPPC expands the ‘relevant economic factors’ described in the *SPS Agreement* to differentiate between the ‘direct’ and ‘indirect’ effects of a pest, and provides examples of factors that will typically be relevant to an import risk analysis.

In each case, consequence assessments do not extend to considering the benefits or otherwise of trade in a given commodity, or the impact of import competition on industries or consumers in the importing country.

The direct and indirect consequences considered in this import risk analysis are discussed below based on the framework provided in the *Guidelines for Import Risk Analysis* (2001).

## **Direct criteria**

### **Plant life or health**

Examples from ISPM 11 Rev.1 that could be considered for the direct consequences on plant life or health:

- known or potential host plants;
- types, amount and frequency of damage;
- crop losses, in yield and quality;
- biotic factors (e.g. adaptability and virulence of the pest) affecting damage and losses;
- abiotic factors (e.g. climate) affecting damage and losses;
- rate of spread;
- rate of reproduction;
- control measures (including existing measures), their efficacy and cost;
- effect of existing production practices; and,
- environmental effects.

### **Human life or health**

This factor is not listed in ISPM 11 Rev. 1 for plant pests.

### **Any other aspects of environmental effects not covered above (e.g. the physical environment or other life forms—micro-organisms, etc.).**

Examples from ISPM 11 Rev.1 that could be considered for the direct consequences on any other aspects of the environment:

- reduction of keystone plant species;
- reduction of plant species that are major components of ecosystems (in terms of abundance or size), and endangered native plant species (including effects below species level where there is evidence of such effects being significant); and,
- significant reduction, displacement or elimination of other plant species.

## **Indirect criteria**

Indirect consequences are the costs resulting from natural or human processes associated with the incursion of a disease.

### **Control, eradication, etc.**

Examples from ISPM 11 Rev.1 that could be considered for the indirect consequences on eradication, control, *etc.*:

- changes to producer costs or input demands, including control costs;
- feasibility and cost of eradication or containment;

- capacity to act as a vector for other pests; and,
- resources needed for additional research and advice.

### **Domestic trade and International trade**

Examples from ISPM 11 Rev.1 that could be considered for the indirect consequences on domestic and international trade (the two are considered separately):

- effects on domestic and export markets, including particular effects on export market access; and,
- changes to domestic or foreign consumer demand for a product resulting from quality changes.

### **Environment**

Examples from ISPM 11 Rev.1 that could be considered for the indirect consequences on the environment:

- environmental and other undesired effects of control measures;
- social and other effects (e.g. tourism);
- significant effects on plant communities;
- significant effects on designated environmentally sensitive or protected areas;
- significant change in ecological processes and the structure, stability or processes of an ecosystem (including further effects on plant species, erosion, water table changes, increased fire hazard, nutrient cycling, etc.); and,
- costs of environmental restoration.

### **Communities**

Examples from ISPM 11 Rev.1 that could be considered for the indirect consequences on the communities:

- effects on human use (e.g. water quality, recreational uses, tourism, animal grazing, hunting, fishing) (this is listed under indirect effects on environment in ISPM 11 Rev.1).

Further examples that could be considered (not listed in ISPM 11 Rev.1) for indirect consequences on communities include reduced rural and regional economic viability, the loss of social amenity and any ‘side effects’ of control measures.

In summary, the direct and indirect consequences described above collectively cover the economic, environmental and social effects of a disease. Given this, the consequences are also mutually exclusive—that is, an effect is not assessed more than once. In particular, the direct effects of a disease on a native or wild species are assessed under the criterion describing the ‘animal or plant life and health, including animal and plant production losses’, whereas the indirect or ‘flow-on’ effects on the environment are assessed under the last indirect criterion.

### **Describing the impact of a pest**

The objective of the assessment of likely consequences is to determine the likely impact of a pest on the Australian community as a whole. Industry effects and effects on sections of the

Australian community are directly relevant to the assessment, but the assessment is focussed at the national level.

The impact of a pest or disease on each direct and indirect consequence criterion is estimated at four levels, local, district, regional and national, and the values derived are translated into a single qualitative score, A–G (Table 18) (see the *Guidelines for Import Risk Analysis* (2001)). In this context, the terms ‘local’, ‘district’, ‘regional’ and ‘national’ are defined as follows.

<i>Local:</i>	An aggregate of households or enterprises—e.g. a rural community, a town or a local government area.
<i>District:</i>	A geographically or geopolitically associated collection of aggregates—generally a recognised section of a State, such as the ‘North West Slopes and Plains’ or ‘Far North Queensland’.
<i>Region:</i>	A geographically or geopolitically associated collection of districts—generally a State, although there may be exceptions with larger states such as Western Australia.
<i>National:</i>	Australia-wide.

At each level, the quantum of impact is described as ‘unlikely to be discernible’, of ‘minor significance’, ‘significant’ or ‘highly significant’.

- An ‘unlikely to be discernible’ impact is not usually distinguishable from normal variation in the criterion.
- An impact of ‘minor significance’ is not expected to threaten economic viability, but would lead to a minor increase in mortality/morbidity or a minor decrease in production. For non-commercial factors, the impact is not expected to threaten the intrinsic ‘value’ of the criterion—though the value of the criterion would be considered as ‘disturbed’. Effects would generally be reversible.
- A ‘significant’ impact would threaten economic viability through a moderate increase in mortality/morbidity, or a moderate decrease in production. For non-commercial factors, the intrinsic ‘value’ of the criterion would be considered as significantly diminished or threatened. Effects may not be reversible.
- A ‘highly significant’ impact would threaten economic viability through a large increase in mortality/morbidity, or a large decrease in production. For non-commercial factors, the intrinsic ‘value’ of the criterion would be considered as severely or irreversibly damaged.

When assessing the local, district, regional and national impact, the frame of reference will be the impact of each disease on the community as a whole. This will often differ markedly from the effect of the disease on the local, district, regional or national population of directly affected parties.

A related consideration is the *persistence* of an effect. In general, where the effect is prolonged, as is the case if it is thought to persist for several production cycles or if regeneration will take several generations, the consequences will be considered greater. If an effect is not prolonged, then consequences are likely to be less serious.



**Table 18 The assessment of local, district, regional and national consequences**

Impact score	G	Highly significant	—	—	—
	F	Significant	Highly significant	—	—
	E	Minor	Significant	Highly significant	—
	D	Unlikely to be discernible	Minor	Significant	Highly significant
	C	—	Unlikely to be discernible	Minor	Significant
	B	—	—	Unlikely to be discernible	Minor
	A	—	—	—	Unlikely to be discernible
		<i>National</i>	<i>Regional</i>	<i>District</i>	<i>Local</i>
Level					

**Approach to the consequence assessment for New Zealand apple fruit**

In this analysis, a single assessment of consequences was determined for each pest. This is because the outbreak scenario is the same for each of the identified exposure groups (see Probability of Distribution).

The assessment of consequences for New Zealand apple fruit was carried out in two steps.

- The magnitude of impact of a pest on each of the direct and indirect criteria was evaluated.
- The magnitude of impact obtained for each of the direct and indirect criteria was combined to give an overall (qualitative) estimate of the consequences of establishment or spread.

The first step was undertaken using the descriptive (qualitative) system outlined above.

The second step was undertaken following the decision rules below. These rules are mutually exclusive and will be addressed in the order that they appear in the list. For example, *if the first set of conditions does not apply, the second set will be considered. If the second set does not apply, the third set will be considered ...*, and so forth until one of the rules applies.

1. Where the consequences of a pest with respect to any direct or indirect criterion are 'G', the overall consequences are considered to be 'extreme'.
2. Where the consequences of a pest with respect to more than one criterion are 'F', the overall consequences are considered to be 'extreme'.
3. Where the consequences of a pest with respect to a single criterion are 'F' and the consequences of a pest with respect to each remaining criterion are 'E', the overall consequences are considered to be 'extreme'.

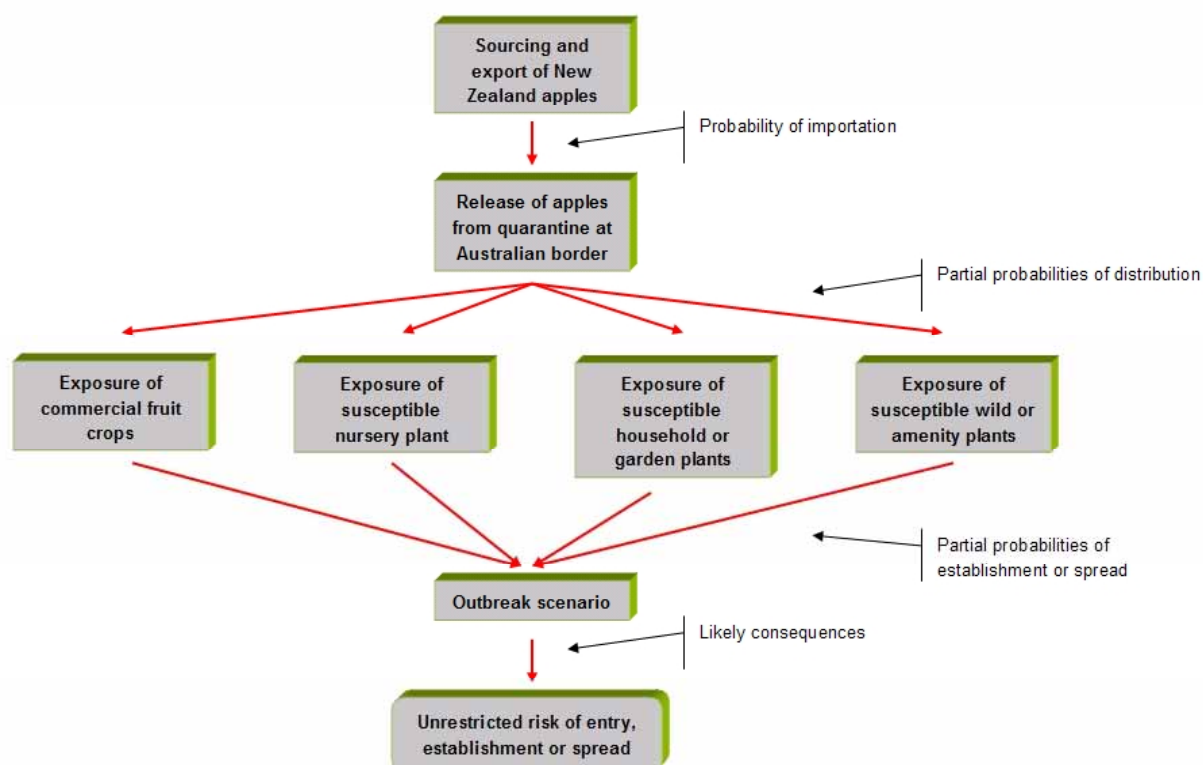
4. Where the consequences of a pest with respect to a single criterion are 'F' and the consequences of a pest with respect to remaining criteria is not unanimously 'E', the overall consequences are considered to be 'high'.
5. Where the consequences of a pest with respect to all criteria are 'E', the overall consequences are considered to be 'high'.
6. Where the consequences of a pest with respect to one or more criteria are 'E', the overall consequences are considered to be 'moderate'.
7. Where the consequences of a pest with respect to all criteria are 'D', the overall consequences are considered to be 'moderate'.
8. Where the consequences of a pest with respect to one or more criteria are 'D', the overall consequences are considered to be 'low'.
9. Where the consequences of a pest with respect to all criteria are 'C', the overall consequences are considered to be 'low'.
10. Where the consequences of a pest with respect to one or more criteria are 'C', the overall consequences are considered to be 'very low'.
11. Where the consequences of a pest with respect to all criteria are 'B', the overall consequences are considered to be 'very low'.
12. Where one or more direct or indirect effects are 'B', the overall consequences associated with the outbreak scenario are considered to be 'negligible'.
13. Where all direct and indirect effects are 'A', the overall consequences associated with the outbreak scenario are considered to be 'negligible'.

## UNRESTRICTED ANNUAL RISK

Risk is a function of the likelihoods of an event occurring and the consequences or impact resulting from that event. A combination of probabilities of entry, establishment or spread with the results of the consequence assessment provided estimates of the 'unrestricted annual risk' associated with each pest if apples were imported from New Zealand for 12 months without phytosanitary restrictions.

A schematic representation of risk estimation is provided in Figure 12. In practical terms, the procedure was undertaken for each quarantine pest in two separate steps:

- calculation of the annual probability of entry (importation and distribution), establishment or spread; and,
- combination of the annual probability of entry, establishment or spread with the estimate of consequences to give the unrestricted annual risk of entry, establishment or spread.

**Figure 12 Estimation of unrestricted annual risk**

The annual probability of entry, establishment or spread obtained for each pest was combined with the assessment of consequences, to give the unrestricted annual risk of entry, establishment or spread.

Probabilities and consequences were combined using the 'rules' shown in the risk estimation matrix in Table 19. The principle underlying this matrix is that the cells are expressed in the unit of consequence, and represent the 'expected loss' associated with each particular combination of probability and consequences. In view of the imprecision inherent in an essentially qualitative assessment, it was conservatively assumed that probabilities greater than or equal to Biosecurity Australia's definition of 'Moderate' were not sufficiently small to reduce consequences *within the limits of measurement*. This means that the first two rows of the matrix mirror the consequence scale on the horizontal axis. The remaining levels of probability—that is, 'Low', 'Very Low', 'Extremely Low' and 'Negligible'—reduced the consequences by one, two, three and four categories, respectively, or to 'Negligible'.

**Table 19 Risk estimation matrix: estimation of the annual risk**

<b>Annual probability of entry, establishment or spread</b>	<i>High likelihood</i>	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
	<i>Moderate</i>	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
	<i>Low</i>	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk	High risk
	<i>Very low</i>	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk
	<i>Extremely low</i>	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk
	<i>Negligible likelihood</i>	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk
		<i>Negligible impact</i>	<i>Very low</i>	<i>Low</i>	<i>Moderate</i>	<i>High</i>	<i>Extreme impact</i>
<b>Consequences</b>							

## METHOD FOR PEST RISK MANAGEMENT

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Risk management describes the process of identifying and implementing measures to mitigate risks so as to achieve Australia's appropriate level of protection, or tolerance for loss, while ensuring that any negative effects on trade are minimised. Appropriate level of protection is considered a societal value judgement that reflects the maximal risk (or expected loss) from a disease incursion that Australia considers acceptable.

To implement risk management appropriately, it is necessary to understand the difference between 'unrestricted' and 'restricted' risk estimates. Unrestricted risk estimates are those derived in the absence of any risk management, or using only internationally accepted baseline risk management strategies. In contrast, restricted or mitigated risk estimates are those derived when 'risk management' is applied.

The result of the 'risk assessment' for New Zealand apples was an unrestricted risk estimate for each of the identified pests of quarantine concern. This was compared with Australia's appropriate level of protection, which is shown in the risk estimation matrix (Table 19) as the band of cells associated with a 'very low' risk. This step is termed 'risk evaluation'. An unrestricted risk that is either 'negligible' or 'very low' met Australia's appropriate level of protection and was considered 'acceptable'. In this situation, risk management was not justified. However, where an unrestricted risk was 'low', 'moderate', 'high' or 'extreme', risk management measures were identified and applied and, for each of these, the 'restricted' risk was re-calculated.

It is possible that some quarantine treatments will cause harm to the environment. In this analysis, quarantine treatments were not recommended unless any potential harm to the environment was assessed—this includes harm from residues. In making this judgement, relevant considerations included local legal requirements, manufacturer's advice on usage and national or international standards.



## PEST RISK ASSESSMENT RESULTS

### Results of pest categorisation

In Part B of this document 442 pests of apples were categorised according to their presence or absence in Australia, including regulatory status where applicable, their potential for being on the pathway (association with apple fruit), their potential for establishment or spread in Australia, and the potential consequences of establishment or spread.

Table 20 is a summary of the total number of species that:

- are known to be associated with apples in New Zealand;
- are absent, or presence in Australia is uncertain, or of regional concern;
- have the potential for being on the pathway;
- have the potential for establishment or spread;
- have the potential for consequences; and,
- are considered further in the risk assessment.

**Table 20 Outcome of the pest categorisation process**

Groups	Associated with apples in New Zealand	Not in Australia or of regional concern	Potential for being on pathway (Likely)	Potential for establishment or spread (Feasible)	Potential for consequences (Significant)	No. of species to be considered further
Insects	285	160	34	34	17	17
Mites	33	22	5	5	1	1
Snails	3	2	0	-	-	0
Spiders	4	2	0	-	-	0
Bacteria	3	1	1	1	1	1
Fungi	94	9	7	7	2	2
Nematodes	8	0	-	-	-	0
Viruses	9	1	0	-	-	0
Diseases of unknown etiology	3	2	0	-	-	0
<b>Total</b>	<b>442</b>	<b>199</b>	<b>47</b>	<b>47</b>	<b>21</b>	<b>21</b>

### **List of species to be considered further**

As listed in Table 20, 21 species required further consideration in the risk assessment. These included nine species of insects, one bacterium and one fungus to be considered for the whole of Australia (Table 21) and, in addition, five insects, one mite and one fungus to be considered for Western Australia only (Table 22). Three species of insects that contaminate apple fruit are also considered further (Table 23).

**Table 21 Pests of apple fruit considered further for the whole of Australia**

<b>Insects</b>	
<i>Dasineura mali</i> Keiffer (Diptera: Cecidomyiidae)	Apple leafcurling midge
<i>Planotortrix excessana</i> (Walker) (Lepidoptera: Tortricidae)	Greenheaded leafroller
<i>Planotortrix octo</i> Dugdale (Lepidoptera: Tortricidae)	Greenheaded leafroller
<i>Ctenopseustis herana</i> (Feld. & Rogen.) (Lepidoptera: Tortricidae)	Brownheaded leafroller
<i>Ctenopseustis obliquana</i> (Walker) (Lepidoptera: Tortricidae)	Brownheaded leafroller
<i>Graphania mutans</i> (Walker) (Lepidoptera: Noctuidae)	Grey-brown cutworm
<i>Stathmopoda horticola</i> Dugdale (Lepidoptera: Oecophoridae)	Garden featherfoot, oecophorid moth
<i>Pyrgotis plagiatana</i> (Walker) (Lepidoptera: Tortricidae)	Native leafroller
<i>Thrips obscuratus</i> (Crawford) (Thysanoptera: Thripidae)	New Zealand flower thrips
<b>Pathogens</b>	
<i>Erwinia amylovora</i> (Burrill 1882) Winslow et al.	Fire blight
<i>Nectria galligena</i> Bres.	European canker

**Table 22 Pests of apple fruit considered further for Western Australia only**

<b>Insects</b>	
<i>Cydia pomonella</i> (L) (Lepidoptera: Tortricidae)	Codling moth
<i>Diaspidiotus ostreaeformis</i> (Curtis) (Hemiptera: Diaspididae)	Oystershell scale
<i>Grapholita molesta</i> Busck (Lepidoptera: Tortricidae)	Oriental fruit moth
<i>Planococcus mali</i> Ezzat & McConnell (Hemiptera: Pseudococcidae)	Mealybug
<i>Pseudococcus calceolariae</i> (Maskell) (Hemiptera: Pseudococcidae)	Citrophilus mealybug



**Mites**

<i>Panonychus ulmi</i> (Koch) (Acari: Tetranychidae)	European red mite
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**Pathogens**

<i>Venturia inaequalis</i> (Cooke) G. Winter	Apple scab
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**Table 23 Potential contaminants of consignments of apple fruit****Insects**

<i>Arhopalus ferus</i> (Mulsant) (Coleoptera: Cerambycidae)	Burnt pine longhorn beetle
<i>Conoderus exsul</i> Sharp (Coleoptera: Elateridae)	Click beetle
<i>Nysius huttoni</i> White (Hemiptera: Lygaeidae)	Wheat bug

**Species that were considered further in the previous draft IRA but not in this revised draft IRA**

Table 24 lists six arthropod species, which were assessed further in the previous draft IRA (Biosecurity Australia, 2000). However, in this revised IRA they were removed from further consideration because they are not likely to be on pathway based on the assessment of further available information and clarifications by MAFNZ (see part B of this document).

**Table 24 Species assessed further in the previous draft IRA but not in the current revised draft IRA****Insects**

<i>Carpophilus</i> spp.	Unidentified species of dried fruit beetle listed in (MAFNZ, 2000b)
' <i>Cnephasia</i> ' <i>jactatana</i> (Walker) (Lepidoptera: Tortricidae)	Black lyre moth (MAFNZ, 2000b)
<i>Eriophyes mali</i> Burts	Apple blister mite (MAFNZ, 2000b)
<i>Graphania</i> sp.	Unidentified species of cutworm listed in (Collyer and van Geldermalsen, 1975)
<i>Pseudococcidae</i> species	Unidentified species of mealybugs listed in (MAFNZ, 2000b)
<i>Tortricinae</i> species	Unidentified species of leafrollers listed in (MAFNZ, 2000b)

### **Results of risk assessments for quarantine pests**

The Pest Categorisation identified 21 pest species as potential quarantine pests requiring further consideration, 11 as of concern to whole of Australia, 7 of concern to Western Australia and 3 as contaminants of apple fruit (Tables 32–35). Detailed risk assessments conducted on these pests are reported in this section commencing with a brief introduction to each pest. More information relevant to the risk assessment on each of these pests is given in Part B Appendix 3 Datasheets. The outcome of the detailed risk assessment on the 21 potential quarantine pests is summarised in Table 25.

Table 25 shows that the unrestricted biosecurity risk due to the pests fire blight, European canker, apple scab, apple leafcurling midge, four leafrollers, codling moth and the wheat bug are above Australia's ALOP and require risk management measures.

**Table 25 Summary of the assessment of unrestricted risk of quarantine pests**

<b>Common name of Pest</b>	<b>Annual probability of entry, establishment or spread (PEES)</b>	<b>Consequences</b>	<b>Unrestricted annual risk</b>	<b>Assessed for management measures / Yes or No.</b>
<b>Pests of concern to the whole of Australia</b>				
Fire blight	Low	High	Moderate	Yes
European canker	Low	Moderate	Low	Yes
Apple leafcurling midge	Moderate	Low	Low	Yes
Brownheaded leafroller	High	Low	Low	Yes
Brownheaded leafroller	High	Low	Low	Yes
Greenheaded leafroller	High	Low	Low	Yes
Greenheaded leafroller	High	Low	Low	Yes
Grey-brown cutworm	Very low	Low	Negligible	No
Garden Featherfoot, oecophorid moth	Very low	Low	Negligible	No
Native leafroller	Very low	Low	Negligible	No

Common name of Pest	Annual probability of entry, establishment or spread (PEES)	Consequences	Unrestricted annual risk	Assessed for management measures / Yes or No.
New Zealand flower thrip	Low	Low	Very low	No
Apple scab	Low	Moderate	Low	Yes
<b>Pest of concern to Western Australia</b>				
Codling moth	Low	Moderate	Low	Yes
Oystershell scale	Extremely low	Low	Negligible	No
Oriental fruit moth	Very low	Low	Negligible	No
Mealybug	Low	Low	Very low	No
Citrophilius mealybug	Low	Low	Very low	No
European red mite	Very low	Low	Negligible	No
<b>Contaminants</b>				
Burnt pine <sup>19</sup> longhorn beetle	Negligible	NA	NA	No
Click beetle	Negligible	NA	NA	No
Wheat bug	High	Moderate	Moderate	Yes

NA= not assessed.

<sup>19</sup> The burnt pine longhorn beetle is primarily a contaminant of wood packaging. Current procedures have been agreed between NZMAF and AQIS on the treatment of this pests during the insect flight season.

## **PESTS FOR WHOLE OF AUSTRALIA**

The following risk assessments are for:

- Fire blight
- European canker
- Apple leafcurling midge
- Brownheaded and Greenheaded leafrollers
- Grey-brown cutworm
- Garden Featherfoot, oecophorid moth
- Native leafroller
- New Zealand flower thrip
- Apple scab

## **Fire blight**

### **Introduction**

Fire blight, caused by the bacterium *Erwinia amylovora*, has been reported from over 40 countries including New Zealand (Bonn and van der Zwet, 2000). Fire blight-like symptoms were detected in the Royal Botanic Gardens in Melbourne in April 1997, and diagnostic tests have confirmed that the causal organism was *E. amylovora* (Rodoni *et al.*, 1999). National surveys conducted for three years after the detection of *E. amylovora* have confirmed the absence of the disease in Australia (Rodoni *et al.*, 1999).

Cells of *E. amylovora* are gram-negative rods of about  $0.3\ \mu\text{m} \times 1\text{--}3\ \mu\text{m}$  in size, surrounded by a capsule of polysaccharide material (Paulin, 2000). *E. amylovora* is capable of growth between  $3^{\circ}\text{C}$ – $37^{\circ}\text{C}$  with the optimum at  $25^{\circ}\text{C}$ – $27^{\circ}\text{C}$  (Paulin, 2000), although minor variations have been reported on the temperature requirements.

Fire blight is the most serious bacterial disease affecting *Malus* spp. (apple), *Pyrus* spp. (pear), *Cydonia* spp. (quince), *Eriobotrya japonica* (loquat), and amenity hosts including *Crataegus* spp. (hawthorn), *Cotoneaster* spp. (cotoneaster) and *Pyracantha* spp. (firethorn). These hosts belong to the sub-family *Maloideae* of the family *Rosaceae* (Beer, 1990; CABI, 2003a). *Rosa rugosa* (sub-family *Rosoideae*) (Starr *et al.*, 1951) and *Prunus salicina* (sub-family *Amygdaloideae*) (Mohan and Thomson, 1996) are other host species in the family *Rosaceae* that are infected by *E. amylovora*.

The pathogen overwinters almost exclusively in the previous season's cankers (Beer and Norelli, 1977) and the primary inoculum is produced predominantly as ooze on the surface of cankers. The disease cycle begins when cankers on infected hosts ooze bacteria (Brooks, 1926), but non-oozing cankers can also harbour bacteria (Miller and Schroth, 1972). The number of cankers necessary for an outbreak may be as few as one to four per hectare (Brooks, 1926). Primary and secondary inocula can also originate from wild, amenity, household and garden plants. The pathogen enters through natural openings (e.g. stomata, nectaries) or wounds (e.g. caused by pruning or hail). Insects, wind, rain and pruning tools are the main methods of spreading primary inoculum of *E. amylovora*. Bees are the primary agents for secondary spread of inoculum from infested flowers to newly opened flowers (Thomson, 2000).

*E. amylovora* infects flowers, young leaves, stems and fruits. Flowers are highly susceptible to infection by *E. amylovora* (Keil and van der Zwet, 1972a) where populations of *E. amylovora* occur almost exclusively on stigmas, reaching  $10^6$  to  $10^7$  colony forming units (cfu) per flower (Thomson, 2000). Infection occurs when bacteria spread by rain or dew enter the nectaries. Often the first symptoms accompanied by ooze are seen on the outer surface of the receptacle of fruitlets and the stalks (Biggs, 1990).

Infection of succulent vegetative tissues often produces a characteristic shepherd's-crook symptom. This is accompanied or followed by a discolouration of the stem and attached leaves and the exudation of ooze. Steiner (2001) indicated that *E. amylovora* is a competent epiphyte capable of colonising and multiplying on the surfaces of plants. However, Leben (1965) reported that *E. amylovora* is not a strict epiphyte on the leaf surface. Leaves are rarely infected, but are prone to infection after hail damage (Biggs, 1990). *E. amylovora* was not detected on leaves before the appearance of fire blight symptoms in the orchard (Miller and

Schroth, 1972; Miller and van Diepen, 1978), but was present shortly after the appearance of disease symptoms (Crosse *et al.*, 1972). Multiplication of *E. amylovora* could not be demonstrated on leaf surfaces, and bacteria died within a few hours when exposed to solar radiation or high humidity (Maas Geesteranus and de Vries, 1984). In contrast, *E. amylovora* was detected on 100 per cent of leaves by a polymerase chain reaction (PCR) technique from orchards free of fire blight symptoms, but it was not known whether bacteria were alive or dead using this technique (McManus and Jones, 1995a).

Infected fruits differ in appearance depending on when they were infected. Fruit infected with *E. amylovora* when immature often shrivel and remain attached to trees through winter, but do not show any signs of oozing. Those infected following injury by hail or insects often develop red, brown or black lesions and may exude ooze (Biggs, 1990). Epiphytic colonisation of the stigmatic surfaces of flowers by *E. amylovora* may result in bacteria persisting in the dry flower parts subsumed into the calyx-end (Hale *et al.*, 1987; Thomson, 1986) or stalk-end of mature fruit (Hale and Clark, 1989). They also reported the survival of *E. amylovora* on the surface of fruit. In rare instances, *E. amylovora* has been recovered from internal tissues of mature fruit but only when the fruits were within 30 cm of the inoculum source of severely blighted trees (van der Zwet *et al.*, 1990). In Canada, *E. amylovora* was recovered from mature apples harvested from an orchard inter-planted with pears infected with *E. amylovora* (Sholberg *et al.*, 1988). They also isolated an average of  $10^{3.3}$  cfu of viable *E. amylovora* per millilitre of water washed off apples at harvest, from a severely infected, hail damaged orchard in Canada.

Other information relevant to the (Thomson, 1992b; Hale *et al.*, 1996b) biology and epidemiology of *E. amylovora* is available in the datasheet in Appendix 3 in Part B.

## **Risk scenario**

The risk scenario of particular relevance to *E. amylovora* is that associated with the epiphytic (external) infestation and endophytic (internal) infection of mature fruit. Epiphytic infestation can occur at the stem- and calyx-end and on the surface of mature fruit. *E. amylovora* cannot be detected by visual inspection. Endophytic infection occurs internally in the tissues. If endophytic infection occurs early, such fruit would probably remain as mummified fruit on the tree. However, late infections may not express internal symptoms until after a period of cold storage.

Importation of trash is another potential pathway for introduction of *E. amylovora*. This pathway was not considered in this analysis, because the scope of this assessment is limited to export from New Zealand of mature apples free from trash.

## **Probability of importation**

The initiating step for the importation scenario for apple fruit is the sourcing of apples from orchards in New Zealand, whereas the end-point is the release of imported apples from the port of entry. The importation scenario is divided into eight steps and the likelihood of *E. amylovora* being present at each step is summarised in Figure 13. The available evidence supporting the likelihood assessments is provided in the text that follows.

**Figure 13 The importation steps and the likelihood of *E. amylovora* being present at each step**



**Importation step 1  
(Imp1)  
High**

The likelihood that *E. amylovora* is present in source orchards in New Zealand: **High**.

*Epidemiology*

- Fire blight is endemic in New Zealand's North and South Islands (Cunningham, 1920; Reid, 1930; Wilson, 1970). The disease is more common in the Hawke's Bay region, where 48 per cent of orchards are located, and in the Auckland region than it is in the South Island. The lower disease incidence in the South Island results mainly from the lower temperature during flowering (Hale and Clark, 1990).
- In the 1994–1995 growing season, the percentage of designated export areas (DEAs) withdrawn from the Japan export program because of the presence of fire blight symptoms within the orchard and the buffer zone after three inspections was 58.8 per cent in Hawke's Bay, 63.1 per cent in Nelson, 48.8 per cent in Blenheim, and 24.5 per cent in Canterbury. In the 1995–1996 season the DEA rejection rate was 56.1 per cent in Nelson, and 16.1 per cent in Blenheim, and in the 1996–1997 season, it was 12.2 per cent in Blenheim (NZ Government, 2000). This shows that *E. amylovora* is present in orchards throughout the major production areas in New Zealand.

*Varietal susceptibility*

- All commercial varieties of apple grown in New Zealand are susceptible to *E. amylovora* (MAFNZ, 2002c). The use of susceptible dwarfing rootstocks (e.g. M.9 and M.26) currently used for high-density plantings would increase the susceptibility of scions grafted onto the rootstock (van der Zwet and Beer, 1995). Therefore, high-density plantings in New Zealand would be prone to damage by *E. amylovora*.

*Climate and environment*

- Mean monthly rainfall and temperature values for the period 1971–2000 for Napier (Hawke's Bay), Nelson, Blenheim and Alexandra (Otago region) showed that climatic conditions were ideal for the occurrence of fire blight (NIWA, 2003)  
[http://www.niwa.cri.nz/edu/resources/climate/overview/climate\\_rainfall](http://www.niwa.cri.nz/edu/resources/climate/overview/climate_rainfall).

*Orchard management*

- Several measures are widely used in orchards in New Zealand for management of fire blight. These include pruning out overwintering cankers to remove the source of primary infection, spraying copper fungicides as bactericides during the dormant period sometimes until the green shoot tip stage in spring, and applying streptomycin based on infection periods



(New Zealand Government , 2000).

### Summary

Fire blight caused by *E. amylovora* is present in all pome fruit production areas in New Zealand, all commercial varieties are susceptible, environmental conditions are conducive for disease development, and disease management measures are not fully effective. The likelihood for Imp1 was assessed as high.

### Importation step 2 (Imp2)

Very low

The likelihood that picked fruit is infested/infected with *E. amylovora*: **Very low**.

### Infection/infestation of orchard blocks/trees

- During blossoming *E. amylovora* was regularly detected from flowers, shoots, immature and mature fruit, in orchards with 75 strikes (i.e. infected shoots) per tree in Auckland, Hawke's Bay, Nelson and Blenheim in New Zealand (Hale *et al.*, 1987).

### Infection/infestation of mature fruit

- *Erwinia amylovora* was isolated from three per cent of mature fruit harvested from a severely infected orchard (75 strikes/tree), in which 50 per cent of immature fruit was infested (Hale *et al.*, 1987). This is a 94 per cent reduction in the number of infested fruits as they move from the immature to mature state. Hale *et al.* (1987) also reported the isolation of *E. amylovora* from less than one per cent of fruit from a severely infected orchard. *E. amylovora* was detected in two per cent of fruit from orchards with fire blight symptoms (Hale and Taylor, 1999).
- Clark *et al.* (1993) showed that the maximum calyx infestation of fruitlets sampled from disease free orchards in New Zealand was 8.7 per cent. If the 94 per cent reduction stated above is applied to the 8.7 per cent, the final expected calyx infestation in mature fruit would be 0.5 per cent. Applying the same figure of 94 per cent reduction to 21.8 per cent of calyx infestation in immature fruits from orchards with one or two strikes per tree (Clark *et al.*, 1993), they can be expected to show a calyx infestation rate of 1.3 per cent when mature.
- In New Zealand, *E. amylovora* was detected by a DNA hybridisation method (detection limit  $10^2$  *E. amylovora* cells) in 12.5 per cent of calyxes and in 25 per cent of peduncles of mature fruit from trees with 20 strikes per tree (Hale and Clark, 1989). They concluded that calyx infestation resulted from *E. amylovora* invading flower parts and that stalk infection may have resulted from secondary spread of bacteria rather than through the vascular system, because there was no external or internal discolouration of the vascular tissues of the stalks.
- In the USA, van der Zwet *et al.* (1990) found that four per cent of non-disinfested fruit from a visibly clean orchard developed

fire blight symptoms when wounded on the surface. This indicates that bacteria were present on the surface of the fruit.

- Sholberg *et al.* (1988) isolated an average of  $10^{3.3}$  cfu of viable *E. amylovora* per millilitre of water washed off apples at harvest, from a severely infected, hail damaged orchard in Canada. They also isolated viable *E. amylovora* from 100 per cent of fruit harvested from symptomless apple trees grown adjacent to blighted pear trees.
- van der Zwet *et al.* (1990) reported recovering endophytic populations of *E. amylovora* from apples within 30 cm of blighted shoots. This is the only report of endophytic infection from the USA.

#### *No infection/infestation of mature fruit*

- *E. amylovora* was not isolated from over 1,500 mature symptomless fruit harvested from two lightly infected (one to two strikes per tree) orchards in New Zealand (Hale *et al.*, 1987; Hale *et al.*, 1996b). *E. amylovora* was not isolated from the calyx-end or main portion of any of the 300 fruit harvested from orchards free from fire blight symptoms in New Zealand (Hale *et al.*, 1987).
- In Canada, Dueck (1974a) did not isolate *E. amylovora* from external or internal tissues of mature apples harvested from severely infected trees.

#### *Summary(Roberts et al., 1989; van der Zwet et al., 1990)*

Mature fruit can be infested by *E. amylovora* in New Zealand, the USA and Canada, but typically only very low levels will be infested and internal fruit infection is rare. There is evidence to show that *E. amylovora* can be found on symptomless trees. The likelihood for Imp2 was assessed as very low.

#### **Importation step 3 (Imp3)**

**Very low**

The likelihood that clean fruit is contaminated by *E. amylovora* during harvesting and transport of apples to the packing house:  
**Very low.**

#### *Contamination at picking*

- Mature fruits harvested into picking bags have the potential to be surface-contaminated by infested/infected plant material. According to Leben (1965) *E. amylovora* is not a strict leaf surface epiphyte, but Steiner (2001) suggests it is a competent epiphyte. Miller and Schroth (1972) have indicated that *E. amylovora* is present on leaves usually after blossom infection has occurred in the orchard. Maas Geesteranus and de Vries (1984) showed that *E. amylovora* (washed cells) were killed by desiccation within 24 hours or within one to two days when stored at 20°C, or within a few hours when exposed to 75 per cent relative humidity or exposure to six hours of solar radiation. Gottwald *et al.* (2002) also showed that bacteria that

ooze onto plant surfaces die quickly and that this process is accelerated by exposure to direct light. Hailstorms or thunderstorms can cause injuries to leaves and fruit. Such injuries seem to play an important role in most infections and outbreaks (Brooks, 1926). The bacteria on leaves and fruit surfaces may cause infection. Therefore, fruit and leaves have the potential to contaminate clean fruit if they are harvested during or shortly after hailstorms or thunderstorms.

#### *Contamination in soil*

- Thomson (1969) recovered *E. amylovora* from soil collected beneath blighted trees during spring in an orchard in the USA. Hildebrand *et al.* (2001) showed that *E. amylovora* was not recovered from soil five weeks after inoculation. Thomson (2000) was of the opinion that soil is of little epidemiological significance in the spread of fire blight in orchards.

#### *Contamination in bins*

- *E. amylovora* has been recovered from contaminated wood one month (McLarty, 1927), four months (Keck *et al.*, 1996) and 11 months (Nachtigall *et al.*, 1985) after inoculation. *E. amylovora* has survived on oak wood for over 20 days and poplar wood for over 40 days in inoculation trials (Ceroni *et al.*, 2003). They also showed that the pathogen could survive on packing paper for 14–24 days. However, transfer of the pathogen from contaminated sources to fruit has not been demonstrated. Keck *et al.* (1996) found that hydrophobic surfaces (e.g. plastic bins) appear to favour survival of the pathogen for four months but, conversely Ceroni *et al.* (2003) showed that plastic surfaces were not good for survival of *E. amylovora* (Ceroni *et al.*, 2003).

#### *Contamination during transport*

- Bins used for transporting fruit to the packing house can be contaminated with soil and plant material infested/infected by *E. amylovora* when they are left on the ground. Infected leaves usually remain attached to the tree until the winter. Bacteria from infected tissue would be washed down to the soil during rain but their survival time in soil is limited (Hildebrand *et al.*, 2001). Sometimes, wounds created at handling predispose them to infection. However, infection of uninjured fruit surfaces with *E. amylovora* or bins from soil has not been demonstrated.

#### *Summary*

Although *E. amylovora* can survive on leaves and wood and in soil for varying periods, it has not been demonstrated that uninjured mature fruit can become infected from these sources. The likelihood for Imp3 was assessed as very low.

#### **Importation step 4**

The likelihood that *E. amylovora* survives routine processing

(Imp4)  
Moderate

procedures in the packing house: **Moderate.**

*Precooling*

- Fruits would be kept in cold storage for a short time before they are put through the packing house procedures. This short period of cold storage period would not reduce the bacterial population in or on fruit.

*Washing*

- Goodman (1983) showed that the survival time of suspensions of *E. amylovora* in distilled water was very short, indicating that it might be connected with some defect in the outer membrane of the bacterial cell. However, the water dump will use tap water, not distilled water. Maas Geesteranus and de Vries (1984) suggested that the polysaccharide layer is readily dispersed by water and that bacteria treated in this way were killed by desiccation within 24 hours. However, there is conflicting data on the effect of water on bacterial survival. It should be noted that water is essential for the spread of bacteria from stigmas to the hypanthium (floral cup). Therefore, too much reliance cannot be placed on the ability of water to kill bacterial cells.
- Epiphytic bacteria, especially those inside the protected calyx cavity would not be removed in the water dump because of the likely formation of air pockets at least in some fruit, but some bacteria on the fruit surface may be washed off. There is also no evidence that numbers of bacteria infecting/infesting fruit, particularly the bacteria in protected sites of the fruit will be reduced by washing the fruit with high-volume, high-pressure water.
- Washing will have no effect on any bacteria in internal tissues (endophytic infections) of fruit.
- Hale and Clark (1992) have shown that chlorine at a concentration of 100 ppm for one minute in the dump tank was effective in eliminating *E. amylovora* from the surfaces of inoculated fruit. Even if chlorine is used in the dump tank, bacteria on the fruit surface may not be killed unless its concentration is maintained at 100 ppm. If this concentration were maintained it is likely that chlorine would eliminate surface bacteria but those in the calyx-end of fruit would remain because of the likely formation of air pockets. The efficacy of chlorine is also affected by the accumulation of organic matter (Smith, 1962) and the pH of the chlorine solution.
- Only some packing houses use chlorine in the dump tank. The concentration of chlorine varies between packing houses and in most it is well below the effective concentration (MAFNZ, 2004).

*Brushing*

- Brushing would not remove bacteria in the stem- and calyx-end of fruit, because they are inaccessible.

#### *Waxing*

- Bacteria will survive low temperature waxing as the thermal death point of *E. amylovora* ranges from 45°C–50°C (van der Zwet and Keil, 1979).

#### *Sorting and grading*

- Infected fruits that show obvious discolouration or rotting symptoms are likely to be removed during sorting and grading. However, bacteria infesting the surface or stem- and calyx-end, and internal infections of fruit not showing obvious rotting symptoms will not be detected during visual inspection.

#### *Packaging*

- Packaging, which aims to minimise moisture loss and maximise heat dissipation, will not reduce the bacterial population in protected sites or on the surface of fruit.

#### *Cold storage*

- The effect of cold storage on the survival of *E. amylovora* shows highly variable results. Under cold storage (c. 0°C), *E. amylovora* on inoculated or contaminated fruit survived for 34 weeks (Nachtigall *et al.*, 1985), but details of the method were not given. The average number of *E. amylovora* cells on mature fruit at the initiation of the experiment was  $10^7$  cfu per ml and the population decreased to an undetectable level after six months in cold storage (Sholberg *et al.*, 1988).
- Hale and Taylor (1999) conducted an experiment by keeping fruit inoculated at the calyx-end with different concentrations ( $10^1$ ,  $10^2$ ,  $10^3$ ,  $10^4$ ,  $10^5$ ,  $10^6$ ,  $10^7$  cfu) in cold storage ( $2^\circ\text{C} \pm 0.5^\circ\text{C}$ ) for 25 days, or kept in cold storage for 25 days and incubated at room temperature (c.  $20^\circ\text{C}$ ) for a further 14 days in the laboratory. The results indicate that, after cold storage alone, *E. amylovora* was detected by PCR in 90 per cent of fruit inoculated with  $10^7$  cfu and in <8 per cent of fruit inoculated with  $<10^1$ ,  $10^2$  or  $10^3$  after 25 days. *E. amylovora* was isolated from only 75 per cent of fruit inoculated with  $10^7$  cfu and from 10 per cent of fruit inoculated with  $10^4$  or  $10^5$  cfu. However, after cold storage and incubation, *E. amylovora* was detected in 35 per cent of fruit and in three per cent of fruit inoculated with  $10^7$  and  $10^5$  cfu respectively but not in fruit inoculated with  $10^1$ ,  $10^2$ ,  $10^3$ ,  $10^4$  cfu.

In another experiment, fruit inoculated with the above concentrations was subjected to cold storage, or cold storage and incubation, in commercial conditions. The results showed that, after cold storage, *E. amylovora* was detected by PCR in 66, 28, 10 and 3 per cent of fruit inoculated with  $10^7$ ,  $10^5$ ,  $10^3$

and  $10^1$  cfu respectively. *E. amylovora* was isolated from fruit inoculated with  $10^7$  cfu. After cold storage and incubation, *E. amylovora* was detected by PCR in 36 per cent of fruit inoculated with  $10^7$  cfu, six per cent inoculated with  $10^5$  cfu but not any other fruit. *E. amylovora* was isolated from fruit inoculated with  $10^7$  cfu or  $10^5$  cfu but not from any other fruit.

- Hale and Taylor (1999) also showed that after cold storage, *E. amylovora* was detected to varying levels in fruit inoculated with  $10^1$ ,  $10^3$ ,  $10^5$  and  $10^7$  cfu per fruit by PCR, but isolation was only possible from fruit inoculated with  $10^7$  cfu. However, after cold storage and incubation at room temperature, *E. amylovora* was detected by PCR in fruit inoculated with  $10^7$  and  $10^5$  cfu, but not detected in any other fruit. Hale and Taylor (1999) also reported that, before cold storage, *E. amylovora* was detected by PCR in two per cent of fruit from orchards with fire blight symptoms, but not in any fruit after either cold storage or after cold storage and incubation. *E. amylovora* was not isolated from any fruit tested. *E. amylovora* was neither detected nor isolated from fruit harvested from symptomless orchards before or after cold storage.
- A recent experiment Taylor and Hale (2003) with fruit from the closed-calyx variety, Braeburn, showed that bacteria in the calyx decreased from  $10^6$  cfu to  $10^2$  cfu over 20 days and from  $10^4$  to non-culturable levels after 14 days. They showed that populations of *E. amylovora* in calyxes infested with  $10^2$  cfu decreased to non-culturable levels after eight days in cold storage. PCR tests detected *E. amylovora* in calyxes infested with  $10^6$  and  $10^4$  cfu but not with  $10^2$  cfu after 20 days in cold storage.
- Roberts (2002) reported that, out of 30,000 apple fruits sampled from trees adjacent to infected trees and then cold stored for two to three months, none of the fruit developed external symptoms, and none of the 1,500 fruit examined internally showed any internal symptoms.
- Only early season fruit would be stored for a short period. Most of the harvested fruit would be in long-term storage (either cold storage or controlled atmosphere (CA) storage). There is data on the efficacy of cold storage on the survival of *E. amylovora* populations, there is none on the effect of CA storage.

### Summary

Although most packing house operations do not reduce bacterial infestation and infection, cold storage appears to significantly lower the number of bacteria present as infestations on the fruit surface and in the calyx. However, the efficacy of cold storage in reducing bacterial populations depends on the initial level of inoculum present in fruit before cold storage. It appears that cold storage is ineffective in reducing bacterial populations to non-culturable levels

when they are present at high inoculum doses. No information is available on the effect of CA on bacterial populations. The likelihood for Imp4 was assessed as moderate.

**Importation step 5  
(Imp5)**

**Very low**

The likelihood that clean fruit is contaminated by *E. amylovora* during processing in the packing house: **Very low**.

- These bacteria are unlikely to be released into water in the dump tank because of the formation of air pockets. *E. amylovora* was not detected on leaves before the appearance of fire blight symptoms in the orchard (Miller and Schroth, 1972; Miller and van Diepen, 1978), but was present after the development of symptoms (Crosse *et al.*, 1972). Exposure to solar radiation or high humidity has a detrimental effect on the multiplication of *E. amylovora* (Maas Geesteranus and de Vries, 1984). A high level of inoculum is likely to be present only if fire blight symptoms are evident in the orchard or in the vicinity and there are favourable environmental conditions for multiplication of the pathogen.
- Placing bins with fruit into the water dump will introduce trash into the tank. The infested/infected trash would carry bacteria if severe fire blight occurs in the orchard. Bacteria are likely to contaminate clean fruit if the correct concentration of chlorine is not maintained or organic matter is allowed to accumulate in the dump tank (Smith, 1962) or the pH is incorrect. Maas Geesteranus and de Vries (1984) and Goodman (1983) suggested that water may affect the cell wall of bacteria. Renewal of water or water plus chlorine in the water dump every 600 bins would reduce the chances of contaminating clean fruit.
- Disinfestation of fruit with chlorine is carried out in most packing houses. Chlorine is used at 15–20 ppm in the water dump and 75–100 ppm as spray rinse (MAFNZ, 2004).
- Wounds on fruits will predispose them to infection (Brooks, 1926). However, bruised fruit would be rejected in the packing house if the wounds are visible. Undamaged fruit are unlikely to be affected by *E. amylovora*.
- Grime commonly builds up on the packing lines, and the top layer would harbour bacteria if a high volume of trash enters the packing line. Clean fruit would be contaminated with bacteria if the packing line has a lot of debris infested/infected with *E. amylovora*, especially when packing fruit harvested from infested/infected orchards. This is very unlikely in export packing houses with high standards of hygiene. The amount of leaves entering such packing houses would be low. Most packing lines in export packing houses are scrubbed and thoroughly washed during the off-season, so they are unlikely to be an important pathway for contamination.
- Contamination from calyx infestations is unlikely to occur during storage. Rots developing from endophytic infections

would contaminate the fruits touching the rotting area, but endophytic infections occur only rarely.

- There have been no reports to suggest that a large amount of fruit is rejected as a result of rots developing from contamination of fruit by *E. amylovora* during processing in the packing house.

#### Summary

Bacteria in calyxes are unlikely to be released into the water and trash would have an extremely low population of bacteria in orchards that are free from fire blight symptoms. The likelihood for Imp5 was assessed as very low.

#### Importation step 6 (Imp6) High

The likelihood that *E. amylovora* survives palletisation, quality inspection, containerisation and transportation, and remains undetected: **High**.

- Bacteria are not visible and will almost certainly survive quality inspection.
- *E. amylovora* populations in the calyxes of mature fruit, irrespective of their level, are not reduced during palletisation, quality inspection, containerisation and transportation.

#### Summary

If bacteria are present in or on fruit in high numbers, they can still survive palletisation, quality inspection, containerisation and transportation to Australia. The likelihood for Imp6 was assessed as high.

#### Importation step 7 (Imp7) Negligible

The likelihood that clean fruit is contaminated by *E. amylovora* during palletisation, quality inspection and transportation to Australia: **Negligible**.

- Surface contamination of clean fruit can occur only if bacteria ooze out from internally infected fruit. Such fruit are rarely found (van der Zwet *et al.*, 1990). Rotten fruits either are not harvested, discarded at harvest or rejected before entering the packing line. If rotten fruits are present after cold storage, they are discarded at pre-export inspection.

#### Summary

Contamination of fruit would not occur at this step because most rotting fruit would be rejected before or after cold storage. The likelihood for Imp7 was assessed as negligible.

#### Importation step 8 (Imp8) High

The likelihood that *E. amylovora* survives and remains with fruit after on-arrival minimum border procedures: **High**.

- The minimum border procedures as described in the method section would not reduce the viability of *E. amylovora*.



**Conclusions—probability of importation**

When the above likelihoods were inserted into the simulation model, the probability of importation of *E. amylovora* from one year of trade was found to be **Very low**.

**Probability of distribution**

The initiating step for the distribution scenario is the release of imported apples from the port of entry, whereas the last step is the pest being distributed (as a result of the processing, sale or disposal of these apple fruit) in a viable state to an endangered area and subsequently being transferred to a suitable host.

To assess the probability of distribution, the distribution scenario is addressed in the three subheadings below. First, is a brief description of the sequence of events leading to a successful exposure of the pest from a single infested/infected apple to a susceptible host plant. Second, is the assessment of partial probability of distribution of the pest in relation to each of the exposure groups. Third, is the conclusion for the probability of distribution.

**Sequence of events for successful exposure**

The sequence of events that has to be completed for successful exposure of host plants to *E. amylovora* from infested or infected apples is summarised below.

In mature harvested fruit, cells of *E. amylovora* occur predominantly in remnant flower parts in the calyxes. Bacteria can also be present on the stem-end and on the surface of fruit. Endophytic infection can occur but it is a rare event.

Cold storage of apples will reduce the epiphytic bacterial population on fruit. The population numbers are probably reduced because of low levels of nutrients in the calyxes, rather than exposure to low temperatures. *E. amylovora* on fruit that survives cold storage or controlled atmosphere would enter the endangered area.

On entry, apples are consumed and waste (whole, partially eaten, cores and peels) is disposed of in landfills via garbage collection or into backyard compost pits/heaps, which may be close to a susceptible host plant.

*Erwinia amylovora* in fruit waste must be in a viable state. Waste material should either have an adequate inoculum dose or bacteria present in it must multiply to a concentration that could initiate an infestation/infection. Discarded waste would be rapidly colonised by other micro-organisms or consumed by insects, mammals or birds, and the fireblight bacteria destroyed by bacteriophages in the soil.

To transfer *E. amylovora* to a susceptible host, a vector must pick up the bacteria in sufficient concentration to initiate a new infection. Many arthropods have been identified that could potentially transfer inoculum of *E. amylovora* from waste to a susceptible host, but none have been shown to do so.

Finally, sufficient inoculum must be transferred to a receptive site in a susceptible host, mainly confined to the sub-family *Maloideae* of the family *Rosaceae*. The most susceptible sites are blossoms. These are abundant in spring in pome and other susceptible fruit trees and at other times on susceptible amenity plants. Infection can also be initiated in the absence of flowers through natural openings or wounds caused by insect damage or hail damage, etc.

Successful infection would take place under favourable environmental conditions, provided that each step listed above is completed.

Apple fruit imported from anywhere in New Zealand is more likely to have populations of *E. amylovora* as calyx infestations. There are several biological and epidemiological factors that may contribute to the exposure of the bacterium to a receptive site in a susceptible host. The available scientific evidence for critical events for exposure of susceptible hosts to *E. amylovora* is cited in the text given below.

*E. amylovora* will enter the environment through the disposal of infected waste as spoiled whole fruit, partially consumed fruit or fruit peels and cores. The pathogen then must be able to survive in or on fruit, in discarded waste or in soil. Exopolysaccharides of *E. amylovora* capsules prevent cells from losing water, which can be important under dry environmental conditions (Geider, 2000). *E. amylovora* synthesises amylovoran as the capsular exopolysaccharide (EPS), which is induced in environments with suitable carbon sources (Hildebrand *et al.*, 2001). *E. amylovora* cells present in calyxes do not have access to these carbon sources (Taylor *et al.*, 2003a) and this may explain the rapid decline of bacteria in the calyx and hence the lack of growth and multiplication. When discarded into the general soil environment, *E. amylovora* can survive for a limited period (Ark, 1932; Hildebrand *et al.*, 2001; Thomson, 1969). When waste material is disposed of into landfills or compost heaps, contamination caused by soil micro-organisms will result in its rapid decay. *E. amylovora* is often over grown with other bacteria when isolations are done from organic material, suggesting that the pathogen may not survive long in that environment (AQIS, 1998a). Bacteriophages that destroy *E. amylovora* have also been readily isolated from soil beneath apple and pear trees (Baldwin and Goodman, 1963; Erskine, 1973; Hendry *et al.*, 1967; Schnabel *et al.*, 1998). *E. amylovora* cells can survive in the dark for considerable periods, but are killed rapidly when exposed to ultraviolet light in full sunlight (Southey and Harper, 1971). *E. amylovora* does not produce resting cells (Roberts *et al.*, 1998) and is vulnerable to above ground desiccation (Maas Geesteranus and de Vries, 1984). Survival in soil is not considered to be epidemiologically significant (Roberts *et al.*, 1998; Thomson, 2000).

For *E. amylovora* to establish, factors such as availability, numbers and distribution of susceptible hosts are important considerations. Receptivity of the host is another issue that will determine establishment. In Australia, abundant susceptible host plants are grown as monocultures. These are most receptive to infection during spring when they are flowering, because flowers are the most susceptible sites. There are also several amenity trees that are sparsely distributed but able to produce flowers almost throughout the year (Merriman, 1996). Infection can also occur through natural openings or wounds (Biggs, 1990).

*E. amylovora* does not have specific vectors or mechanism to allow transmission from an apple to a suitable host. The most likely mechanism of transfer of bacteria from discarded apples to a receptive site in a susceptible host is by browsing insects (AQIS, 1998a). Bacteria were not transferred from contaminated calyxes by insects, wind or rain (Taylor *et al.*, 2003a). Bacteria are disseminated by water but are vulnerable to desiccation if the water film dries out before they reach the infection site (Maas Geesteranus and de Vries, 1984). Hale *et al.* (1996b) also reported that there was no detectable spread of *E. amylovora* from heavily infested calyxes.

An adequate inoculum dose of *E. amylovora* is required for successful exposure of the pathogen to a host. Hildebrand (1939) reported that a single bacterium was sufficient to cause infection in detached flowers when it was placed directly in the hypanthium and incubated under optimal conditions in the greenhouse. van der Zwet *et al.* (1994) showed that five

bacteria were sufficient to cause fire blight symptoms in apple flowers in one season, but in another season a minimum of 5,000 bacteria per blossom was required for infection to occur. In New Zealand, experiments were conducted to determine the number of *E. amylovora* cells required to infect apple and cotoneaster flowers (Hale *et al.*, 1996b). They found that, when flowers were inoculated with  $10^0$  to  $10^4$  cfu, there were no disease symptoms and *E. amylovora* was not detected. Disease symptoms were only observed when the inoculum dose of *E. amylovora* exceeded  $10^6$  cfu (Taylor *et al.*, 2003b). Such populations may exist in fruit from heavily infected orchards but not in fruit from lightly infected or symptomless orchards (Hale and Taylor, 1999). It is highly unlikely that the minimum dose required for infection will be found in apple waste.

Taking the above evidence into consideration, it is extremely unlikely that there is continuity in the pathway for dissemination of *E. amylovora* to a susceptible host. Therefore, the probability of transfer of *E. amylovora* from waste discarded at any utility point to susceptible hosts was assessed as negligible.

### ***Partial probability of distribution***

The partial probability of distribution (PPD) was estimated separately for each of the four exposure groups: commercial fruit crops; nursery plants; household and garden plants; and, wild and amenity plants.

The details and the method of calculation for the PPD of the four exposure groups are explained in the method section and the results are presented in the series of tables and figures below. The information from these tables and figures was used to assess the probability of distribution of *E. amylovora* to all the exposure groups.

Table 26 indicates the proportions of the five utility points near each of the exposure groups of *E. amylovora*.

**Table 26 The proportions of utility points near host plants susceptible to *E. amylovora* in the four exposure groups**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Proximity</b> Orchard wholesalers	Certain	Very low	Low	Low
<b>Proximity</b> Urban wholesalers	Extremely low	Very low	Very low	Very low
<b>Proximity</b> Retailers	Very low	Low	Very low	Very low
<b>Proximity</b> Food services	Extremely low	Extremely low	Very low	Very low
<b>Proximity</b> Consumers	Very low	Very low	Low	Low

Figure 14 provides an estimate of the relative amounts of infested/infected apples discarded from different utility points near each of the exposure groups of *E. amylovora*.

**Figure 14 Pictorial representation of infested/infected apples discarded by utility points near exposure groups of *E. amylovora***

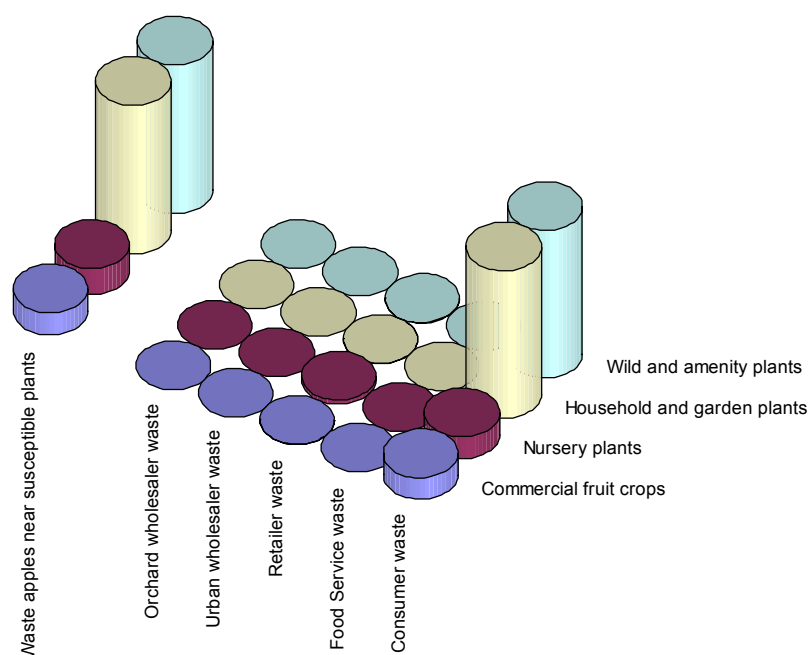


Table 27 is the summary of the probability that exposure of the host plants would result from a discarded single infested/infected apple from different utility points. Evidence is provided in the text below under the different exposure groups.

**Table 27 The probability of exposure of susceptible host plants to *E. amylovora* by utility points discarding a single infested/infected apple near exposure groups**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Exp</b> Orchard <sup>20</sup> wholesaler waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Urban	Negligible	Negligible	Negligible	Negligible

<sup>20</sup> As indicated in the method section, for pathogens waste includes discarded infested/infected apples.

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
wholesaler waste				
<b>Exp</b> Retailer waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Food service waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Consumer waste	Negligible	Negligible	Negligible	Negligible

### *Commercial fruit crops*

#### *Commercial fruit crops near utility points*

The proportions of the five utility points near commercial fruit crops susceptible to *E. amylovora* are shown in Table 26. It was estimated that commercial fruit crops are certain to be located near all orchard wholesalers, very unlikely to be near retailers and consumers, and extremely unlikely to be near urban wholesalers and food services because most of these are in metropolitan areas.

The relative amounts of infested/infected apples discarded near commercial fruit crops susceptible to *E. amylovora* are indicated in Figure 14.

#### *Exposure to host*

As shown in Table 27, it is considered that the probabilities that exposure of commercial fruit crops would result from a discarded single infested/infected apple from different utility points would all be negligible. Other supporting evidence is provided in the text below.

Factors common to all exposure scenarios for various host-utility group combinations are given in the sub-section on the sequence of events for successful exposure of susceptible hosts to *E. amylovora*. Supporting evidence for factors specific to different host groups are provided in the text below under each host group.

Major commercial fruit crops susceptible to *E. amylovora* are apple (*Malus* spp.) and pear (*Pyrus* spp.). Other fruit trees are quince (*Cydonia* spp.) and loquat (*Eriobotrya japonica*) and rarely Japanese plum (*Prunus salicina*). Apples and pears are grown in large monocultures in commercial orchards, whereas other fruit trees are less extensively grown.

<b>Exp</b> commercial fruit crops from orchard wholesaler waste	<p>The probability that exposure of commercial fruit crops would result from a discarded single infested/infected apple from orchard wholesalers: <b>Negligible</b>.</p> <ul style="list-style-type: none"> <li>Most orchard wholesalers would dispose of their waste in an isolated area within the orchard premises. To maintain good hygienic conditions the waste disposal sites are unlikely to be near commercial fruit crops.</li> <li>Some orchard wholesalers dispose of their waste into landfill sites. Commercial fruit crops are unlikely to be near these sites.</li> </ul>
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**Negligible**

**Exp** commercial fruit crops  
from urban wholesaler waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from a discarded single infested/infected apple from urban wholesalers: **Negligible**.

- Urban wholesalers dispose of their waste into landfill sites. Commercial fruit crops will not be near these sites.

**Exp** commercial fruit crops  
from retailer waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from a discarded single infested/infected apple from retailers: **Negligible**.

- Most retailers are in metropolitan and suburban areas not close to commercial fruit crops.
- Retailer waste in metropolitan and suburban areas is disposed of in landfills and commercial fruit crops will not be near these sites.
- Some retailers in rural areas may utilise their waste for composting. Some composting sites may be near commercial orchards.

**Exp** commercial fruit crops  
from food service waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from a discarded single infested/infected apple from food services: **Negligible**.

- Commercial fruit crops will not be near landfill sites in metropolitan areas where food service waste is disposed of.

**Exp** commercial fruit crops  
from consumer waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from a discarded single infested/infected apple from consumers: **Negligible**.

- Most consumers are located in metropolitan and suburban areas. People in metropolitan areas and some in urban areas would dispose of their waste in landfills. Commercial fruit crops will not be near these sites.
- Population density near commercial orchards is low.
- Some consumer waste in suburban and rural areas may be utilised for composting. Some commercial fruit crops are likely to be near compost heaps.

### *Nursery plants*

#### *Nursery plants near utility points*

The proportions of the five utility points near nursery plants susceptible to *E. amylovora* are shown in Table 26. It was estimated that nursery plants are unlikely to be near retailers, very unlikely to be near orchard wholesalers, urban wholesalers and consumers, and extremely unlikely to be near food services.

The relative amounts of infested/infected apples discarded near nursery plants susceptible to *E. amylovora* are indicated in Figure 14.

### *Exposure to host*

As shown in Table 27, it is considered that the probability that exposure of nursery plants would result from a discarded single infested/infected apple from different utility points would all be negligible.

Factors common to all exposure scenarios for various host-utility group combinations are given in the sub-section on the sequence of events for successful exposure of susceptible hosts to *E. amylovora*. Supporting evidence for factors specific to different host groups are provided in the text below under each host group.

Common nursery plants include apple (*Malus* spp. including crab apples), cultivated and wild species of pear (*Pyrus* spp.), quince (*Cydonia* spp.), loquat (*Eriobotrya japonica*), Japanese plum (*Prunus salicina*) and roses (*Rosa rugosa*).

**Exp** nursery plants from  
orchard wholesaler waste  
**Negligible**

The probability that exposure of nursery plants would result from a discarded single infested/infected apple from orchard wholesalers: **Negligible.**

- Some orchardists may raise their own nursery plants or run a parallel wholesale business. Also, pome fruit nurseries may be near orchards.
- Nurseries are likely to have susceptible varieties of pome fruit raised on highly susceptible rootstocks. These are planted at high densities and would have favourable micro-climatic conditions for rapid establishment and spread of fire blight.
- Nursery plants would be susceptible mostly during flowering or when injuries occur.
- It is highly unlikely, for hygienic reasons, that pome fruit or other amenity tree nurseries would be near wholesaler waste disposal sites.

**Exp** nursery plants from urban  
wholesaler waste  
**Negligible**

The probability that exposure of nursery plants would result from a discarded single infested/infected apple from urban wholesalers: **Negligible.**

- Pome fruit nurseries are extremely unlikely to be near landfill sites in which urban wholesaler waste is disposed of.
- There are rare instances of nurseries being near urban landfill sites. In general, nurseries maintain a high hygienic standard by regular application of fungicides and other chemicals to ensure freedom from disease.

**Exp** nursery plants from retailer  
waste  
**Negligible**

The probability that exposure of nursery plants would result from a discarded single infested/infected apple from retailers: **Negligible.**

- Nursery plants such as fruit trees (e.g. apple, pear) and ornamentals (e.g. roses) are sold in major retail outlets. Retailer waste is temporarily stored in bins within the premises. There is a low likelihood of transfer of the pest, unless the same people handling fruit are also managing nursery plants.
- Retail nurseries keep numerous plant species at high densities.



In rare instances, some nurseries may be near waste disposal sites but these will maintain a high hygienic standard to prevent pest damage.

**Exp** nursery plants from food  
service waste

**Negligible**

The probability that exposure of nursery plants would result from a discarded single infested/infected apple from food services:

**Negligible.**

- Nurseries would not be near landfill sites in which food services waste is disposed of.

**Exp** nursery plants from  
consumer waste

**Negligible**

The probability that exposure of nursery plants would result from a discarded single infested/infected apple from consumers:

**Negligible.**

- Most consumers in metropolitan and suburban areas dispose of their waste into landfills. Nurseries are generally not located near these sites.

### *Household and garden plants*

#### *Household and garden plants near utility points*

The proportions of the five utility points near household and garden plants susceptible to *E. amylovora* are shown in Table 26. It was estimated that household and garden plants are unlikely to be near orchard wholesalers and consumers, and are very unlikely to be near urban wholesalers, retailers and food services.

The relative amounts of infested/infected apples discharged or discarded near household and garden plants susceptible to *E. amylovora* are given in Figure 14.

#### *Exposure to host*

As shown in Table 27, it is considered that the probability that exposure of household and garden plants would result from a discard single infested/infected apple, from different utility points would all be negligible. Extra evidence, if available, is provided in the text below.

Factors common to all exposure scenarios for various host-utility group combinations are given in the sub-section on the sequence of events for successful exposure of susceptible hosts to *E. amylovora*. Supporting evidence for factors specific to different host groups are provided in the text below under each host group.

The most common household and garden plants would be apple (*Malus* spp.), pear (*Pyrus* spp.) and roses (*Rosa rugosa*); less common host plants would be quince (*Cydonia* spp.) and loquat (*Eriobotrya japonica*).

**Exp** household and garden  
plants from orchard wholesaler  
waste

**Negligible**

The probability that exposure of household and garden plants would result from a discarded single infested/infected apple from orchard wholesalers: **Negligible.**

- Orchard wholesale waste sites are located in an isolated area within the orchard premises and are not near household and garden plants.

**Exp** household and garden  
plants from urban wholesaler waste  
**Negligible**

The probability that exposure of household and garden plants would result from a discarded single infested/infected apple from urban wholesalers: **Negligible**.

- Urban wholesaler waste is disposed of in landfill sites and household plants are unlikely to be near these sites because residential properties would be located away from them.

**Exp** household and garden  
plants from retailer waste  
**Negligible**

The probability that exposure of household and garden plants would result from a discarded single infected from retailers: **Negligible**.

- Retailer waste would be disposed of in landfill sites, which are generally not near residential properties.
- Household and garden plants near retailers will not be exposed to retailer waste because it is kept in bins before disposal.
- Major retailers will have hosts susceptible to *E. amylovora* near apple fruit displayed for sale. Retail nurseries are sometimes found near fresh food markets.

**Exp** household and garden  
plants from food service waste  
**Negligible**

The probability that exposure of household and garden plants would result from a discarded single infested/infected apple from food services: **Negligible**.

- Food service industries are unlikely to have host plants susceptible to *E. amylovora* within their premises.
- Waste from food services is disposed of in landfill sites.

**Exp** household and garden  
plants from consumer waste  
**Negligible**

The probability that exposure of household and garden plants would result from a discarded single infested/infected apple from consumers: **Negligible**.

- Most consumers are in metropolitan and suburban areas, and their waste is disposed of in landfills. Household and garden plants susceptible to *E. amylovora* are unlikely to be in metropolitan areas but are certain to be in suburban areas.
- Local authorities encourage recycling of waste to prepare compost. This is becoming a common practice in some rural and suburban areas where susceptible household and garden plants are found.
- Pome fruit trees are common garden plants in temperate parts of Australia.

### *Wild and amenity plants*

#### *Wild and amenity plants near utility points*

The proportions of the five utility points near wild and amenity plants susceptible to *E. amylovora* are shown in Table 26. It was considered that wild and amenity plants are unlikely to be near orchard wholesalers and consumers, and very unlikely to be near urban wholesalers, retailers and food services.

The relative amounts of infested/infected apples discarded near wild and amenity plants susceptible to *E. amylovora* are indicated in Figure 14.

*Exposure to host*

As shown in Table 27, it is considered that the probability that exposure of wild and amenity plants would result from a discarded single infested/infected apple, from different utility points would all be negligible.

Factors common to all exposure scenarios for various host-utility group combinations are given in the sub-section on the sequence of events for successful exposure of susceptible hosts to *E. amylovora*. Supporting evidence for factors specific to different host groups are provided in the text below under each host group.

Host plants of *E. amylovora* in this category includes several ornamental species of hawthorn (*Crataegus* spp.), firethorn (*Pyracantha* spp.), cotoneaster (*Cotoneaster* spp.), serviceberries (*Amelanchier* spp.), mountain-ash (*Sorbus* spp.) and *Stranvaesia davidiana*. Apart from these species, crab apples (*Malus* spp.) and wild species of pear (*Pyrus* spp.) may also be present.

**Exp** wild and amenity plants  
from orchard wholesaler waste  
wholesaler)

**Negligible**

The probability that exposure of wild and amenity plants would result from a discarded single infested/infected apple from orchard wholesalers: **Negligible**.

- Orchard wholesale waste sites are mostly located within the orchard premises and are not located near wild and amenity plants. However, some amenity plants (e.g. cotoneaster) may be present as hedgerows in the orchard boundary.
- Susceptible feral plants (e.g. volunteer apple seedlings, crab apples, etc.) may be present near an orchard wholesaler's waste disposal sites.
- Susceptibility of native plants to *E. amylovora* is unknown.

**Exp** wild and amenity plants  
from urban wholesaler waste

**Negligible**

The probability that exposure of wild and amenity plants would result from a discarded single infested/infected apple from urban wholesalers: **Negligible**.

- Urban wholesaler waste is disposed of in landfills. Several susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds (e.g. crab apple trees, apple seedlings, firethorn, cotoneaster, etc.).
- Some susceptible host plants (e.g. Manchurian pear) may be near urban wholesalers, but waste from these premises will be kept in bins and would not be exposed to susceptible plants.

**Exp** wild and amenity plants  
from retailer waste

**Negligible**

The probability that exposure of wild and amenity plants would result from a discarded single infested/infected apple from retailers: **Negligible**.

- Retailer waste would be disposed of in landfills. Susceptible hosts may grow in the wild near these sites as a consequence of dispersal of seeds of susceptible plants by birds.

**Exp** wild and amenity plants  
from food service waste  
**Negligible**

The probability that exposure of wild and amenity plants would result from a discarded single infected apple from food services: **Negligible.**

- Food services would dispose of their waste in landfills. Seedlings originating from seeds dispersed by birds would be present.

**Exp** wild and amenity plants  
from consumer waste  
**Negligible**

The probability that exposure of wild and amenity plants would result from a discarded single infested/infected apple from consumers: **Negligible.**

- Most consumers in metropolitan and suburban areas dispose of their waste in landfills. Susceptible hosts may grow from seeds in the wild near these sites as result of dispersal by birds.
- Some consumers may discard apple cores, rotten fruit or partially eaten fruit into the environment. This is likely to occur near parks, gardens, recreation sites and along roadsides where susceptible plants may be found. However, the density of host plants near these sites would be low.
- Local authorities encourage recycling of waste to make compost, and this is becoming a common practice in some rural areas. Garden hedgerows and the neighbourhood of some localities may have susceptible amenity plants (e.g. cotoneaster, hawthorn).
- Pome fruit trees are common horticultural plants in back gardens in some parts of Australia. These may be found near compost heaps.

### ***Conclusion—probability of distribution***

The partial probability of distribution from each of the utility points to each of the exposure groups is summarized in Table 28. The simulation model using the @risk calculated this. The quantitative model evaluated the effect of the ‘volume of trade’ during a specified period when calculating the partial probability of distribution.

**Table 28 Partial probabilities of distribution (PPD)<sup>21</sup> for *E. amylovora***

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Orchard wholesalers</b>	Extremely low	Extremely low	Extremely Low	Extremely low
<b>Urban wholesalers</b>	Negligible	Extremely low	Extremely low	Extremely low
<b>Retailers</b>	Very low	Very low	Very low	Very low
<b>Food services</b>	Extremely low	Extremely low	Extremely low	Extremely low
<b>Consumers</b>	Low	Low	Moderate	Moderate
PPD <sup>22</sup>	Low	Low	Moderate	Moderate

### Probability of establishment or spread

The assessment for the probability of establishment or spread is carried out in the following manner. Firstly, partial probability for establishment and for spread was assessed separately based on the relevant available scientific information. Secondly, the combined partial probability of establishment or spread for each of the four exposure groups was assessed. The relevant information for the assessment for the probability of establishment or spread is presented below against the factors listed ISPM 11, Rev. 1.

#### *Partial probability of establishment*

ISPM 11 factor	Relevant information
<b>Availability of suitable hosts, alternate hosts and vectors in the PRA area</b>	<ul style="list-style-type: none"> <li>In Australia the sub-family <i>Maloideae</i> has at least 16 host genera susceptible to fire blight, each containing several species (given within parentheses). They are: service berry, <i>Amelanchier</i> spp. (6); chokeberry, <i>Aronia</i> spp. (3); Japanese quince, <i>Chaenomeles</i> spp. (5); cotoneaster, <i>Cotoneaster</i> spp. (30); hawthorn, <i>Crataegus</i> spp. (19); quince, <i>Cydonia</i> spp. (3); loquat, <i>Eriobotrya</i> sp. (1); <i>Heteromeles</i> sp. (1); apple, <i>Malus</i> spp. (17); medlar, <i>Mespilus</i> sp. (1); photinia, <i>Photinia</i> spp. (4); firethorn, <i>Pyracantha</i> spp. (8); pear, <i>Pyrus</i> spp. (9); Indian hawthorn, <i>Raphiolepis</i> spp. (2); mountain ash, <i>Sorbus</i> spp. (23); and, <i>Stranvaesia</i> spp. (23) (AQIS, 1998b).</li> <li>Occasionally, natural infections of <i>E. amylovora</i> occur on</li> </ul>

<sup>21</sup> Probability of distribution for pathogens is actually referring to the probability of entry.

<sup>22</sup> Partial probability of distribution is actually referring to the probability of entry and was estimated by @risk.

ISPM 11 factor	Relevant information
Suitability of the environment	<p>species not belonging to the sub-family <i>Maloideae</i>; for example, on Japanese plums (<i>Prunus salicina</i>) when there is an active source of inoculum of <i>E. amylovora</i> nearby (Mohan and Thomson, 1996). In Germany, <i>E. amylovora</i> was detected on young fruits of plums (<i>P. domestica</i>) (Berger <i>et al.</i>, 2000).</p>
	<ul style="list-style-type: none"> <li>• Susceptibility of native plants of the sub-family <i>Maloideae</i> to <i>E. amylovora</i> is unknown.</li> <li>• Limited observations indicate that continuous flowering of <i>Malus</i> spp., <i>Pyrus</i> spp., <i>Crataegus</i> spp., <i>Cotoneaster</i> spp. and <i>Cydonia</i> spp. occurs between August and January, and that of <i>Eriobotrya</i> spp. and <i>Amelanchier</i> spp. occurs between April and June (Merriman, 1996). Production of secondary blossom (rat-tails) in late spring and early summer is likely to prolong the potential period of disease establishment.</li> <li>• Australia has either the same species or the same genus but different species of the 27 insect vectors (AQIS, 1998a) listed for the USA. Several crawling, browsing, flying or other animals have the potential to spread bacterial ooze from overwintering cankers to blossoms (Schroth <i>et al.</i>, 1974). Pollinating insects, primarily bees, are agents of secondary spread of the pathogen.</li> <li>• In most years, environmental conditions in many Australian apple- and pear-growing areas (notably the Goulburn Valley) are favourable for infection (Penrose <i>et al.</i>, 1988; Wimalajeewa and Atley, 1990; Fahy <i>et al.</i>, 1991). Apple production in Australia is confined to high rainfall areas. In these areas, the temperature during the blossoming period is higher than the threshold required for fire blight development (Roberts, 1991).</li> <li>• Incidence of blossom blight increased at relative humidities above 60 per cent, with 100 per cent infection at relative humidities above 85 per cent (Norelli and Beer, 1984). These conditions occur in the spring and summer in most locations where pome fruit is grown.</li> <li>• Hailstorms are common in pome fruit growing areas in Australia (QFVG, 2000). These cause injuries on plant tissues, and predispose them to infection (Brooks, 1926; Keil <i>et al.</i>, 1996).</li> <li>• Several potential infection days (PIDs) and multiple infection periods (MIPs) for fire blight occur at blossoming in apple production areas of Queensland, New South Wales and Victoria (Atley, 1990; Fahy <i>et al.</i>, 1991; QFVG, 1996) (Wimalajeewa and Atley, 1990).</li> </ul>

ISPM 11 factor	Relevant information
<b>The potential for adaptation of the pest</b>	<ul style="list-style-type: none"> <li>Repeated use of streptomycin can result in the development of resistant strains (Thomson <i>et al.</i>, 1993; Jones and Schnabel, 2000). Resistance is determined by a chromosomal gene, and is not readily transferred in conjugation studies. Streptomycin-resistant strains were found in New Zealand (Thomson <i>et al.</i>, 1993), but no reports of occurrence of resistance since the 1990's.</li> <li>Stable differences in virulence of some strains have been found on different genotypes of varieties of apple (Norelli <i>et al.</i>, 1984).</li> </ul>
<b>The reproductive strategy of the pest</b>	<ul style="list-style-type: none"> <li>Under favourable conditions, bacteria may divide every 20 minutes by binary fission (dividing the cytoplasm into two approximately equal parts by a transverse membrane). At this rate, one bacterium could produce one million bacteria in 10 hours (Agrios, 1997). Only one day of optimum temperature would be sufficient for low populations of <i>E. amylovora</i> to multiply to <math>10^5</math> to <math>10^6</math> cfu per blossom (Thomson <i>et al.</i>, 1999).</li> <li>The stigmas of blossoms are the most receptive sites for initiation of new infections; where bacteria can multiply rapidly, populations often reach <math>10^6</math> to <math>10^7</math> cfu per healthy flower (Thomson, 1986). However, blossom infection occurs only when bacteria reach the hypanthium (floral cup) under favourable conditions (Thomson, 2000).</li> </ul>
<b>Minimum population needed for establishment</b>	<ul style="list-style-type: none"> <li>One bacterium placed directly in the hypanthium was sufficient to cause blossom infection under controlled inoculations in the laboratory (Hildebrand, 1937). In some seasons five bacteria and in another 5,000 were sufficient to cause blossom infection (van der Zwet, 1994).</li> <li>Hale <i>et al.</i> (1996b) found that when blossoms were inoculated with <math>10^0</math> to <math>10^4</math> cfu there were no disease symptoms and <i>E. amylovora</i> could not be detected in the blossoms. Taylor <i>et al.</i> (2003b) demonstrated that successful infection of flowers occurred only when the populations of <i>E. amylovora</i> exceeded <math>10^6</math> cfu per flower four days after inoculation.</li> </ul>
<b>The method of pest survival</b>	<ul style="list-style-type: none"> <li>Exopolysaccharides in <i>E. amylovora</i> capsules prevent cells from losing water, which can be an important means of survival under dry environmental conditions (Geider, 2000). Polysaccharide material is readily rehydrated, enhancing the viability of bacterial cells (Keil and van der Zwet, 1972a). Bacteria can also form dry strands of polysaccharide material. These are present mainly during blooming and are considered important in dissemination (Ivanoff and Keitt, 1937).</li> <li><i>E. amylovora</i> can survive in the previous year's cankers (Beer and Norelli, 1977) and as latent infections in internal stem tissues (Brooks, 1926; Miller, 1929).</li> <li>Populations of <i>E. amylovora</i> can survive in soil over winter</li> </ul>

ISPM 11 factor	Relevant information
	<p>(Thomson, 1969) and could act as a source primary inoculum. Ark (1932) demonstrated that the pathogen survived under natural conditions for about three months. However, a more recent study showed that <i>E. amylovora</i> declined rapidly in untreated soil collected from a field, and the pathogen was no longer detected five weeks after inoculation (Hildebrand <i>et al.</i>, 2001). Bacteriophages that destroy <i>E. amylovora</i> are readily isolated from soil beneath apple and pear trees (Baldwin and Goodman, 1963; Hendry <i>et al.</i>, 1967).</p> <ul style="list-style-type: none"> <li>• <i>E. amylovora</i> could survive 11 weeks in nectar and eight weeks in honey at 4°C. Survival was much shorter at higher temperatures. Debris, wax and propolis (bee glue, used by bees to cement the combs to hives and close up cells) were bad media for survival. In pollen, <i>E. amylovora</i> survived 40 weeks at 15°C and more than 50 weeks at 4°C (Wael <i>et al.</i>, 1990).</li> <li>• Under low relative humidity, the bacteria can survive in the dry exudate from cankers for one to two years (Rosen, 1938; Hildebrand, 1939) but under humid conditions survival time was much shorter (Hildebrand, 1939).</li> <li>• <i>E. amylovora</i> can survive in the dark for considerable periods, but is killed rapidly on exposure to ultraviolet light in full sunlight (Southey and Harper, 1971).</li> </ul>
<b>Cultural practices and control measures</b>	<ul style="list-style-type: none"> <li>• Streptomycin is the most effective chemical to control fire blight, particularly at blossoming (van der Zwet and Keil, 1979).</li> <li>• New chemicals (e.g. oxytetracycline, fosetyl-aluminium, oxolinic acid) have been tested in the USA and found to be effective as replacements for copper compounds and streptomycin (Psallidas and Tsiantos, 2000), but they are used because of phytotoxicity and resistance problems with streptomycin. These chemicals cannot be used in Australia because they are not registered for use to control fire blight.</li> <li>• Naturally occurring bacterial antagonists (e.g. <i>Pantoea agglomerans</i> (synonym: <i>Erwinia herbicola</i>) and <i>Pseudomonas fluorescens</i>) have proven to be effective against blossom infection (Johnson and Stockwell, 2000), but they are not widely used.</li> </ul>

#### Conclusion—partial probability of establishment

Based on the above evidence, partial probability of establishment for each of the exposure groups is assessed as follows.

Partial probability of establishment for commercial fruit crops: **High**.

Partial probability of establishment for nursery plants: **High**.

Partial probability of establishment for household and garden plants: **Moderate**.



Partial probability of establishment for wild and amenity plants: **Moderate**.

***Partial probability of spread***

ISPM 11 factor	Relevant information
<b>Suitability of the natural and managed environment</b>	<ul style="list-style-type: none"> <li>In most years, environmental conditions in many Australian apple- and pear-growing areas (notably the Goulburn Valley) are favourable for infection and spread of <i>E. amylovora</i> (Penrose <i>et al.</i>, 1988; Wimalajeewa and Atley, 1990; Fahy <i>et al.</i>, 1991). Large areas of land are planted with cultivars of apple and pear susceptible to fire blight as a monoculture (e.g. the Goulburn Valley).</li> <li>Flowering periods extend over three months; for example, from the second week of September to the third week of November in Orange, New South Wales (Penrose <i>et al.</i>, 1988).</li> <li>Alternative hosts in the vicinity of orchards are available either as intentionally planted trees or volunteer plants established from seeds dispersed in the environment (Billing, 1980) or as nearby susceptible native plants (Paulin <i>et al.</i>, 1993).</li> <li>Hail, strong winds or thunderstorms cause injuries on plant tissues, and predispose them to infection (Brooks, 1926; Keil <i>et al.</i>, 1996). Rain (wind-blown or splashed) is probably the major factor in spreading primary inoculum from oozing overwintering cankers (Miller, 1929) and is also a means of secondary spread of <i>E. amylovora</i> inoculum (Thomson, 1986). Rain also indirectly aids survival and spread of the bacterium by diluting nectar in blossoms and providing more favourable conditions for multiplication (Ivanoff and Keitt, 1941). The presence of ooze, accompanied by warm temperatures and rain, provides ideal conditions for spread and infection (Hildebrand, 1939). During rain, dried ooze gets rehydrated and is then spread by splash dispersal (Eden-Green, 1972).</li> </ul>
<b>Presence of natural barriers</b>	<ul style="list-style-type: none"> <li>The major apple production areas are confined to six States in Australia. These areas have differing climatic conditions and are separated by long distances, including desert areas between some States. There is potential for rapid spread within growing areas but not between them, unless simultaneous infections occur in each area or infected plants are transported to new areas across these natural barriers.</li> <li>There is circumstantial evidence that <i>E. amylovora</i> can be spread long distances over land or sea by birds (Meijneke, 1974; Billing, 1974b) or by deposition of solid aerosols transported by high altitude air currents (Meijneke, 1974).</li> </ul>

ISPM 11 factor	Relevant information
<b>Potential movement of pest with commodities or conveyances</b>	<ul style="list-style-type: none"> <li>• <i>E. amylovora</i> has been isolated from the calyxes of apple fruit at harvest (Hale <i>et al.</i>, 1987).(van der Zwet <i>et al.</i>, 1990) The pathogen could be spread via fruit, but spread via this pathway has not been demonstrated (Taylor <i>et al.</i>, 2003a).</li> <li>• The pathogen can spread from infected to healthy trees by pruning tools, hands, boots and machinery (Psallidas and Tsiantos, 2000). It also can spread through trash (leaves, stems, twigs and soil).</li> <li>• <i>E. amylovora</i> can survive on artificially contaminated wood for limited periods, but transfer from there has not been demonstrated on uninjured fruit (Ceroni <i>et al.</i>, 2003).</li> <li>• The pathogen has spread over long distances through movement of planting material (Bonn, 1979; van der Zwet and Walter, 1996; Calzolari <i>et al.</i>, 1982).</li> </ul>
<b>Intended use of the commodity</b>	<ul style="list-style-type: none"> <li>• The intended use of imported mature apple fruit would be for human consumption.</li> </ul>
<b>Potential vectors of pest</b>	<ul style="list-style-type: none"> <li>• Seventy-seven genera of arthropods have been implicated in the secondary spread of <i>E. amylovora</i>. These include honeybees, aphids, pear psylla (<i>Psylla pyricola</i>), tarnished plant bug (<i>Lygus pratensis</i>), leafhoppers and numerous flies (van der Zwet and Keil, 1979).</li> <li>• Of the 27 insect vectors listed for the USA (van der Zwet and Keil, 1979), Australia has either the same species or the same genus but different species (AQIS, 1998a).</li> <li>• Managed hives of honeybees are used in contract pollination of apple orchards. Feral honey bees can also act as pollinators. Bees generally fly up to two to four kilometres to forage, and they are major vectors in the rapid spread of <i>E. amylovora</i> (Hoopingarner and Waller, 1992).</li> <li>• Apple leafcurling midge (<i>Dasineura mali</i>) causes damage to leaves, and predisposes them to infection by <i>E. amylovora</i>. However, there is no evidence to implicate the adult midge as a vector for dissemination of <i>E. amylovora</i> (Gouk and Boyd, 1999).</li> <li>• In Germany, Hildebrand <i>et al.</i> (2000) detected <i>E. amylovora</i> in 4.3 per cent of insects caught from apple trees with localised symptoms. Of this 4.3 per cent, 2.1 per cent were contaminated with bacteria (Hildebrand <i>et al.</i>, 2000). <i>E. amylovora</i> could be detected in or on green lacewing (<i>Chrysoperla carnea</i>) for at least five days after coming in contact with the bacterium, and in or on aphids (<i>Aphis pomi</i>) for 12 days (Hildebrand <i>et al.</i>, 2000).</li> </ul>
<b>Potential natural enemies</b>	<ul style="list-style-type: none"> <li>• Commercial formulations of strains of <i>Pseudomonas fluorescens</i> and <i>Pantoea agglomerans</i> (synonym: <i>Erwinia herbicola</i>) that produce antibiotics and compete for space and</li> </ul>

ISPM 11 factor	Relevant information
	<p>nutrients have been used as biocontrol agents (Wilson and Lindow, 1993; Vanneste, 1996). <i>E. herbicola</i> is recorded from rosaceous hosts in Australia (APPD, 2003). <i>P. fluorescens</i> has not been reported on rosaceous hosts in Australia.</p> <ul style="list-style-type: none"> <li>New antagonists for the control of <i>E. amylovora</i>, such as non-virulent strains of <i>E. amylovora</i>, yeasts, gram-positive bacteria and mixtures of bacteriophages specific to <i>E. amylovora</i> have shown promise in cultural tests or greenhouse assays, but they have not been widely tested under field conditions (Ritchie and Klos, 1977; Palmer <i>et al.</i>, 1997).</li> </ul>

#### *Conclusion—partial probability of spread*

Based on the above evidence, partial probability of spread for each of the exposure groups is assessed as follows.

Partial probability of spread for commercial fruit crops: **High**.

Partial probability of spread for nursery plants: **High**.

Partial probability of spread for household and garden plants: **High**.

Partial probability of spread for wild and amenity plants: **Low**.

#### **Combined partial probability of establishment or spread**

The combined partial probability of establishment or spread for each exposure group was determined by combining probability of establishment and probability of spread using the matrix of ‘rules’ for combining descriptive likelihoods presented in the method section. The results are given in Table 29.

**Table 29 Combined partial probabilities of establishment or spread of *E. amylovora***

	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Establishment</b>	High	High	Moderate	Moderate
<b>Spread</b>	High	High	High	Low
<b>PPES<sup>23</sup></b>	High	High	Moderate	Low

Additional evidence to support the combined partial probability of establishment or spread for specific exposure groups is provided in the text below.

<sup>23</sup> PPES = partial probability of establishment or spread.

<p><b>Commercial fruit crops</b> <b>High</b></p>	<ul style="list-style-type: none"> <li>All apple varieties grown in Australia are susceptible to <i>E. amylovora</i>. Australian pome fruit production areas have climatic conditions conducive to fire blight development. Orchards are now planted at higher densities, which require smaller trees. This is accomplished using dwarfing rootstocks (e.g. M.26, M.9) and tree training techniques. Budding a susceptible scion to a highly susceptible rootstock makes the plants more vulnerable to <i>E. amylovora</i>. Streptomycin, which is effective against <i>E. amylovora</i>, is not a registered chemical for control of fire blight in Australia.</li> </ul>
<p><b>Nursery plants</b> <b>High</b></p>	<ul style="list-style-type: none"> <li>Nurseries produce apple varieties and other amenity plants highly susceptible to <i>E. amylovora</i> for commercial planting in orchards. These high-density plantings provide easy access to susceptible tissues for propagules of the pathogen, and favourable micro-climatic conditions created by high-density planting would enable disease establishment and spread. However, use of some copper formulations, which act as bactericides, may prevent the spread of the pathogen if it were to establish. The use of infected scion wood has been identified as the major route for introduction of the pathogen to areas free from the disease.</li> </ul>
<p><b>Household and garden plants</b> <b>Moderate</b></p>	<ul style="list-style-type: none"> <li>Several fruit trees and hedgerow plants are highly susceptible to <i>E. amylovora</i>. The variety and number of fruit trees that can be grown in backyards will depend on the availability of space. Many households would have several fruit trees susceptible to <i>E. amylovora</i> (e.g. apple and pear). Use of chemicals is not the preferred method of disease control in most households but sanitation methods are commonly undertaken. Successful eradication of the disease would depend on the ability of householders to recognise it early and take timely action.</li> </ul>
<p><b>Wild and amenity plants</b> <b>Low</b></p>	<ul style="list-style-type: none"> <li>Susceptibility of native plants of the sub-family <i>Maloideae</i> to <i>E. amylovora</i> is unknown. It is likely that some plants established from seeds dispersed by birds (e.g. cotoneaster and firethorn) and apple cores discarded by consumers near parks and along the roads may serve as sources of inoculum. However, wild and amenity plants are scattered over a wide area, and are unlikely to be near an infected fruit.</li> </ul>

## Assessment of consequences

Impact scores allocated for the direct and indirect criteria are given in Table 30. Available supporting evidence is provided in the text below.

**Table 30 Impact scores for *E. amylovora***

Direct impact	Impact scores
Plant life or health	F
Human life or health	A
Any other aspects of the environment	A
Indirect impact	
Control or eradication	E
Domestic trade or industry	E
International trade	D
Environment	A
Communities	C

**Direct impact**

**Plant life or health – F** Consequences affecting plant life or health would be significant at the national level and highly significant at the regional level. A rating of ‘F’ was assigned to this criterion.

- Fire blight, caused by *E. amylovora* is the most serious disease of pome fruit trees worldwide (Schroth *et al.*, 1974).
- Fire blight epidemics can develop rapidly in orchards with no history of the disease, killing many large limbs or even whole trees. In some instances, fire blight causes no significant economic damage, even in orchards with severe blight in the previous season. Within these extremes, the incidence and severity of the disease can vary between orchards and seasons (Steiner, 2000).
- In addition to pome fruit, *E. amylovora* can infect several host species belonging to the sub-family *Maloideae* of the family *Rosaceae* (CABI, 2003a). Native plants belonging to the sub-family *Maloideae* are widespread in Australia, but susceptibility of these plants and the likely extent of losses are unknown (AQIS, 1998a).
- In New Zealand, losses for the Hawke’s Bay region were estimated to be at least NZD10 million in 1998 (Vanneste, 2000).
- In the USA, the annual damage from fire blight is estimated at USD200–500 million, despite regular control of the disease (Kennedy, 1980).
- A fire blight outbreak on apple in south-west Michigan in May

2000, caused losses estimated at USD42 million, including USD10 million in crop losses for the season, USD9 million in tree losses and USD23 million in crop losses expected until new plantings become established (Longstroth, 2001; Longstroth, 2002).

- In Australia the loss of production, in a worst-case scenario, for all production areas in Australia was estimated at 50 per cent and 20 per cent for pear and apple, respectively (Roberts, 1991).
- Bhati and Rees (1996) estimated that the annual potential loss in pome fruit production would be AUD125 million if *E. amylovora* were to establish in all regions of Australia. This represents 37.5 per cent of the gross annual value of pear fruit production in Australia.
- If fire blight were to occur, the value of lost production between 1997 and 2002 would have been AUD424 million in Victoria, AUD141 in New South Wales, AUD97 million in Tasmania, AUD66 million in Western Australia, AUD50 million in South Australia and AUD49.4 million in Queensland, a total of AUD827 million over the five-year period (Oliver *et al.*, 1997).
- The Tasmanian apple industry has a gross value of AUD70 million and accounts for approximately 18 per cent of the total Australian production and 65 per cent of Australian apple exports. It is estimated that, if fire blight were to establish, up to 30 per cent of production would be lost over five years (TAPGA, 2002).
- The average farm gate value of apple and pear in South Australia is estimated at AUD36 million, which represents approximately eight per cent of the total field crop value of AUD542 million. A 10 per cent loss of yield was estimated to cost growers about AUD3.5 million or at least AUD11.1 million of gross South Australian food revenue (AAPGA, 2000).
- The Western Australian pome fruit industry has an estimated farm gate value AUD47.1 million (AAPGA, 2000).
- Stanthorpe in Queensland produces approximately 45,000 tonnes of apples at a gross value of around AUD35 million. Street (1996) estimated the loss of annual income as a result of a fire blight outbreak in Stanthorpe to be AUD20.9 million, of which growers in the Shire of Stanthorpe would lose AUD7 million. Queensland Fruit and Vegetable Growers (QFVG) predicted an annual production loss of AUD20.9 million, if fire blight occurred in the Granite Belt region (QFVG, 2000).
- The New South Wales Apple and Pear Industry is worth AUD66.2 million in gross value of production (New South Wales Farmers' Association, 2000; Oliver *et al.*, 1997).

- In Victoria, in a worst-case scenario, the potential loss in pear and apple production in the Goulburn Valley was estimated at 40 per cent and one per cent, respectively (Roberts, 1991). (Hinchy and Low, 1990) estimated an annual loss of AUD77 million, if fire blight became established in the Goulburn Valley. If fire blight infection was five per cent in the Goulburn Valley, the estimated cost for pears would be AUD2.9 million a year (Bhati and Rees, 1996). Oliver *et al.* (1997) estimated that the total revenue loss for the Goulburn Valley as a result of fire blight would have been AUD410 million between 1997 and 2002.
- If *E. amylovora* were to occur in the Goulburn Valley, prevention and control measures would be implemented. Dead trees would be replaced, tolerant varieties would be replanted or other crops might even replace pome fruit. When combined with the effects of imports, the loss of production, and reduced net farm income, pome fruit production could permanently decline by 55 to 60 per cent (Kilminster, 1989).
- One tonne of pears used for canning, returns AUD270 to the grower and is converted to approximately AUD1,890 worth of canned pears at the wholesale level. One tonne of fresh apple returns about AUD400 to the grower worth about AUD1,375 at the wholesale market. It is estimated that fruit valued at AUD80 million is valued at AUD400 million at wholesale and double that at retail level (Northern Victorian Fruitgrowers, Association Ltd., 2000). Ardmona and SPC (now amalgamated) canning factories in Shepparton, Victoria, generate sales of AUD415 million a year, of which approximately AUD120 million is in exports (Commonwealth of Australia, 2001). Ardmona bought about AUD30 million worth of fruit per year, and canned fruit generated added value amounting to AUD160 million. A reduction in the throughput of pome fruit products would result in capital-intensive processing plants designed for continuous operation in the Goulburn Valley being underused (Kilminster, 1989).

**Human life or health –  
A**

There are no known direct impacts of *E. amylovora* on human life or health, and the rating assigned to this criterion was therefore ‘A’.

**Any other aspects of  
environmental effects  
– A**

There are no known other direct impacts of *E. amylovora* on the environment, and the rating assigned to this criterion was therefore ‘A’.

**Indirect impact**

**Control or eradication  
– E**

The indirect impact on new or modified eradication, control, surveillance/monitoring and compensation strategies would be minor at the national level, significant at the regional level and highly significant at the district level. The rating assigned to this criterion was therefore ‘E’.

- In the USA, management of fire blight adds about 30 per cent to chemical costs and an additional USD100 per acre for pruning costs annually. These figures translate to AUD700 and AUD1000 per hectare for pears and apples respectively and AUD275 per hectare for pruning (Oliver *et al.*, 1997).
- In the event of a fire blight outbreak, the Australian Government and State Governments would incur substantial costs associated with regulatory enforcement and implementation of the contingency plan (control/eradication and surveillance/monitoring).
- The *E. amylovora* eradication program in and around Melbourne, Victoria, cost the Australian Government and the Victorian State Government about AUD2.8 million (Australian National Audit Office., 2000).
- Payment of compensation for growers affected by fire blight could involve large sums of money.
- Replanting a hectare of apples in the Batlow region of NSW is estimated to cost at least AUD10, 000 (Commonwealth of Australia, 2001).
- Additional costs would be incurred for modification of orchard management programs, including the use chemicals, disinfestation of machinery, and regulatory enforcement of quarantine conditions.
- Organic growers may be compelled to use streptomycin (in the absence of an effective alternative). This would result in these growers immediately losing their certification for growing organic apples and the premium prices for such products (Commonwealth of Australia, 2001).

**Domestic trade or  
industry – E**

The indirect impact on domestic trade or industry would be minor at the national level, significant at the regional level and highly significant at the district level. A rating of ‘E’ was therefore assigned to this criterion.

- Restrictions in interstate movement and trade of fruit and susceptible host plants are likely to occur, as they did after the detection of *E. amylovora* in the Royal Botanic Gardens, Melbourne.
- The viability of several other sectors associated with pome fruit production, such as packing houses, transport operators, packaging suppliers, repairers of agricultural equipment,



agricultural suppliers, the banking and finance sector and retail industries in general within all growing regions, would certainly be affected.

- A fire blight outbreak in Australia would result in at least a 50 per cent reduction in fresh apple fruit in both the export and domestic markets. Supplies to the juicing sector could decline by 30 to 40 per cent if the apple supply fell by 50 per cent (Kilminster, 1989).
- The transport sector is estimated to generate a turnover of AUD471 million in the Goulburn Valley, Victoria. This represents 1,050 jobs, or around 4.6 per cent of local employment. The freight industry's value is estimated at AUD218 million, representing around 500 jobs. Transport operators in the Goulburn Valley spend around AUD33.4 million annually, of which 76 per cent is spent locally. Each year, trucks to the value of AUD52 million are purchased locally.
- The value of interactions with the banking and finance sector in the Goulburn Valley is around AUD3.4 million and from the business services sector, AUD21 million, annually.
- Fertilisers and chemicals constitute 10 per cent of total grower costs for pome fruit production in the Goulburn Valley. It is estimated that growers purchase AUD7 to 8 million worth of sprayers. Based on the assumption of a 40 per cent reduction in pome fruit production, this region will lose between AUD2 to 3 million annually (Street, 1996).
- Australia is currently the world's fourth largest exporter of honey. In Victoria, alone 38,300 beehives are used for pollination in pome fruit orchards (Commonwealth of Australia, 2001). An outbreak of fire blight could lead to a reduction in bee foraging resulting in lowered production of honey and fewer hives being available for contract pollination of orchards.

#### International trade – D

The indirect impacts on international trade are unlikely to be discernible at the national level, and would be of minor significance at the regional level, significant at the district level and highly significant at the local level. A rating assigned to this criterion was 'D'.

- The estimated loss of export revenue for 1997 would have been AUD25 million and a total loss of AUD183 million between 1997 and 2002 (Oliver *et al.*, 1997).
- Apples and pears are exported to premium markets in the UK and other countries in Europe, and to the bulk markets of south-east Asia. At present, none of these countries impose restrictions on apple imports from countries where *E. amylovora* occurs.
- Access to markets in countries free from *E. amylovora* would

be affected. Several importing countries will either not import fruit from Australia, suspend imports pending scrutiny of data on the disease or impose phytosanitary measures which could result in Australia losing competitive advantage over other producers. South American countries, for example, require a chlorine dip of fruit, and Japan delayed approving the importation of apples from Tasmania by about two years pending the outcome of disease surveys, after detection of *E. amylovora* in the Royal Botanical Gardens, Melbourne.

- Australia will lose market share in fresh fruit exports as a result of the shortage of export quality fruit and the high cost of production. This would result in other countries entering the markets, which Australia traditionally supplied. If this occurred, Australia would lose further export markets and/or be forced to reduce margins to ensure export orders are maintained (Kilminster, 1989).

#### Environment – A

Any indirect impacts of fire blight on the environment are unlikely to be discernible. A rating of ‘A’ was assigned to this criterion.

- A significant issue that concerns the community is the possibility of development of resistance to streptomycin among bacteria, and the transfer of such resistance to humans. (Commonwealth of Australia, 2001). Application of antibiotics is likely to affect microflora, and could lead to the establishment of antibiotic-resistant strains of pathogens or to the contamination of soil or water. However, data is not available to back any of these claims. Streptomycin is not registered for agricultural use in Australia.
- Streptomycin-resistant strains have been detected in apple orchards in Hawke’s Bay in New Zealand (Thomson *et al.*, 1993) where routine application of streptomycin was done.

#### Communities – C

The indirect impacts on communities are unlikely to be discernable at the regional level, and would be of minor significance at the district level and significant at the local level. A rating of ‘C’ was assigned to this criterion.

- In Australia, the pome fruit industry employs 3,200 at base level and 16,000 at peak level (Street, 1996). The estimated national job losses would have been 2,484 from 1997 to 2002 (Oliver *et al.*, 1997).
- The combined permanent work force in SPC Ltd, Ardmona Foods Ltd (now amalgamated) together with Henry Jones Foods (IXL) was estimated at 760. During peak fruit processing months, they employ an additional 2,350 staff (Oliver *et al.*, 1997). A shortage of fruit would result in reduced staffing requirements, thereby increasing the unemployment rate.
- A fire blight outbreak would have a very significant impact on orchardists, processors and their employees. It would also

significantly affect the regional economies and the social fabric (Kilminster, 1989).

- Flow-on effects arising out of a fire blight outbreak in regional pome fruit growing areas would seriously affect the local economies through loss of employment in the pome fruit industry and associated service industries.
- A fire blight outbreak would threaten the economic viability of the about 330 growers in the Goulburn Valley, Victoria. The pome fruit growing area covers about 7,000 ha, with individual orchards of 5 to 200 ha. The Goulburn Valley accounts for 14 per cent of apple and 86 per cent of pear production in Australia (Oliver *et al.*, 1997). It is estimated that about 272 growers have more than 30 hectares, which represents 85 per cent of the total number of orchards in the Goulburn Valley (Oliver *et al.*, 1997). These are most likely family-operated orchards and, if they became commercially non-viable, there would be significant social and financial impacts. In the Goulburn Valley alone, the estimated total loss of full-time jobs would have been 1,102 over the period 1997–2002 (Oliver *et al.*, 1997). Youth unemployment increased from 13 per cent to 24 per cent over the period 1986–1991. Employment opportunities would diminish with the reduction in growing and processing activities, and might even lead to a net outflow of people, especially young people (Oliver *et al.*, 1997).
- Stanthorpe, Queensland, potentially supports a total workforce of about 450 and around 2,200 during the peak season. An outbreak of fire blight would cause loss of jobs (Street, 1996).

### **Conclusion—consequences**

Based on the decision rule described in the method section, i.e. where the consequences of a pest with respect to a single criterion is ‘F’ and the consequences of a pest with respect to remaining criteria are not unanimously ‘E’, the overall consequences are considered to be ‘high’. Therefore the overall consequence of *E. amylovora* are **High**.

### **Unrestricted annual risk**

Unrestricted annual risk is the result of combining annual probability of entry, establishment or spread with the outcome of overall consequences. Probabilities and consequences are combined using the ‘rules’ shown in the risk estimation matrix in the method section. The unrestricted annual risk estimation for *E. amylovora* is shown in Table 31.

**Table 31 Risk estimation for *E. amylovora***

Overall probability of entry, establishment or spread <sup>24</sup>	<b>Low</b>
Consequences	<b>High</b>
Unrestricted annual risk	<b>Moderate</b>

As indicated in Table 31 above, the unrestricted risk for *E. amylovora* is Moderate, which is above Australia's appropriate level of protection (ALOP) of very low; therefore risk management is required for this pest.

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<sup>24</sup> Calculated by @ risk.

## **European canker**

### **Introduction**

European canker caused by the fungus *Nectria galligena* is an important disease of apples and pears and many species of hardwood forest trees (Swinburne, 1975). The disease was present in six orchard blocks within four orchards in Spreyton, Tasmania from about 1954, but it was eradicated by 1991 (Ransom, 1997). Currently Australia is free of the disease.

Some common host genera of the pathogen are *Acer* (maple), *Aesculus* (horse chestnut), *Alnus* (alder), *Betula* (birch), *Carya* (hickory), *Cornus* (dogwood), *Corylus* (hazel), *Fagus* (beech), *Fraxinus* (ash), *Juglans* (walnut and butternut), *Liriodendron tulipifera* (tulip tree), *Malus* (apple), *Populus* (aspen), *Prunus* (cherry), *Pyrus* (pear), *Quercus* (oak), *Rosa* (rose), *Salix* (willow), *Sorbus* (rowan tree), *Tilia* (American basewood) and *Ulmus* (elm).

The disease affects mostly branches and trunks of trees causing cankers. Infection is initiated either through leaf and bud scars, bark disruptions such as pruning cuts and wounds, and woolly aphid galls (Brook and Bailey, 1965; Swinburne, 1975). The most serious cankers are those that develop at the crotch, which can cause the death of several branches or the entire tree (Butler, 1949). In apple and pear, fruit is also infected and develops rot. Typically infection of fruit takes place at the blossom end, either through the open calyx, lenticels and scab lesions or wounds caused by insects. This is called 'eye rot' (McCartney, 1967; Swinburne, 1964; Swinburne, 1975). Sometimes the rot can develop at the stem-end (Bondoux and Bulit, 1959; Swinburne, 1964) or rarely on the fruit's surface when the skin is damaged (Bondoux and Bulit, 1959). In France the rot has been observed to spread to the seed cavity of the fruit and the fungus could be isolated from the mycelium that surrounds the seeds (Bondoux and Bulit, 1959), but this was not observed in California (McCartney, 1967). In dessert varieties, infection of the fruit generally leads to the development of rot before harvest (Swinburne, 1964; Swinburne, 1971a; Swinburne, 1975), but infection can sometimes remain latent and develop only during storage (Bondoux and Bulit, 1959). In cooking varieties, rot rarely becomes apparent until after three to seven months of storage (Swinburne, 1975). Foliage is not affected (Butler, 1949). Apple varieties vary greatly in their susceptibility to the disease, but no variety is immune (McKay, 1947).

The fungus has several strains that differ in cultural characteristics, but the strains appear to be largely non-specific in their pathogenicity to different hosts (Flack and Swinburne, 1977; Ng and Roberts, 1974). The fungus produces two types of spores; conidia in spring and summer, and ascospores in autumn and winter. Spores are dispersed by rain splash and wind and possibly by insects and birds (Agrios, 1997; Butler, 1949). Germination of spores occurs over a range of temperatures from 2–30°C, the optimum being 20°C (Munson, 1939).

The disease can be severe enough to necessitate the replacement of trees, ranging from ten per cent of trees (Lovelidge, 1995) to the whole plantation (Grove, 1990a). Losses of 10–60 per cent of the fruit crop caused by rot from European canker has been recorded in various parts of the world (Swinburne, 1975). Damage to host species used for timber, through reduction in quality and quantity of marketable logs, particularly in North America has been reported (CABI, 2003a), although there is no estimate of the magnitude of this loss.

Sanitation (i.e. removal and burning of cankered limbs or trees and spraying with fungicides) is the only control measure possible.

Other information relevant to the (Thomson, 1992b; Hale *et al.*, 1996b)biology of *N. galligena* is available in the datasheet in Appendix 3 in Part B.

### **Risk scenario**

The risk scenario in respect of *N. galligena* when importing apple fruit is primarily the latent infection in fruit that would not have been expressed or detected either at harvesting or during processing in the packing house. In dessert varieties of apples, any infection of fruit generally develops in the orchard. As New Zealand mostly exports dessert varieties the risk of latent infection is reduced. However, the length of time an infection on fruit can remain latent is a function of the acidity of the variety. This means that infection could remain latent in dessert varieties that have relatively higher acidity, especially if infection took place late in the season. Any infestation on the surface of the fruit that later gains entry into the fruit and causes infection may also be a minor concern.

The pest does not affect leaves so leaf material in trash is not a concern. Small twigs in trash are of concern as the disease occurs on branches, but the likelihood of this happening in export quality apples would be negligible. Entry of the pest through packing material contaminated with spores of the fungus would also have a negligible likelihood.

### **Probability of importation**

The initiating step for the importation scenario for apple fruit is the sourcing of apples from orchards in New Zealand, while the end-point is the release of imported apples from the port of entry. The importation scenario is divided into eight steps and the likelihood of the *N. galligena* being present at each step is summarised in Figure 15. The available evidence supporting the likelihood assessments is provided in the text that follows.

**Figure 15 The importation steps and the likelihood of *N. galligena* being present at each step**



#### Importation step 1

(Imp1)

**Low**

The likelihood that *N. galligena* will be present in source orchards in New Zealand: **Low**.

- According to Atkinson (1971) the disease currently occurs predominantly in Whangarei and Auckland in the North Island. Recent research by Wilton (2002a) reports that the disease had been established in Auckland, Waikato, Bay of Plenty and Taranaki for many years and is now established in Nelson and a few orchards in Gisborne.
- A survey conducted in 52 orchards in the apple exporting areas of the North Island (central Hawke's Bay) and the South Island (Nelson, Marlborough and Central Otago) in 1999 found the disease to be present only in one orchard in Nelson (MAFNZ ,

2000c). However, by 2002 it appears to have spread to a few orchards in Motueka and Moutere area and pockets of Walmea orchards of Nelson (Murdoch, 2002).

- New Zealand has confirmed that the disease is present in the Waikato, Gisborne and Nelson districts (MAFNZ., 2003e).
- In addition, lesions of the disease have been found occasionally in Hawke's Bay, but there has been no evidence of the disease spreading from these initial lesions (Wilton, 2002b).
- The four districts where the disease is present, namely Waikato, Auckland, Gisborne and Nelson, constitute 41 per cent of New Zealand's apple exports (Table 5, New Zealand apple industry). These districts have annual mean rainfalls close to or greater than 1,000 mm (Table 2, New Zealand apple industry). The disease appears in wet springs (MAFNZ., 2003e).
- All varieties grown in these areas are susceptible, but the disease is kept under control through orchard management practices.

#### *Summary*

Although the disease is known to be present in areas producing 41 per cent of export fruit, because it is reported from only a few orchards in these regions the likelihood that the disease would be present in source orchards in New Zealand the likelihood for Imp1 was assessed as low.

#### **Importation step 2 (Imp2)**

#### **Very low**

The likelihood that picked fruit is infested/infected with *N. galligena*: **Very low**.

- European canker is mostly a disease of branches and twigs (Agrios, 1997; CABI, 2003a).
- Fruit infection will not occur unless the pathogen is present on the tree or within the orchard (Bondoux and Bulit, 1959).
- Most varieties exported by New Zealand are dessert varieties where infection by *N. galligena* often expresses itself as a rot in the orchard before harvest (Swinburne, 1975) and affected fruit either fall before maturity or are eliminated during picking (Bondoux and Bulit, 1959). However, any latent infection caused by late infection of the fruit will not be visible at picking.
- The application of fungicides for control of the disease apple scab (*Venturia inaequalis*) which is present in New Zealand also significantly reduced the incidence of infection by *N. galligena* (Swinburne and Cartwright, 1973).
- Fungicidal dips before storage are not used in New Zealand (MAFNZ, 2003a), indicating that latent infection is not a major issue.
- However, Brook and Bailey (1965) report that fruit rot caused



by *N. galligena* occurs occasionally in New Zealand. Some infestation of fruit due to spores that got onto flowers but did not develop into infection, and spores washed onto the fruits during fruit maturation is also likely.

#### Summary

Considering the above information the likelihood for Imp2 was assessed as very low.

#### Importation step 3 (Imp3)

Negligible

The likelihood that clean fruit is contaminated by *N. galligena* during picking or transport to the packing house: **Negligible**.

- Cankers of *N. galligena* produce spores throughout the year; conidia in summer and ascospores in winter (Berrie *et al.*, 2000).
- Infected mature fruit would mostly produce conidia. Any infected fruit that over-wintered on trees and mummified could also have perithecia and ascospores (Butler, 1949; McCartney, 1967; Swinburne, 1964), but this situation is unlikely in an export orchard.
- Picked fruit could be surface-contaminated by: (a) pickers' hands or gloves getting contaminated with spores by them accidentally touching cankers or infected fruit while picking; (b) spores carried in rain splash or wind currents landing on clean fruit if it rains or is windy during harvesting and transport; and, (c) trash (twigs) with spores touching fruit in bins.

#### Summary

Based on the information that infected mummified fruit is unlikely to occur in export orchards, and that picked fruit could be contaminated in rainy or windy weather, the likelihood for Imp3 was assessed as negligible.

#### Importation step 4 (Imp4)

Very Low

The likelihood that by *N. galligena* survives routine processing procedures in the packing house: **Very low**.

#### Precooling

- Fruits would be cold stored for a short time before they are put through the rest of the packing house procedures beginning washing. This short cold storage period would not reduce any infection or infestation in or on the fruit. This period will also be too short for expression of latent infection.

#### Washing

- Initial washing of fruit in a dump tank and subsequent high-pressure washing will remove most infestations and conidia on infection sites, but infections themselves will survive these procedures.

#### *Polishing*

- Polishing could create minute damages on the surfaces of fruit and these can assist in the spread of infection.

#### *Waxing*

- Waxing could help hold conidia, or hyphae on to the fruit. However any spores that were present as infestation or on infections would have been removed to a high degree by the previous washing steps.

#### *Sorting and grading*

- Most varieties exported by New Zealand are dessert varieties and, if infected, the fruit often develops rot before harvest (Swinburne, 1975). Infection remains latent until after storage in some varieties such as Fuji and Granny Smith and in cooking varieties (Swinburne, 1975). Sorting and grading will remove fruit with visible infections to a high degree, but any latent infection will not be detected. New Zealand does not export much volume of cooking varieties where infection remains latent until after three to seven months of storage.

#### *Cold Storage*

- Any temporary cold storage soon after harvest, before processing begins, is likely to be very short, a few days at the most. Post-harvest fungicide treatments are not used in New Zealand (MAFNZ, 2003a). The pest would survive this temporary cold storage and the period of storage will be too short for significant expression of latent infections.
- Any infection or infestation that remains at the end of packing house procedures will survive cold storage before transport, as the ability of the pest to survive low temperatures is a major reason for its ability to infect even dormant trees (Marsh, 1940).

#### *Summary*

The fruit of dessert varieties, the main apple exports from New Zealand, often develops rot before harvest if infected, whereas latent infection is more commonly found in cooking varieties which are only low-volume exports from New Zealand. However latent infection that could take place in late season in dessert varieties can survive the pack house procedures. The likelihood for Imp4 was assessed very low.

**Importation step 5  
(Imp5)**

**Extremely Low**

The likelihood that clean fruit is contaminated by *N. galligena* during processing in the packing house: **Extremely low**.

- The dump tank could be contaminated by spores from small cankers on twigs or infections on fruit. Any spores present as infestation on fruits and leaves and in soil adhering to the bottom of bins could also get into the dump tank. New fruit infection from conidia in the dump tank could take place through the calyx, lenticels or scab lesions, or through wounds caused by insects or bruising. However, these contaminations will be removed by the subsequent high-pressure water wash minimising infection of clean fruit.
- Low prevalence of the disease in major exporting areas and the fact that most packing houses in New Zealand replace the water in tanks every 600 bins (see section on apple industry in New Zealand) also minimises the opportunities for contamination of dump tanks.
- Removal of surface infestation and conidia produced on any infected points during washing in the dump tank and during the later high pressure wash minimises opportunities for contamination of clean fruit during other processing steps such as brushing, polishing, waxing, sorting and grading.

**Importation step 6  
(Imp6)**

**Moderate**

The likelihood that *N. galligena* survives palletisation, quality inspection, containerisation and transportation and remains undetected: **Moderate**.

- Some infected fruit that was not detected during sorting will be detected at quality inspection. However, sorting will not detect latent infection or any remaining infestation and these will survive palletisation, containerisation and transport as there are no mechanisms in these procedures to remove them.
- The time between step 4 and step 6 will not be long enough for latent infection to express itself to a significant level. As spores are microscopic, any remaining surface infestation will also remain undetected and survive.

**Importation step 7  
(Imp7)**

**Negligible**

The likelihood that clean fruit is contaminated by *N. galligena* during palletisation, quality inspection and transportation is: **Negligible**.

- Contamination of clean fruit during palletisation, quality inspection, containerisation and transport is possible only if fruit, twigs, etc. infected with conidia and/or ascospores is present in the areas where these procedures take place. Such sources of inoculum would have been removed earlier.
- Any fruit carrying latent infection or infestation has the potential to contaminate clean fruit particularly if latent infection expresses itself during transportation. Some rot caused by latent infection may develop during transportation to Australia, but significant production of conidia during this period to contaminate clean fruit cannot be expected.

**Importation step 8  
(Imp8)**

**High**

The likelihood that *N. galligena* remains with the fruit after on-arrival minimum border procedures: **High**.

- It would be latent infection and some infestation that would remain when the fruit arrives in Australia. Some rot caused by latent infections may also express itself during transport to Australia. However, the on-arrival minimum border procedures carried out for an unrestricted-risk situation will not detect these infections or infestations.

**Conclusions—probability of importation**

When the above likelihoods were inserted into the simulation model, the probability of importation of *N. galligena* from one year of trade was found to be **Extremely low**.

**Probability of distribution**

The initiating step for the distribution scenario is the release of imported apples from the port of entry, while the last step is the pest being distributed (as a result of the processing, sale or disposal of these apple fruit) in a viable state to an endangered area and subsequently being transferred to a suitable host.

In order to assess the probability of distribution, the distribution scenario is addressed in three subheadings below. First is a brief description of the sequence of events leading to a successful exposure of a susceptible host to the pest from infested/infected apple. Second is the assessment of partial probability of distribution of the pest in relation to each of the exposure groups. Third is the conclusion for the probability of distribution.

**Sequence of events for successful exposure**

The sequence of events that has to be completed for a successful exposure of host plants to *N. galligena* from infested/infected apples is summarised below.

Any infection on a discarded fruit would be one developing from either a latent infection, a surface infestation that existed before, or a small infection spot that escaped detection earlier. Such an infection is more likely to have conidia than ascospores, as the former are the spores to develop first. Perithecia with ascospores generally develop on infected fruit that is left on the tree and mummifies over winter (Swinburne, 1964). They only rarely develop on an infected fruit sitting in a waste dump.

Natural wounds such as those caused by leaf fall in autumn and bud burst in spring, pruning cuts and wounds on bark, as well as flowers on the host plant, lenticels and open calyxes of fruit are major infection sites. One or more of these opportunities are available during most of the year.

Approximately 1,000 conidia are required for leaf scar infection (CABI, 2003a). However, in artificial inoculations as few as 12 (McCracken *et al.*, 2003b) or 10 (Cooke, 2003) conidia have produced infections, and these conidial numbers are considered to resemble natural situations (McCracken *et al.*, 2003b).

Conidia are mostly dispersed by rain splash and wind (CABI, 2003a). The most probable maximum distance for dispersal by rain splash is 10 m (Marsh, 1940), although one report suggests that this might be as much as 125 m under stormy conditions (CABI, 2003a). However, these distances apply to conidia present on cankers on trees and the distances are likely to be less for conidia on an infected fruit on the ground.

Dispersal by insects and birds is also a possibility (Agrios, 1997; Butler, 1949). Birds inhabit branches of tree and also feed on discarded fruit. They could get the spores on their feet or beaks while feeding on a discarded fruit and transfer them to a branch of a susceptible plant, noting especially that European canker is a disease of branches. Woolly aphids have been observed to carry conidia of *Nectria* (Munson, 1939). However, transfer by birds or insects have not been demonstrated.

Liquid phase water is required for the germination of conidia and their viability is affected by temperature, relative humidity and desiccation. Viability is sharply reduced when conidia are exposed to relative humidity between 85–100 per cent for 3–12 hours at 11°C and 19°C (Dublin and English, 1975a).

### ***Partial probability of distribution***

The partial probability of distribution (PPD) was estimated separately for each of the four exposure groups: commercial fruit crops; nursery plants; household and garden plants; and, wild and amenity plants.

The details and the method of calculation for the PPD of the four exposure groups are explained in the method section and the results are presented in the series of tables and figures below. The information from these tables and figures was used to assess the probability of distribution of *N. galligena* to all the exposure groups.

Table 32 indicates the proportions of the five utility points near each of the exposure groups of *N. galligena*.

**Table 32 The proportion of utility points near host plants susceptible to *N. galligena* in the four exposure groups**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Proximity</b> Orchard wholesalers	Certain	Very Low	Low	Very Low
<b>Proximity</b> Urban wholesalers	Extremely Low	Very Low	Very low	Very Low
<b>Proximity</b> Retailers	Very Low	Low	Very Low	Very Low
<b>Proximity</b> Food services	Extremely Low	Extremely low	Very Low	Very Low
<b>Proximity</b> Consumers	Very Low	Very Low	Low	Low

Figure 16 provides an estimate of the relative amounts of infested/infected apples discarded from different utility points near each of the exposure groups of *N. galligena*.

**Figure 16 Pictorial representation of infested/infected apples discarded by utility points near exposure groups of *N. galligena***

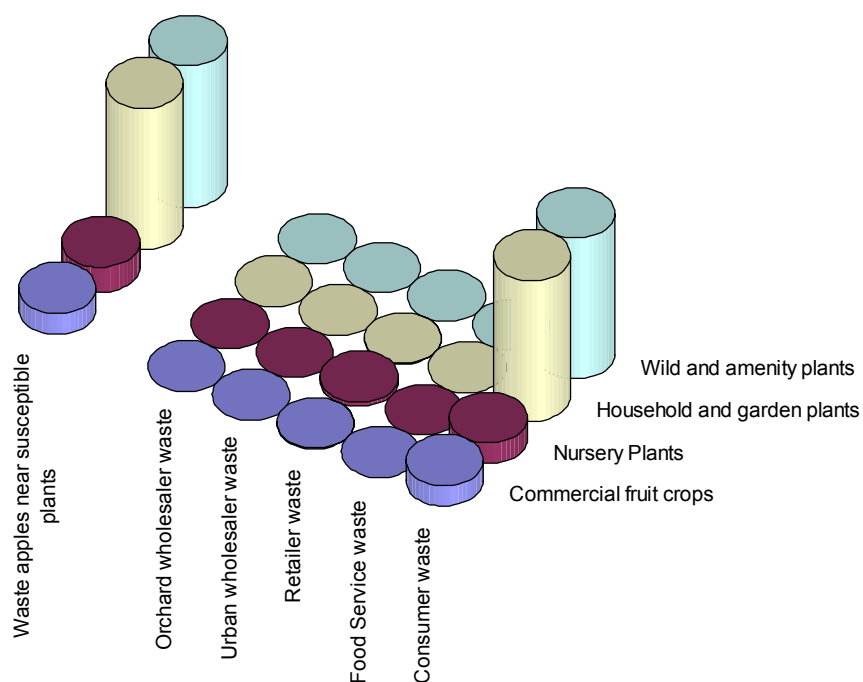


Table 33 is the summary of the probability that exposure of the host plants would result from a discarded single infested/infected apple, from different utility points. Evidence is provided in the text below under different exposure groups.

**Table 33 The probability of exposure of susceptible host plants to *N. galligena* by utility points discarding a single infested/infected apple near exposure groups**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Exp</b> Orchard <sup>25</sup> wholesaler waste	Extremely Low	Negligible	Negligible	Negligible
<b>Exp</b> Urban wholesaler waste	Negligible	Negligible	Negligible	Extremely Low
<b>Exp</b> Retailer waste	Extremely Low	Negligible	Negligible	Extremely Low
<b>Exp</b> Food service waste	Negligible	Negligible	Negligible	Extremely Low
<b>Exp</b> Consumer waste	Negligible	Negligible	Extremely Low	Extremely Low

#### *Commercial fruit crops*

#### *Commercial fruit crops near utility points*

The proportions of the five utility points near commercial fruit crops susceptible to *N. galligena* are shown in Table 32. It was estimated that commercial fruit crops are certain to be located near all orchard wholesalers, very unlikely to be near retailers and consumers, and extremely unlikely to be near urban wholesalers and food service.

The relative amount of infested/infected apples discarded from different utility points near commercial fruit crops susceptible to *N. galligena* is indicated in Figure 16.

#### *Exposure to host*

As shown in Table 33, it is considered that the probability that exposure of commercial fruit crops would result from a discharged single infested/infected apple from different utility points would be extremely low for orchard wholesalers and retailers, and negligible for urban wholesalers, food services and consumers. The sequence of events that can lead to exposure of susceptible plants to *N. galligena* and extra evidence, if available, is provided in the text below.

Some factors common to all exposure scenarios for various host group-utility group combinations are given below. Factors specific to different host groups are then discussed under each host group.

While orchard wholesaler waste would often be dumped at a site within the premises, almost all waste from urban wholesalers, retailers and food service industries, and a significant proportion of consumer waste will end up in landfill. Therefore possible exposure of host

<sup>25</sup> As indicated in the method section, for pathogens waste includes discarded infested/infected apples.

plants from that waste in landfill will need consideration. Either consumers themselves or composting agencies will compost a proportion of consumer waste and exposure from such composting material would be another consideration. Compost heaps and bins are generally covered and transfer by wind, rain splash or birds is unlikely. Rapid decay and high temperatures (up to 60°C) inside compost heaps would inactivate any hyphae and spores of *N. galligena*. However some survival of the pest under incomplete composting, especially in domestic backyards is possible. The fact that the pathogen on an infected fruit undergoing decay in a dumpsite, landfill, or compost heap will be subjected to competition by other saprophytic organisms is also relevant.

**Exp** commercial fruit crops  
from orchard wholesaler waste  
**Extremely Low**

The probability that exposure of commercial fruit crops would result from a discarded single infested/infected apple from orchard wholesalers: **Extremely low**.

- A waste dump site within the premises in which orchard wholesalers generally discard packing house waste would be close to commercial orchards that have susceptible hosts in a high density monoculture.
- In addition to natural infection sites such as leaf scars, other infection points such as pruning cuts would be quite common in commercial orchards.
- The distance from the dumpsite to the orchard apple trees is often likely to be greater than 10 m and a transfer of conidia from an infected fruit in the dumpsite to orchard trees by wind or rain splash is extremely unlikely.
- Woolly aphid is a common pest of apple in Australia. They colonise, in addition to stems and roots, the calyx, core and surface of fruit on trees. It is extremely unlikely, however, that they would colonise a discarded fruit and transfer *Nectria* to a healthy tree.
- Orchardists generally have arrangements to keep birds away.

**Exp** commercial fruit crops  
from urban wholesaler waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from a discarded single infested/infected apple from urban wholesalers: **Negligible**.

- Commercial fruit crops will not be near landfill sites where urban wholesaler waste is disposed, and transfer by any agent is not possible.

**Exp** commercial fruit crops  
from retailer waste  
**Extremely low**

The probability that exposure of commercial fruit crops would result from a discarded single infested/infected apple from retailers: **Extremely low**.

- There are more retailers than urban wholesalers. Some retailers could be in country areas. The landfills to which retailers in country towns discard waste could at times be close to commercial orchards.

**Exp** commercial fruit crops  
from food service waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, a pest or contaminated packaging material from food service establishments: **Negligible**.



**Exp** commercial fruit crops  
from consumer waste

**Negligible**

- Commercial fruit crops will not be near landfill sites in metropolitan areas where food service waste is disposed.

The probability that exposure of commercial fruit crops would result from a discarded single infested/infected apple from consumers: **Negligible**.

- There will be no commercial fruit crops either near landfills in which most consumer waste is disposed of or near composting sites to which the remainder of consumer waste goes.

### *Nursery plants*

#### *Nursery plants near utility points*

The proportions of the five utility points near nursery plants susceptible to *N. galligena* are shown in Table 32. It was estimated that nursery plants are unlikely to be near retailers, very unlikely to be near orchard wholesalers, urban wholesalers and consumers and extremely unlikely to be near food services.

The relative amount of infested/infected apples discarded from different utility points near nursery plants susceptible to *N. galligena* is indicated in Figure 16.

#### *Exposure to host*

As shown in Table 33, it is considered that the probability that exposure of nursery plants would result from a discarded single infested/infected apple from different utility points would all be negligible. Extra evidence, if available, is provided in the text below.

**Exp** nursery plants from  
orchard wholesaler waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from a discarded single infested/infected apple from orchard wholesalers: **Negligible**.

- Although pome fruit growers and nurseries are largely two different industries, some orchard wholesalers could have pome fruit nurseries within or near their orchards.
- A new orchard being established or replanted, for example, for organic production may have large numbers of nursery plants packed in one place, and the orchardist may undertake re-packing of imported fruit at a significant scale until the orchard comes into production.
- Plants in a nursery could be in high densities with susceptible tissue near the ground, meaning there is a greater likelihood of the pest reaching them through rain splash. The environment within nursery plants could, for example, also be more moist and humid than in the orchard.
- However, orchard wholesalers' dump sites will not be near pome fruit nursery plants or nurseries selling other hosts to European canker. Transfer of conidia by rain splash or wind in this case from an infected fruit is highly unlikely.

**Exp** nursery plants from urban  
wholesaler waste  
**Negligible**

The probability that exposure of susceptible nursery plants would result from a discarded single infested/infected apple from urban wholesalers: **Negligible**.

- Nurseries with host plants to *Nectria* would not be located close to landfill sites to which urban wholesaler waste goes.
- Retail nurseries generally maintain high hygienic standards through regular fungicide sprays, etc. so that even in a rare situation where a retail nursery is close to a waste dumpsite the likelihood of a successful exposure of the pest to an infected fruit to a host nursery plant would be negligible.

**Exp** nursery plants from retailer  
waste  
**Negligible**

The probability that exposure of susceptible nursery plants would result from a discarded single infested/infected apple from retailers: **Negligible**.

- A significant number of retailers both in metropolitan as well as country areas would have both apple fruit and nursery plants that are host to European canker for sale in the same shop. Although fruit waste from these retail shops mostly ends up in landfills, that waste can temporarily stay in bins within the shop. However, there will be no mechanisms for transfer of the pest from an infected fruit in such a bin to a host nursery plant in the shop, unless the same person works in both areas and touches an infected or infested fruit as well as nursery plants. These commodities are generally in different sections of the shop. Retailer waste going to landfill will not be near susceptible nursery plants.

**Exp** nursery plants from food  
service waste  
**Negligible**

The probability that exposure of susceptible nursery plants would result from a discarded single infested/infected apple from food service establishments: **Negligible**.

- Food service industries are mostly in metropolitan areas and there will be no nursery plants near landfills in which their waste is disposed.

**Exp** nursery plants from  
consumer waste  
**Negligible**

The probability that exposure of susceptible nursery plants would result from a discarded single infested/infected apple from consumers: **Negligible**.

- There will be no nursery plants near landfills in which most consumer waste is disposed.
- Although significant numbers of consumers would visit nurseries, especially in spring/summer months, there is negligible likelihood of their transferring conidia from a fruit that is infected or infested to a nursery plant.

*Household and garden plants*

*Household and garden plants near utility points*

The proportions of the five utility points near household and garden plants susceptible to *N. galligena* are shown in Table 32. It was estimated that household and garden plants are

unlikely to be near orchard wholesalers and consumers, and are very unlikely to be near urban wholesalers, retailers and food services.

The relative amount of infested/infected apples discarded from different utility points near household and garden plants susceptible to *N. galligena* is indicated in Figure 16.

#### *Exposure to host*

As shown in Table 33, it is considered that the probability that exposure of household and garden plants would result from a discarded single infested/infected apple from different utility points would be negligible except for consumer waste which is extremely low. Extra evidence, if available, is provided in the text below.

**Exp** household and garden plants from orchard wholesaler waste

**Negligible**

The probability that exposure of susceptible household plants would result from a discarded single infested/infected apple from orchard wholesalers: **Negligible**.

- The likelihood of transfer from an infected fruit discarded to a waste dumpsite on the premises to an isolated household or garden plant in the orchardist's property is negligible.

**Exp** household and garden plants from urban wholesaler waste

**Negligible**

The probability that exposure of susceptible household plants would result from a discarded single infested/infected apple from urban wholesalers: **Negligible**.

- Household or garden plants will not be located near landfill sites in which waste is discarded by urban wholesalers.
- Even if there are a few host plants in urban wholesaler premises, waste will not come close to them.

**Exp** household and garden plants from retailer waste

**Negligible**

The probability that exposure of susceptible household plants would result from a discarded single infested/infected apple from retailers: **Negligible**.

- Household and garden plants around the premises of retailers will not be exposed, as retailers' waste is kept in bins and taken to landfill.
- Household and garden plants for sale in retail shops were considered under nursery plants above.

**Exp** household and garden plants from food service waste

**Negligible**

The probability that exposure of susceptible household plants would result from a discarded single infested/infected apple from food service establishments: **Negligible**.

- Food service industries may have some household and garden plants susceptible to European canker, especially roses, on their premises. However, they generally dispose of their food waste in a systematic manner to landfill.

**Exp** household and garden plants from consumer waste

**Extremely low**

The probability that exposure of susceptible household plants would result from a discarded single infested/infected apple from consumers: **Extremely low**.

- Hosts of European canker such as apple, pear, maple, black cherry and roses are common household and garden plants. Hosts such as common hornbeam (*Carpinus betulus*) and

blackgum (*Nyssa sylvatica*) may be found in some gardens.

- Consumers also handle a backyard compost heap as well as the above host plants in the yard during gardening practices.

#### *Wild and amenity plants*

##### *Wild and amenity plants near utility points*

The proportions of the five utility points near wild and amenity plants susceptible to *N. galligena* are shown in Table 32. It was estimated that wild and amenity plants are unlikely to be near consumers and very unlikely to be near orchard wholesalers, urban wholesalers, retailers and food services.

The relative amount of infested/infected apples discarded from different utility points near wild and amenity plants susceptible to *N. galligena* is indicated in Figure 16.

##### *Exposure to host*

As shown in Table 33, it is considered that the probability that exposure of amenity plants would result from a discarded single infested/infected apple from different utility points would all be extremely low except for wholesaler waste which is negligible. Extra evidence, if available, is provided in the text below.

**Exp** wild and amenity plants  
from orchard wholesaler waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from a discarded single infested/infected apple from orchard wholesalers: **Negligible**.

- Although most vegetation around an orchard packing house will be fruit trees, a few wild plant species that are host to European canker may be found. Transfer of the pest from an infected fruit discarded within the premises to an isolated wild plant is negligible.

**Exp** wild and amenity plants  
from urban wholesaler waste  
**Extremely low**

The probability that exposure of susceptible wild plants would result from a discarded single infested/infected apple from urban wholesalers: **Extremely low**.

- Considerable numbers of wild/amenity plants that are host to European canker could be located near landfill sites in which urban wholesale waste is generally disposed.
- Seedlings of many of these plants as well as those of pome fruit seedlings arising from discarded seeds can be found in landfill sites.
- Rain splash of conidia from an infected fruit in landfill to a wild sapling nearby or a bird feeding on the infected fruit and transferring the pest to a branch of a large wild host plant nearby may have an extremely low likelihood.

**Exp** wild and amenity plants  
from retailer waste  
**Extremely low**

The probability that exposure of susceptible wild plants would result from a discarded single infested/infected apple from retailers: **Extremely low**.

- Evidence provided above for urban wholesaler waste applies.

**Exp** wild and amenity plants  
from food service waste  
**Extremely low**

The probability that exposure of susceptible wild plants would result from a discarded single infested/infected apple from food service establishments: **Extremely low**.

- Evidence provided above for urban wholesaler waste applies.

**Exp** wild and amenity plants  
from consumer waste  
**Extremely low**

The probability that exposure of susceptible wild plants would result from a discarded single infested/infected apple from consumers: **Extremely low**.

- The evidence provided above for urban wholesalers applies to that component of consumer waste going to landfill.
- Some wild and amenity plants that are host to *Nectria* can be found along roadsides, and in parks and recreation sites. Consumers could discard an infected apple at these places.

### **Conclusion—probability of distribution**

The partial probability of distribution from each of the utility points to each of the exposure groups is summarised in Table 34. These were calculated by the simulation model using @risk. The quantitative model evaluated the effect of the ‘volume of trade’ during a specified period when calculating the partial probability of distribution.

**Table 34 Partial probabilities of distribution (PPD)<sup>26</sup> for *N. galligena***

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
Orchard wholesalers	Extremely Low	Negligible	Negligible	Negligible
Urban wholesalers	Negligible	Negligible	Negligible	Extremely Low
Retailers	Very Low	Extremely Low	Extremely Low	Very Low
Food service	Negligible	Negligible	Extremely Low	Very Low
Consumers	Extremely Low	Extremely Low	High	High
<b>PPD</b>	<b>Very Low</b>	<b>Extremely Low</b>	<b>High</b>	<b>High</b>

<sup>26</sup> Partial probability of distribution is actually referring to the probability of entry and was estimated by @risk.

## Probability of establishment or spread

The assessment for the probability of establishment or spread is carried out in the following manner. Firstly, partial probability for establishment and for spread was assessed separately based on the relevant available scientific information. Secondly the combined partial probability of establishment or spread for each of the four exposure groups was assessed. The relevant information for the assessment for the probability of establishment or spread is presented below against the factors listed ISPM 11, Rev. 1.

### ***Partial probability of establishment***

---

ISPM 11 factor	Relevant information
<b>Availability of suitability hosts, alternate hosts and vectors in the PRA area</b>	<ul style="list-style-type: none"><li>• Pome fruits are grown at a commercial scale as well as backyard plants in many States of Australia. In apple, all cultivars are susceptible, although susceptibility is greater in some than in others. Breeding programs seeking to develop resistant cultivars are still in progress (CABI, 2003a). Many of the other host plants are also widely distributed in Australia as ornamental, garden, amenity, and wild/forest species, etc. meaning that hosts of the pest are widely available across Australia.</li><li>• The biology of the pest is such that the proximity between plants within most host groups is sufficient for the pest to complete its life cycle.</li><li>• Involvement of insects and birds as vectors is suspected (Butler, 1949; Agrios, 1997). In particular, the possible role of woolly aphid as a vector has been mentioned (Brook and Bailey, 1965; Marsh, 1940; Munson, 1939), although infection through this route has not been demonstrated and its involvement is doubted by some (McKay, 1947). Conidia of a similar pathogen of apple, <i>Venturia inaequalia</i>, have also been observed on the legs of aphids (Dillon-Weston and Petherbridge, 1933).</li></ul>
<b>Suitability of the environment</b>	<ul style="list-style-type: none"><li>• Average annual rainfall greater than 1,000 mm favours establishment of the disease (Grove, 1990a). Such average rainfall is received in coastal areas of Australia and this includes many apple growing areas and high elevation forest areas.</li><li>• Maximum and minimum temperatures, particularly in the temperate regions of Australia, are favourable for establishment of the disease. These temperatures for apple growing areas of Australia are comparable to those of the Auckland and Waikato areas of New Zealand where the disease is well established (compare table 3 in the Apple Industry in New Zealand and table 8 in the Apple Industry in Australia sections).</li><li>• Ascospores and conidia maintain germination ability over a range of temperatures from 2–30°C (Munson, 1939). This</li></ul>

ISPM 11 factor	Relevant information
	range is quite common in the temperate and subtropical parts of Australia.
<b>The potential for adaptation of the pest</b>	<ul style="list-style-type: none"> <li>In Europe the disease is more prevalent in water logged acid soils, and in soils rich in nitrogen but deficient in other minerals, than it is in moderately fertile, non-acid permeable soils (Butler, 1949). Such soil conditions are quite common in Australia.</li> <li>Currently there is no information on strains of the fungus with fungicide tolerance or ability to overcome some resistance observed in certain apple cultivars.</li> </ul>
<b>The reproductive strategy of the pest</b>	<ul style="list-style-type: none"> <li>The high rate of production of spores (conidia and ascospores) throughout the year and their tolerance of low temperatures are considered special adaptations that <i>N. galligena</i> has developed (Marsh, 1940).</li> </ul>
<b>Minimum population needed for establishment</b>	<ul style="list-style-type: none"> <li>The number of conidia required to initiate an infection varied from as few as 12 (McCracken <i>et al.</i>, 2003b), to 50–5,000 (Dublin and English, 1974), or to c. 1,000 (CABI, 2003a).</li> </ul>
<b>The method of pest survival</b>	<ul style="list-style-type: none"> <li>The primary method of survival of the pest is in cankers on infected trunks and branches of affected host plants. The fungus grows slowly into the wood while the host produces callus around the canker year after year.</li> <li>Spores do not appear to help in long-term survival as they are killed by prolonged desiccation (Dublin and English, 1975a).</li> </ul>
<b>Cultural practices and control measures</b>	<ul style="list-style-type: none"> <li>Integrated pest management programs used in Australia, including fungicide applications to control apple scab and other fungal pests, will assist in reducing opportunities for the establishment of the pest. However, lesions produced by apple scab on fruits can act as entry points for European canker (Swinburne, 1975) and presence of apple scab in many States of Australia except WA may assist in the establishment of European canker.</li> </ul>

*Conclusion—partial probability of establishment*

Based on the above evidence, partial probability of establishment for each of the exposure groups is assessed as follows.

Partial probability of establishment for commercial fruit crops: **High**.

Partial probability of establishment for nursery plants: **High**.

Partial probability of establishment for household and garden plants: **Low**.

Partial probability of establishment for wild and amenity plants: **Moderate**.

***Partial probability of spread***

*The factors listed in ISPM 11, Rev. 1 and relevant available information.*

ISPM 11 factor	Relevant information
<b>Suitability of the natural and/or managed environment for spread</b>	<ul style="list-style-type: none"><li>• Spread of the pest to the host species in the natural environment is reported in the USA and Europe. Australia has areas with similar environments to these countries.</li><li>• The fact that the disease spread to a few orchards in Tasmania probably after a single entry point, indicates that the managed environment of Australia can also be favourable for spread.</li></ul>
<b>Potential for movement with the commodities or conveyances</b>	<ul style="list-style-type: none"><li>• CABI (2003a) lists fruit (including pods), bark and stems (above ground shoots/trunks/branches) as host plant parts that can carry spores and hyphae of the pathogen borne internally and externally. Therefore in addition to trade in fruit, the nursery industry, hardwood timber industry and mulch industry can be involved in spread of the pest.</li><li>• A study in the UK, called the ‘millennium project’ (Anonymous, 2001; Berrie <i>et al.</i>, 2000; Lovelidge, 2003; McCracken <i>et al.</i>, 2003a; McCracken <i>et al.</i>, 2003b) concluded that approximately five per cent of the infection in new orchards could be associated with nurseries, but sometimes the problem could be bigger. This type of infection can be important in low rainfall areas and can remain symptomless for three to four years. There are no cost effective methods for detecting the pathogen in symptomless wood making it difficult estimate the size of the problem. In situations of high disease pressure, movement of inoculum from neighbouring sources is more important than nursery infection.</li></ul>
<b>Intended use of the commodity</b>	<ul style="list-style-type: none"><li>• Apples would be used mostly for consumption by humans and would be widely distributed around the States.</li></ul>
<b>Potential vectors of the pest</b>	<ul style="list-style-type: none"><li>• Insects and birds are suspected vectors of European canker (Agrios, 1997; Butler, 1949).</li></ul>

***Conclusion—partial probability of spread***

Based on the above evidence, partial probability of spread for each of the exposure groups is assessed as follows.

Partial probability of spread for commercial fruit crops: **Moderate**.

Partial probability of spread for nursery plants: **High**.

Partial probability of spread for household and garden plants: **Low**.

Partial probability of spread for wild and amenity plants: **Moderate**.



**Combined partial probability of establishment or spread**

The combined partial probability of establishment or spread for each exposure group was determined by combining probability of establishment and probability of spread using the matrix of ‘rules’ for combining descriptive likelihoods presented in the method section. The results are indicated in Table 35.

**Table 35 Combined partial probabilities of establishment or spread of *N. galligena***

	<b>Commercial fruit crops</b>	<b>Nursery plants</b>	<b>Household and garden plants</b>	<b>Wild and amenity plants</b>
<b>Establishment</b>	High	High	Low	Moderate
<b>Spread</b>	Moderate	High	Low	Moderate
<b>PPES<sup>27</sup></b>	Moderate	High	Very Low	Low

Additional evidence to support the combined partial probability of establishment or spread for specific exposure groups is provided in the text below.

- Commercial fruit crop**
- Moderate**
- Commercial fruit growing areas in the Adelaide Hills, Perth Hills and Manjinup have annual mean rainfalls greater than 1,000 mm, and Orange and Batlow in NSW have annual mean rainfalls close to 1,000 mm. These areas account for about 40 per cent of Australian production. The Goulburn Valley and Bacchus Marsh in Victoria, Stanthorpe in Queensland and the Huon Valley in Tasmania, which together account for about 60 per cent of Australian apple production, receive annual rainfall significantly less than 1,000 mm; these areas are unlikely to be favourable for establishment of European canker.
  - In New Zealand, the disease has recently established and spread in Nelson (Murdoch, 2002; Wilton, 2002a) where the average annual rainfall is 970 mm. Lesions have been observed in Hawke’s Bay where average annual rainfall is 803 mm (Wilton, 2002b). Rainfall in Batlow and Orange in NSW are similar to these.
  - Maximum, minimum and mean temperatures in commercial pome fruit growing areas are well within the temperature range of 3–30°C suitable for the germination of spores of the fungus.
  - Monoculture and high density planting in commercial orchards favour establishment or spread of European canker, especially through rain splash and wind, the key methods of spread for this disease.
  - Apple scab disease (caused by the fungus *Venturia inaequalis*),

<sup>27</sup> PPES = partial probability of establishment or spread.

which is thought to provide entry points for the European canker fungus, is present in pome fruit orchards in Australia except in WA.

- Woolly aphid is suspected to be involved in the establishment/spread of the disease and it is also common in commercial orchards in Australia.
- In Europe most damage caused by the disease is in commercial orchards.
- The disease was eradicated from commercial orchards in Spreyton, Tasmania in 1991. It was not in the major growing area of the Huon Valley.

**Susceptible nursery plants**  
**High**

- In New Zealand, the disease is more common and well established in nurseries than in commercial orchards. Spread to new orchards in New Zealand is from infected nurseries (Murdoch, 2002; Wilton, 2002a; Wilton, 2002b).
- Although this is attributed to higher rainfall in the area, frequent watering and maintenance of high humidity in nurseries, spread of the pest through pruning and tools, presence of a range of densely packed host plants, etc. could also be factors responsible.
- New Zealand does not apply mandatory controls on planting materials at nurseries to prevent the spread of the disease to new areas, but most nurseries routinely apply fortnightly copper sprays on stock plants and dip tools and some cuttings in Carbendazim and Captan depending on risk (MAFNZ, 2003a). In spite of these measures the spread to Nelson is thought to be through nursery stock (Murdoch, 2002).
- CABI (2003a) reports that trees can be infected in the nursery shortly after, or during, propagation and this has been observed to cause major losses although there are no published records.

**Susceptible household plants**  
**Very low**

- Host species such as apple (*Malus domestica*), pear (*Pyrus communis*), Roses (*Rosa* spp.), and maples (*Acer* spp.) are common in many households and gardens. Common hornbeam (*Carpinus betulus*) and black gum (*Nyssa sylvatica*) are trees used in large gardens. Some hosts such as trembling aspen (*Populus tremuloides*) could be grown for their medicinal values. Some others such as staghorn sumac (*Rhus typhina*) are listed as potential new crops for Australia (<http://www.newcrops.uq.edu.au/listing/listingindexr.htm>, accessed 10/02/04).
- Household and garden plants are not solely dependent on natural rainfall as they are mostly frequently watered. This means wetness and humidity around these plants could be favourable for establishment of the disease. Less use of pest control and heavy pruning practices may favour establishment and spread. However, the scattered distribution of host plants may restrict spread.

<b>Susceptible wild and amenity plants</b> <b>Low</b>	<ul style="list-style-type: none"> <li>Establishment or spread of the pest to household and garden plants is not recorded in literature.</li> <li>When Tasmania had the disease there were no reports of it on household and garden plants.</li> </ul>
	<ul style="list-style-type: none"> <li>Wild and amenity plants would not be sprayed with fungicides and, as such, once the pest has transferred from an infected fruit to a plant the disease could remain undetected and easily establish or spread within that community.</li> </ul>
	<ul style="list-style-type: none"> <li>Considerable damage to hardwood timber species is reported in the USA in addition to damage to commercial crops.</li> </ul>
	<ul style="list-style-type: none"> <li>The scattered distribution of wild species means rates of establishment and spread are lower compared with commercial crop and nurseries.</li> </ul>
	<ul style="list-style-type: none"> <li>When the disease existed in Tasmania from 1954–1991, it was found only in some commercial orchards (Ransom, 1997) and did not spread to trees in the wild. In New Zealand it is currently reported only in orchards and nurseries.</li> </ul>

### Assessment of consequences

Impact scores allocated for the direct and indirect criteria are shown in Table 36. Available supporting evidence is provided in the text below.

**Table 36 Impact scores for *N. galligena***

Direct	Impact scores
Plant life or health	E
Human life or Health	A
Impact on the environment	E
<b>Indirect</b>	
Control or eradication	D
Domestic trade or industry	D
International trade	B
Environment	C
Communities	C

**Direct impact**

**Plant life, or health – E**

Consequences affecting plant life or health would be minor at the national level, significant at the regional level and highly significant at the district level. The rating assigned to this criterion was therefore ‘E’.

- *Nectria* canker is one of the most economically damaging diseases of apple in Europe, North America and South America (CABI, 2003a). Infection in the nursery is thought to cause major production losses. Appearance of canker lesions on the main stems of young trees in newly planted orchards can at times necessitate replacement ranging from 10 per cent (Lovelidge, 1995) to the whole plantation (Grove, 1990a). The need to remove infected branches could delay fruit production and profitability.
- Generally fruit from trees with canker develop the rot in storage. Losses of 10–60 per cent of the stored fruit crop have been reported from various parts of the world (CABI, 2003a).
- Nursery industries producing or selling pome fruit and other host plants can also be affected significantly if the pest establishes in them.
- *N. galligena* is responsible for damage to many host species used for timber, through reduction of both quality and quantity of marketable logs (CABI, 2003a), although there are no estimates of the magnitude of loss. The damage to species used as garden, amenity, and household plants can also be significant.
- Overall, the direct impact on plant life in an Australian State can have a minor impact on the State’s economy and several States suffering such a minor impact could lead to a minor impact nationally.

**Human life or health – A**

- There are no known direct impacts of *N. galligena* on human life or health and the rating assigned to this criterion was therefore ‘A’.

**Any other aspects of environmental effects – E**

Consequences affecting any other aspects of the environment would be minor at the national level, significant at the regional level and highly significant at the district level. The rating assigned to this criterion was therefore ‘E’.

- The Australian community places a high value on its forest and garden environments. A large number of hosts of *N. galligena* constitute a component of those environments and are widely distributed across the country. Any death of forest plant species due to European canker can lead to reduction of plant species in that ecosystem.

**Indirect impact****Control or eradication  
– D**

The indirect impact on new or modified eradication, control, surveillance/monitoring and compensation strategies is unlikely to be discernable at the national level and of minor significance at the regional level. A rating of ‘**D**’ was assigned to this criterion.

- Once established, eradication of European canker is difficult and expensive. Except for Tasmania, Australia, other countries that have the disease have not been able to eradicate it. Even in Tasmania where the outbreak was restricted to only four orchards the eradication took nearly 40 years (Ransom, 1997).
- General control methods used for European canker include fungicide sprays, paints applied to pruning cuts, cultural control, improving host plant resistance, and prevention of fruit rotting (CABI, 2003a). Implementing these can be costly. Fungicides applied to control apple scab are effective against European canker as well. As scab is present in several States of Australia except WA, the control of scab will reduce costs for the control of European canker. If the disease gets onto forest/wild plant species control would be difficult, as they are not subjected to any integrated pest management programs.
- Cost of eradication and control would be minor at the State level but not discernible at the national level.

**Domestic trade or  
industry – D**

The indirect consequences on domestic trade are unlikely to be discernable at a national level and would be of minor significance at the regional level. A rating of ‘**D**’ was assigned to this criterion.

- Currently pome fruit could move freely across States and Territories except for WA, but the detection of the disease in one State would result in the application of quarantine restriction by other States on fruit as well as planting material. This would create a minor impact on that State but would not be discernible at national level.

**International trade – B**

The indirect consequences on international trade would not be discernible at the national level and would be of minor significance at the local level and a rating of ‘**B**’ was assigned to this criterion.

- In 1998, Australia exported 9.9 per cent of its apple crop at a value of AUD21.6 million. Of the total exports, Tasmania, Western Australia and South Australia account for 70 per cent, 25 per cent and 6 per cent respectively while exports from Victoria, New South Wales and Queensland are considered low.
- Major export markets for Australian apples include Malaysia, Singapore and the UK, with Sri Lanka, Indonesia, Philippines, China (Hong Kong), Taiwan, Fiji and Papua New Guinea constituting other significant markets. Current exports to Japan are for Fuji apples from Tasmania only. All varieties of apples from any part of Australia are permitted to the other countries. Of these importing countries, European canker is not recorded

in the tropical countries Malaysia, Singapore, Sri Lanka, Philippines, China (Hong Kong), Taiwan, Fiji and Papua New Guinea mainly because of lack of host plants and probably climatic conditions. The UK and Japan are the two importing countries with host species and appropriate climate for the disease, and the disease is already present in these two countries. This means that an outbreak of European canker in Australia will not have a significant impact on the current apple export trade. However, Australia will need to put in place special management practices if it is to seek access to new markets in temperate countries free of the disease.

- An outbreak in forest species will not impact on Australian timber exports because timber from species that are hosts to European canker is not exported from Australia.

#### **Environment – C**

The indirect consequences on the environment are unlikely to be discernable at the regional level, would be of minor significance at the district level and significant at the local level. A rating of ‘C’ was assigned to this criterion.

- As stated earlier, many host plants of *N. galligena* are forest, garden and amenity plants. Generally the appearance of the disease is in localised patches and there is no evidence of damage to such plants in New Zealand, or in Tasmania before it eradicated the disease. However, the disease is known to be common on such environmental hosts in North America (CABI, 2003a). In the event of establishment or spread in such species, indirect flow-on effects on the sustainability of forest ecosystems would be significant at the local level and of minor significance at the district level.

#### **Communities – C**

The indirect consequences on communities are unlikely to be discernable at the regional level, would be of minor significance at the district level and significant at the local level. A rating of ‘C’ was assigned to this criterion.

- Sustainability of communities in the nine or so major apple growing areas across Australia is significant to the local economy. Tourism in these areas, especially during harvesting periods, can be significant and depends on the health of the fruit crop.
- During the eradication effort in Tasmania, at least 30 per cent of the trees that had an infected limb removed subsequently developed further infection and entire trees had to be removed (Ransom, 1997). The need to remove trees from orchards or backyards and to quarantine properties would have a minor significance at the district level and be significant at the local level.

**Conclusion—consequences**

Based on the decision rule described in the methodology, i.e. where the consequences of a pest with respect to one or more criteria are ‘E’, the overall consequences are considered to be ‘moderate’. Therefore the overall consequences of *N. galligena* are **Moderate**.

**Unrestricted annual risk**

Unrestricted annual risk is the result of combining annual probability of entry, establishment or spread with the outcome of overall consequences. Probabilities and consequences are combined using the ‘rules’ shown in the risk estimation matrix in the method section. The unrestricted annual risk estimation for *N. galligena* is shown in Table 37.

**Table 37 Risk estimation of *N. galligena***

Overall probability of entry, establishment or spread <sup>28</sup>	<b>Low</b>
Consequences	<b>Moderate</b>
Unrestricted annual risk	<b>Low</b>

<sup>28</sup> Calculated by @ risk.

## **Apple leafcurling midge**

### **Biology**

The apple leafcurling midge (ALCM), *Dasineura mali* (Kieffer), is a fly with four life stages, adult, egg, larva (or maggot) and pupa. Apple trees (including crab apple) are the only hosts of ALCM. This species occurs in Europe, North America and New Zealand.

The adult is a small fly, 1.5–2.5 mm long with dusky wings covered with fine dark hairs. Adult females have a characteristic red abdomen. Larvae are legless red maggots when they first hatch from the eggs, and change to clear white until the final instar when they become bright orange-red in colour. Pupation takes place in a white silken cocoon 2–2.5 mm in length. The pre-pupal stage is orange and clearly visible inside the cocoon, whereas mature pupae are brown (Tomkins, 1998).

Apple leafcurling midge can reproduce only sexually. Laboratory evidence indicates that adults live only 2–6 days and they must mate within that period. Swarming of adults has been observed to precede egg laying by the females, and mating is assumed to occur in these swarms. Virgin females produce a sex pheromone that attracts males for mating, and swarming of males have been observed around virgin females (Harris *et al.*, 1996). Males are not attracted to mated females, including those mated just 1–2 hours previously. Females mate once or twice, whereas males may mate many times, some mating on average 11 times in 30 minutes (HortResearch, 1999b). Males emerge from their pupae earlier than females. Peak male emergence (eclosion) is 1–2.5 hours earlier than peak female emergence (Harris *et al.*, 1996).

Apple leafcurling midge has up to seven generations over the summer depending on latitude and temperature, and individuals survive the winter in New Zealand by overwintering as cocooned larvae (Tomkins, 1998). The female lays several eggs on each leaf and each female lays up to 200 eggs over about three days (CABI, 2002).

Apple leafcurling midge is reported to have arrived in the North Island of New Zealand on East Malling IX apple stock shipped from the Netherlands in 1950 (Morrison, 1953), and was probably transported to other parts of New Zealand on nursery trees in the years following its introduction. By 1956, it was already present in many North Island locations (Berry and Walker, 1989). The most probable means of dispersal would be as cocooned larvae either in soil or being associated with nursery plants (Berry and Walker, 1989).

Some responses to the draft IRA (Biosecurity Australia, 2000) on New Zealand apples incorrectly cite Gouk and Boyd (1999) as the authority for the assertion that apple leafcurling midge is a vector of fire blight. The authors clearly state that ALCM infestations only cause the leaf damage that provides the injury necessary for fire blight infections to occur and ‘there is currently no evidence to implicate the adult midge as a vector for dissemination of *E. amylovora*’ (Gouk and Boyd, 1999).

Other information relevant to the (Hale *et al.*, 1996b) biology of ALCM is available in the datasheet in Appendix 3 of Part B.



## Risk scenario

The risk scenario of concern for ALCM in this IRA is the mature larvae and pupae on apple fruit. The larvae of ALCM prefer to pupate in the ground but some larvae falling from leaves become caught on apples where they pupate.

## Probability of importation

The initiating step for the importation scenario for apple fruit is the sourcing of apples from orchards in New Zealand, whereas the end-point is the release of imported apples from the port of entry. The importation scenario is divided into eight steps and the likelihood of ALCM being present at each step is summarised in Figure 17. The available evidence supporting the likelihood assessments is provided in the text below.

**Figure 17 The importation steps and the likelihood of the apple leafcurling midge being present at each step**



**Importation step 1  
(Imp1)**

**High**

The likelihood that the ALCM is present in the source orchards in New Zealand: **High**.

- Apple leafcurling midge is common in New Zealand apple orchards from Clyde to Auckland, and is probably found wherever apple trees can be grown in New Zealand (Tomkins, 1998).
- Chapman and Evans (1995) note that in recent years ALCM's incidence in commercial apple orchards in the Auckland, Waikato, Hawke's Bay and Nelson districts has increased noticeably.
- ALCM infestation can differ between apple cultivars, although this can vary through the season depending on the availability of shoots suitable for egg laying. Gala types and cultivars with Gala parentage (e.g. Braeburn, Gala, Royal Gala and Pacific Rose™) are particularly prone (Smith and Chapman, 1997).
- No apple cultivar has been found that is free from infestation (HortResearch, 1999b).

*Summary*

Based on the above evidence that ALCM is common in New Zealand apple orchards, the likelihood for Imp1 was assessed as high.

**Importation step 2  
(Imp2)**

**Low**

The likelihood that picked apple fruit is infested with ALCM: **Low**.

- ALCM larvae usually exit a leafroll and fall to the ground to pupate at maturity. Some of these larvae are caught in the stalk-end or calyx-end of fruit as they try to reach the soil. Such larvae pupate on the fruit, with the pupal cocoon firmly attached to the fruit skin.
- Most fruit are only contaminated by a single cocoon, although up to 40 cocoons per fruit have been found on unsprayed trees (Tomkins, 1998; Tomkins *et al.*, 1994).
- A survey of 30 orchard blocks in the Waikato region and one in the Bay of Plenty during the 1993/94 season recorded up to 11.5 per cent of apples contaminated with ALCM pupae or larvae in the Waikato region and around one to two per cent in the Bay of Plenty. However, 63 per cent of the cocoons contained no pupae, indicating the adults had already emerged from their cocoons before fruit was harvested (Tomkins *et al.*, 1994).
- Lowe (1993) reported that 10 per cent of harvested apples were contaminated with pupae or larvae during the 1993/94 season in the Waikato region and up to one per cent in Hawke's Bay.

*Summary*

Based on the information that 10 or 11.5 percent of fruit can be contaminated by ALCM, the likelihood for Imp2 was assessed as low.

**Importation step 3  
(Imp3)****Very low**

The likelihood that clean fruit is contaminated by ALCM during harvesting and transport of apples to the packing house: **Very low**.

- Fruit is picked by hand into harvesting bags, and then transferred into bins kept on the ground in the orchard before transportation to the packing house.
- The only means of contamination occurs when infested leaves are picked during harvest along with the fruit.
- If larvae are present on infested leaf material, they could move onto clean fruit to pupate in the stem-end or calyx-end of apple fruit.
- Typically a leafroll contains 20–30 larvae, but there can be 1–500 (Tomkins, 1998). However, the number of leaves picked is very low: up to 200 leaves per bin (Armour, 2003).

*Summary*

Based on the information that the contamination only occurs when infested leaves are picked and the number of picked leaves is very low, the likelihood for Imp3 was assessed as very low.

**Importation step 4  
(Imp4)****Moderate**

The likelihood that ALCM survives routine processing procedures in the packing house: **Moderate**.

The following packing house operations can influence the viability of ALCM.

*Washing*

- There is no evidence that transfer of fruit through a flotation dump will affect the survival of ALCM. The mature larvae pupate in a tough, white silken cocoon that can protect the pupae while in the dump.
- If the pupal cocoons are firmly attached to the fruit skin at the stalk-end or calyx-end, high-volume/high pressure washing is not likely to dislodge all of them.

*Brushing*

- There is no evidence that a brushing process would affect the survival of ALCM. The pupal cocoon is attached to the stem-end or calyx-end, so brushing would not easily dislodge them.

*Waxing*

- Pupae enclosed in their protective cocoon probably survive low temperature waxing.

#### *Sorting and grading*

- Sorting and grading would remove fruit that is contaminated with pupae. However, given the volume of fruit passing through the grading areas, it is expected that some infested fruit would not be detected and removed.

#### *Packaging*

- Packaging would have little effect on the survival of ALCM. In most cases the packaging of apples is designed to maximise heat discharge from the fruit while minimising loss of moisture.

#### *Cold Storage*

- There is no evidence to suggest that cold storage would significantly reduce the viability of pupae of ALCM. The summer generation pupal stage lasts 13–18 days. However, the overwintering generation remains as pre-pupae or pupae inside the pupal cocoon for much longer. The adult stage lasts only a 2-6 days. ALCM larvae overwinter in cocoons in Europe and northeast USA, suggesting that temporary cold storage will not significantly reduce viability of the pest.

#### *Summary*

The fact that the ALCM has been detected in several USA ports on New Zealand apples exported to the USA (USDA-APHIS, 2003) indicates that some individuals of ALCM will survive the packing house process, and the likelihood for Imp4 was assessed as moderate.

#### **Importation step 5 (Imp5)**

##### **Negligible**

The likelihood that clean fruit is contaminated by ALCM during processing in the packing house: **Negligible**.

- Some fruit arriving at the packing house would have pupae firmly attached to the fruit skin at the stem-end or calyx-end (HortResearch, 1999b).
- Dislodged ALCM pupae would not be able to move about to attach to other fruit.
- ALCM larvae would not persist inside the packing house because there are no immature apple leaves to feed on.
- ALCM adults, if present, would not lay eggs within the packing house because of the absence of immature apple leaves.

#### **Importation step 6 (Imp6)**

##### **High**

The likelihood that ALCM survives palletisation, quality inspection, containerisation and transportation to Australia: **High**.

- Some remaining viable pupae at the stem-end or calyx-end of fruit would survive palletisation, quality inspection, containerisation and refrigerated transport to Australia.
- ALCM has been detected in several USA ports on New

	Zealand apples exported to the USA (USDA-APHIS, 2003).
<b>Importation step 7 (Imp7)</b>	The likelihood that clean fruit is contaminated by ALCM during palletisation, quality inspection and transportation: <b>Negligible</b> .
<b>Negligible</b>	<ul style="list-style-type: none"> <li>• ALCM pupae that are firmly attached to the fruit skin at the stem-end or calyx-end would not be easily dislodged and if dislodged would not move about to attach to other fruit (HortResearch, 1999b).</li> <li>• Thus contamination of fruit by ALCM during palletisation, quality inspection, containerisation and refrigerated transport to Australia would not occur.</li> </ul>
<b>Importation step 8 (Imp8)</b>	The likelihood that ALCM survives and remains with fruit after on-arrival minimum border procedures: <b>High</b> .
<b>High</b>	<ul style="list-style-type: none"> <li>• The minimum border procedures described in the method section would not be effective in detecting ALCM.</li> </ul>

### ***Conclusions—probability of importation***

When the above likelihoods were inserted into the simulation model, the probability of importation of ALCM from one year of trade was found to be **Low**.

### **Probability of distribution**

The initiating step for the distribution scenario is the release of imported apples from the port of entry, and the last step is the pest being distributed (as a result of the processing, sale or disposal of these apple fruit) in a viable state to an endangered area and subsequently being exposed to a suitable host.

To assess the probability of distribution, the distribution scenario is addressed in the three subheadings below. First is a brief description of sequences of events leading to a successful exposure of the pest from infested/infected apple to a susceptible host plant. Second is the assessment of partial probability of distribution of the pest in relation to each of the exposure groups. Third is the conclusion for the probability of distribution.

### ***Sequence of events for successful exposure***

The sequence of events that has to be completed for a successful exposure of a susceptible host to the pest is summarised below.

The insect stage associated with apple fruit is the mature larva or pupa in a cocoon, and there is usually one mature larva or pupa per apple. The only means for ALCM to leave fruit or packaging and enter the environment of exposure groups is adult flying. If mature larvae or pupae survive cold storage or controlled atmosphere storage, adults would need to emerge from the pupal stage after the apples have been taken out of storage. They could emerge at unpacking and repacking facilities or retailers (utility points), on discarded fruit in waste, at landfills where the waste is disposed of, and during transportation of purchased apples from retailers to households.

Adult life span of both sexes is only 2–6 days in laboratory studies. Both the adult male and female have wings and are able to fly. Sexual reproduction is essential, and the female

produces a pheromone that attracts the males for mating. Mated females seek out actively growing shoots on which to lay their eggs.

A successful exposure of ALCM from infested/infected fruit to the host means that the emerged female would need to locate a male with which to mate and then lay her eggs on a susceptible host plant during the two to six days of her adult life span.

### ***Partial probability of distribution***

The partial probability of distribution (PPD) was estimated separately for each of the four exposure groups: commercial fruit crops; nursery plants; household and garden plants; and wild and amenity plants.

The details and the method of calculation for the PPD of the four exposure groups are explained in the method section, and the results are presented in a series of tables and figures below. The information from these tables and figures was used to assess the probability of distribution of ALCM to all the exposure groups.

Table 38 indicates the proportions of the five utility points near each of the exposure groups of ALCM. Apple is the only host for ALCM.

**Table 38 The proportions of utility points near host plants susceptible to apple leafcurling midge in the four exposure groups**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Proximity</b> Orchard wholesalers	Certain	Very Low	Very Low	Very Low
<b>Proximity</b> Urban wholesalers	Extremely Low	Extremely Low	Extremely Low	Extremely Low
<b>Proximity</b> Retailers	Very Low	Very Low	Extremely Low	Extremely Low
<b>Proximity</b> Food services	Extremely Low	Extremely Low	Extremely Low	Extremely Low
<b>Proximity</b> Consumers	Very Low	Very Low	Low	Very Low

Figure 18 gives a pictorial representation of the relative amounts of infested/infected apples, an escaped pest or contaminated packaging material discharged or discarded from different utility points near each of the exposure groups of apple leafcurling midge.

**Figure 18 Pictorial representation of the relative amounts of infested/infected apple waste<sup>29</sup> from utility points to near exposure groups of apple leafcurling midge.**

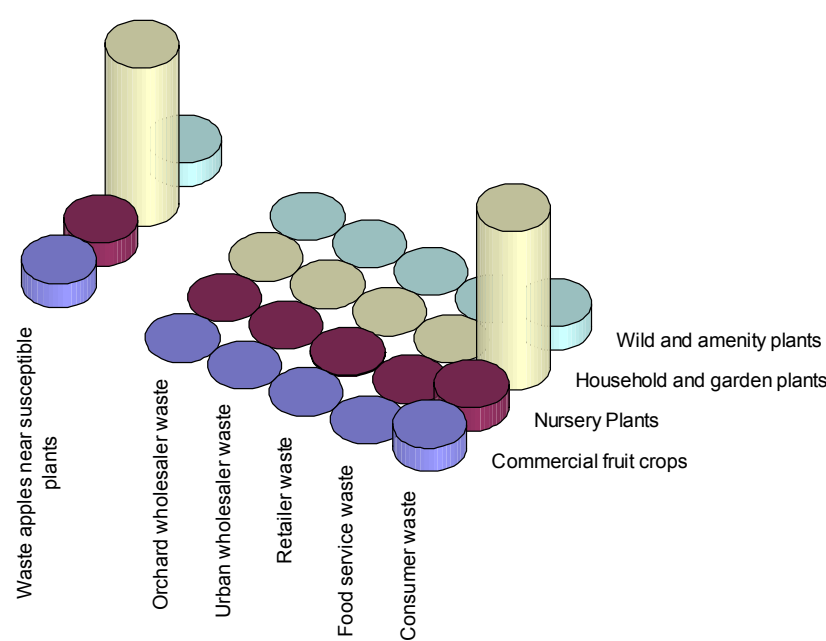


Table 39 is the summary of the probability that exposure of host plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points. Evidence is provided in the text below under different exposure groups.

<sup>29</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or an escaped pest, or contaminated packaging material.

**Table 39 The probability of exposure of susceptible host plants to apple leafcurling midge from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Exp</b> Orchard wholesaler waste <sup>30</sup>	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Urban wholesaler waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Retailer waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Food service waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Consumer waste	Negligible	Negligible	Negligible	Negligible

#### *Commercial fruit crops*

#### *Commercial fruit crops near utility points*

The proportions of the five utility points near commercial fruit crops susceptible to ALCM are shown in Table 38. It was considered that commercial fruit crops are certain to be near all orchard wholesalers, very unlikely to be near retailers and consumers, and extremely unlikely to be near urban wholesalers and food service because most of these are in metropolitan areas.

The relative amounts of infested/infected apples, or an escaped pest, or contaminated packaging material discharged or discarded from different utility points to near commercial fruit crops susceptible to apple leafcurling midge are indicated in Figure 18.

#### *Exposure to host*

Apple is the only commercial fruit crop susceptible to ALCM.

During the two to six days of an adult's life, a successful exposure of ALCM from infested/infected fruit to a susceptible host requires a female to locate a male with which to mate and then to lay her eggs on a susceptible host plant. The chance of this happening depends on several factors, including mortality caused by the handling and consumption of the fruit, the level of infestation/infection and the number of apples in the same utility points, the reproductive strategy and life span of the pest, and availability of susceptible hosts.

As shown in Table 39, it is considered that the probabilities that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an

<sup>30</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or an escaped pest, or contaminated packaging material.



escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** commercial fruit crops  
from orchard wholesaler waste

**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**.

- Apple trees are available in commercial orchards and the midge prefers to lay its eggs on actively-growing young apple leaves.

**Exp** commercial fruit crops  
from urban wholesaler waste

**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**.

- Commercial fruit crops are not in urban areas.
- Urban wholesaler waste is disposed of into bins and taken to landfills. Commercial fruit crops are unlikely to be near these sites.

**Exp** commercial fruit crops  
from retailer waste

**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**.

- Most retailers are in urban areas not close to commercial fruit crops.
- Retailer waste may be used for composting in rural areas, and some of these sites may be near commercial orchards.

**Exp** commercial fruit crops  
from food service waste

**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**.

- Most food services are in urban areas not close to commercial fruit crops.
- Food service industry waste is disposed of into bins and taken to landfills. Commercial fruit crops are unlikely to be near these sites.

**Exp** commercial fruit crops  
from consumer waste

**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**.

- Most consumers are in metropolitan and suburban areas. Waste produced by people in metropolitan areas and some in urban areas is generally disposed of into landfills. Commercial fruit crops would usually not be near these sites.
- Household and population densities around commercial orchards are very low.
- Some consumer waste in suburban and rural areas may be used

for composting. Commercial fruit crops can be close to compost heaps.

### *Nursery plants*

#### *Nursery plants near utility points*

The proportions of the five utility points near nursery plants susceptible to ALCM are shown in Table 38. It was considered that nursery plants are very unlikely to be near orchard wholesalers, retailers and consumers, and extremely unlikely to be near urban wholesalers and food services.

The relative amounts of waste apples discharged or discarded near nursery plants susceptible to apple leafcurling midge are indicated in Figure 18.

#### *Exposure to host*

Apple (including crab apple) is the only nursery plant susceptible to ALCM.

During the two to six days of an adult's life, a successful exposure of ALCM from infested/infected fruit to a susceptible host requires a female to locate a male with which to mate and then to lay her eggs on a susceptible host plant. The chance of this happening depends on several factors, including mortality caused by the handling and consumption of the fruit, the level of infestation/infection and the number of apples in the same utility points, the reproductive strategy and life span of the pest, and availability of susceptible hosts.

As shown in Table 39, it is considered that the probabilities that exposure of nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** nursery plants from  
orchard wholesaler waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**.

- It is highly unlikely, for hygiene reasons, that nurseries would be near wholesaler waste disposal sites.

**Exp** nursery plants from urban  
wholesaler waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**.

- There are rare instances of nurseries being near urban waste dumps.

**Exp** nursery plants from retailer  
waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**.

- Apple nursery plants are sold in major retail outlets.
- Apple is a common plant in nurseries in the temperate regions of Australia, particularly during the dormant period over winter and to a limited extent during the spring and summer.

- Retail garden nurseries have a high density of various plant materials in a small area. They often maintain a high hygienic standard, usually fogging with insecticide, to prevent insect attacks.
- Some fresh food markets have nursery plants near apple fruit. However, there are a limited number of nurseries associated with fresh food markets that also maintain or store actively growing apple trees.

**Exp** nursery plants from food service waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**.

- Nurseries would not be near landfill sites in which food services waste is disposed.

**Exp** nursery plants from consumer waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**.

- Most consumers are in metropolitan and suburban areas, and their waste is disposed of into landfills. Nurseries are generally not near these sites.

### *Household and garden plants*

#### *Household and garden plants near utility points*

The proportions of the five utility points near household and garden plants susceptible to ALCM are shown in Table 38. It was considered that household and garden plants are unlikely to be near consumers, very unlikely to be near orchard wholesalers, and extremely unlikely to be near urban wholesalers, retailers and food services.

The relative amounts of waste apples discharged or discarded near household and garden plants susceptible to apple leafcurling midge are indicated in Figure 18.

#### *Exposure to host*

Apple is the only household or garden plant susceptible to ALCM.

During the two to six days of an adult's life, a successful exposure of ALCM from infested/infected fruit to a susceptible host requires a female to locate a male with which to mate and then to lay her eggs on a susceptible host plant. The chance of this happening depends on several factors, including mortality caused by the handling and consumption of the fruit, the level of infestation/infection and the number of apples in the same utility points, the reproductive strategy and life span of the pest, and availability of susceptible hosts.

As shown in Table 39, it is considered that the probabilities that exposure of household and garden plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** household and garden  
plants from orchard wholesaler  
waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**.

- Orchard wholesale waste sites are usually within the orchard premises and are not near household and garden plants.

**Exp** household and garden  
plants from urban wholesaler waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**.

- Urban wholesaler waste is disposed of into landfill sites that are generally not near residential properties.

**Exp** household and garden  
plants from retailer waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**.

- Retailer waste would be disposed of to landfills that are generally not near residential properties.

**Exp** household and garden  
plants from food service waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**.

- Food service industries are unlikely to have host plants susceptible to ALCM within their premises.
- Waste from food services is disposed of into landfill sites.

**Exp** household and garden  
plants from consumer waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**.

- Most consumers are in metropolitan and suburban areas, and their waste is disposed of into landfills. However, local authorities are now encouraging composting of food waste in suburban backyards rather than disposing of all waste into landfill.
- Using waste to make compost is becoming a common practice in some suburban and rural households.
- Most consumers in metropolitan and suburban areas dispose of their waste to landfills that are generally not near household and garden plants.
- Apple is commonly grown as a garden plant in the temperate regions of Australia.

*Wild and amenity plants**Wild and amenity plants near utility points*

The proportions of the five utility points near wild and amenity plants susceptible to ALCM are shown in Table 38. It was considered that wild and amenity plants are unlikely to be near consumers, very unlikely to be near orchard wholesalers, and extremely unlikely to be near urban wholesalers, retailers and food services.

The relative amounts of waste apples discharged or discarded near wild and amenity plants susceptible to apple leafcurling midge are indicated in Figure 18.

*Exposure to host*

Apple (including crab apple) is the only wild and amenity plant susceptible to ALCM.

During the two to six days of an adult's life, a successful exposure of ALCM from infested/infected fruit to a susceptible host requires a female to locate a male with which to mate and then to lay her eggs on a susceptible host plant. The chance of this happening depends on several factors, including mortality caused by the handling and consumption of the fruit, the level of infestation/infection and the number of apples in the same utility points, the reproductive strategy and life span of the pest, and availability of susceptible hosts.

As shown in Table 39, it is considered that the probabilities that exposure of wild and amenity plants would result from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** wild and amenity plants  
from orchard wholesaler waste

**Negligible**

The probability that exposure of susceptible wild and amenity plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**.

- Orchard wholesale waste sites are usually within the orchard premises and are not near wild and amenity plants.
- Susceptible feral plants (e.g. volunteer apple seedlings, crab apple, etc.) may be near orchard wholesaler's waste disposal sites.

**Exp** wild and amenity plants  
from urban wholesaler waste

**Negligible**

The probability that exposure of susceptible wild and amenity plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**.

- Urban wholesale waste is disposed of at landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds (e.g. crab apple and apple seedlings).

**Exp** wild and amenity plants  
from retailer waste

**Negligible**

The probability that exposure of susceptible wild and amenity plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**.

- Retailer waste would be disposed of to landfills. Susceptible

hosts may grow in the wild near these sites as a result of dispersal of seeds by birds (e.g. crab apple and apple seedlings).

**Exp** wild and amenity plants  
from food service waste

**Negligible**

The probability that exposure of susceptible wild and amenity plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**.

- Food services would dispose their waste into landfills. Seedlings originating from seeds dispersed by birds would be present.

**Exp** wild and amenity plants  
from consumer waste

**Negligible**

The probability that exposure of susceptible wild and amenity plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**.

- Most consumers are in metropolitan and suburban areas and their waste is disposed of into landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds (e.g. crab apple and apple seedlings).
- Consumers discard apple cores into the environment or into bins in parks. Bins for waste in parks may not be removed daily and these would provide a sheltered environment for ALCM to emerge before the fruit desiccates or decays.
- Apple seedlings can establish from discarded apple cores. However, population densities of susceptible wild and amenity apple plants in parks, near recreational facilities and along roadsides may be low.
- Consumers who consider apple cores to be biodegradable may indiscriminately discard them into the environment. Spoilt apples or cores discarded into the wild are likely to be isolated.

### ***Conclusion—probability of distribution***

The partial probability of distribution from each of the utility points to each of the exposure groups is summarised in Table 40. These were calculated by the simulation model using @risk. The quantitative model evaluated the effect of the ‘volume of trade’ during a specified period when calculating the partial probability of distribution.

**Table 40 Partial probabilities of distribution (PPD)<sup>31</sup> for apple leafcurling midge**

UTILITY POINTS	PPD			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Orchard wholesalers</b>	Extremely low	Extremely low	Extremely low	Extremely low
<b>Urban wholesalers</b>	Extremely low	Extremely low	Extremely low	Extremely low
<b>Retailers</b>	Very low	Very low	Extremely low	Extremely low
<b>Food services</b>	Extremely low	Extremely low	Extremely low	Extremely low
<b>Consumers</b>	Low	Low	Moderate	Low
<b>Overall PPD</b>	<b>Low</b>	<b>Low</b>	<b>Moderate</b>	<b>Low</b>

### Probability of establishment or spread

The assessment for the probability of establishment or spread was carried out in the following manner. Firstly, partial probability for establishment and for spread was assessed separately based on the relevant available scientific information. Secondly, the conclusions for the combined partial probability of establishment or spread for each of the four exposure groups was assessed. The relevant information for the assessment for the probability of establishment or spread is presented below against the factors listed in ISPM 11, Rev. 1.

#### *Partial probability of establishment*

ISPM 11 factor	Relevant information
<b>Availability of suitable hosts, alternate hosts and vectors in the PRA area</b>	<ul style="list-style-type: none"> <li>• Apple trees (including crab apples) are the only host of ALCM.</li> <li>• No apple cultivar has been found that is not susceptible to infestation (CABI, 2002; Todd, 1959; Tomkins, 1998).</li> <li>• Apples are grown in all States and Territories in Australia, except in the northern tropical regions, and are also found in suburban backyards in temperate Australia.</li> </ul>
<b>Suitability of the environment</b>	<ul style="list-style-type: none"> <li>• ALCM is found throughout Europe, North America and New Zealand where climatic conditions are similar to those in Australia.</li> <li>• Apples are not grown in protected environments such as in glasshouses.</li> </ul>

<sup>31</sup> Partial probability of distribution is actually referring to the probability of entry and was estimated by @risk.

ISPM 11 factor	Relevant information
<b>The potential for adaptation of the pest</b>	<ul style="list-style-type: none"> <li>• It was thought that ALCM increased its pest status in New Zealand in the 1990s because of resistance to chemicals (organophosphorus insecticides are used for its control). However, tests showed that this was not the case, and there are no reports of ALCM in New Zealand developing resistance to insecticides (HortResearch, 1999b).</li> <li>• Chapman and Evans (1995) tested ALCM's resistance to azinphos-methyl, and concluded that the midge had not developed resistance to azinphos-methyl, and that resistance was therefore unlikely to be the cause of recent outbreaks in certain apple growing districts of New Zealand.</li> <li>• Azinphos-methyl was used for the test because it had been used in New Zealand's apple orchards for longer than any other organophosphate insecticide in. If ALCM had not developed resistance to azinphos-methyl, the species was not likely to have developed resistance to any other organophosphate insecticides.</li> </ul>
<b>The reproductive strategy of the pest</b>	<ul style="list-style-type: none"> <li>• ALCM only reproduces sexually.</li> <li>• Successful mating between a male and a female must occur within the limited 2–6 day life of the adult.</li> <li>• Males are not attracted to mated females, including those mated just 1–2 hours previously.</li> <li>• Females mate once or twice, whereas males mate many times, some mating on average 11 times in 30 minutes (HortResearch, 1999b).</li> <li>• Males emerge from their pupae earlier than females, peak male emergence (eclosion) occurring 1–2.5 hours earlier than peak female emergence (Harris <i>et al.</i>, 1996).</li> <li>• ALCM has up to seven generations over summer depending on latitude and temperature. They survive the winter in New Zealand by overwintering as cocooned larvae (Tomkins, 1998).</li> </ul>
<b>Minimum population needed for establishment</b>	<ul style="list-style-type: none"> <li>• The mated female lays several eggs on each leaf, and each female lays up to 200 eggs over about three days (CABI, 2002). A population can be started from these eggs.</li> </ul>



ISPM 11 factor	Relevant information
<b>Cultural practices and control measures</b>	<ul style="list-style-type: none"> <li>Integrated Pest Management (IPM) programs are used in the production of apples in Australia.</li> <li>New Zealand orchardists use Integrated Fruit Production (IFP) in the production of their fruit (ENZA, 2003) and IFP became a minimum export standard for New Zealand apples in 2000/01 (Anonymous, 2002b).</li> <li>In the context of IFP, ALCM is partially controlled in New Zealand by a parasitic wasp, <i>Platygaster demades</i> (Walker), an introduced biological control agent (Todd, 1959; Tomkins <i>et al.</i>, 2000). This parasitoid is not present in Australia (Evenhuis, 1989).</li> <li>Some natural enemies of ALCM present in New Zealand, such as the European or common earwig (<i>Forficula auricularia</i>), the mirid (<i>Sejanus albisignata</i>) and the whirligig mite (<i>Anystis baccarum</i>) are also present in Australia.</li> </ul>

*Conclusion—partial probability of establishment*

Based on the above evidence, partial probability of establishment for each of the exposure groups is assessed as follows.

Partial probability of establishment for commercial fruit crops: **High**.

Partial probability of establishment for nursery plants: **High**.

Partial probability of establishment for household and garden plants: **High**.

Partial probability of establishment for wild and amenity plants: **Moderate**.

***Partial probability of spread***

ISPM 11 factor	Relevant information
<b>Suitability of natural and/or managed environment</b>	<ul style="list-style-type: none"> <li>ALCM has spread all over New Zealand since its accidental introduction in about 1950. There are similar environments in Australia that would be suitable for its spread.</li> </ul>
<b>Presence of natural barriers</b>	<ul style="list-style-type: none"> <li>The main Australian commercial apple orchards are in six States of Australia with natural barriers including arid areas, climatic differentials and long distances between these areas. It would be difficult for the adults to disperse from one area to another unaided.</li> <li>However, ALCM has some characteristics that assist in its short-range dispersal. Apple host plants are also available between the commercial apple orchards in different areas or States, and this would help the spread of ALCM.</li> <li>ALCM does not require a vector for its dispersal.</li> <li>Both the adult male and female are winged and are capable of flight.</li> <li>Pre-egg-laying flights and colonisation of host plants by the</li> </ul>

ISPM 11 factor	Relevant information
<b>Potential for movement with commodities or conveyances</b>	<p>females, as well as location of females by males accounts for much of the midge's short-range dispersal.</p> <ul style="list-style-type: none"> <li>• Male dispersal is strongly affected by the location of females.</li> <li>• Mated females have been observed to fly for up to an hour before landing on foliage and laying their first egg. Flights between egg-laying may last 15 minutes.</li> <li>• The females are attracted by odours from apple foliage, particularly young foliage.</li> <li>• A mixture of adult flight and the transportation of infested apple trees has probably achieved long-distance movement of ALCM.</li> <li>• The most probable means of dispersal would be as cocooned larvae either in soil or being associated with nursery plants (Berry and Walker, 1989). Midges could readily be associated with nursery trees being despatched for planting in winter, because nursery trees are a favoured over-wintering site.</li> <li>• Existing interstate quarantine control on the movement of nursery stock would reduce the scope for spread of ALCM.</li> </ul>
<b>Intended use of the commodity</b>	<ul style="list-style-type: none"> <li>• Apples would be used mostly for consumption by humans, and would be widely distributed around the States.</li> <li>• If larvae or pupae have contaminated the fruit, they will be distributed with the commodity around the country.</li> </ul>
<b>Potential vectors of the pest</b>	<ul style="list-style-type: none"> <li>• ALCM does not require a vector for its spread because it is capable of independent flight.</li> </ul>
<b>Potential natural enemies</b>	<ul style="list-style-type: none"> <li>• The parasitic wasp <i>Platygaster demades</i> (Walker) of ALCM is not present in Australia (Evenhuis, 1989).</li> <li>• Other natural enemies in the PRA area, especially generalist predators, may be able to attack <i>D. mali</i> but there is no evidence that they would be effective.</li> </ul>

*Conclusion—partial probability of spread*

Based on the above evidence, partial probability of spread for each of the exposure groups is assessed as follows.

Partial probability of spread for commercial fruit crops: **Moderate**

Partial probability of spread for nursery plants: **Moderate**

Partial probability of spread for household and garden plants: **Moderate**

Partial probability of spread for wild and amenity plants: **Low**

***Combined partial probability of establishment or spread***

The combined partial probability of establishment or spread was determined by combining probabilities of establishment and probabilities of spread using the matrix of 'rules' for

combining descriptive likelihoods as presented in the method section. The results are in Table 41.

**Table 41 Combined partial probabilities of establishment or spread of apple leafcurling midge**

	<b>Commercial fruit crops</b>	<b>Nursery plants</b>	<b>Household and garden plants</b>	<b>Wild and amenity plants</b>
<b>Establishment</b>	High	High	High	Moderate
<b>Spread</b>	Moderate	Moderate	Moderate	Low
<b>PPES<sup>32</sup></b>	Moderate	Moderate	Moderate	Low

Additional evidence to support the combined partial probability of establishment or spread for specific exposure groups is provided in the text below.

<b>Commercial fruit crops</b> <b>Moderate</b>	<ul style="list-style-type: none"> <li>Commercial apple growing areas are mainly in Stanthorpe in Queensland, the Adelaide Hills in South Australia, Orange and Batlow in New South Wales, the Goulburn Valley and southern Victoria, the Huon Valley in Tasmania, and the Perth Hills and Manjimup in Western Australia.</li> <li>ALCM has shown its ability to establish or spread readily in North America and New Zealand after its accidental introduction from Europe.</li> </ul>
<b>Nursery plants</b> <b>Moderate</b>	<ul style="list-style-type: none"> <li>ALCM is reported to have arrived in the North Island of New Zealand on East Malling IX apple stock shipped from the Netherlands in 1950 (Morrison, 1953), and it was probably transported to other parts of New Zealand on nursery trees in the years following its introduction. By 1956, it was already present in many North Island locations (Berry and Walker, 1989).</li> <li>A mixture of adult flight and the transportation of infested apple trees has probably achieved long-distance movement of ALCM.</li> </ul>
<b>Household and garden plants</b> <b>Moderate</b>	<ul style="list-style-type: none"> <li>The establishment of ALCM in susceptible household and garden plants will be largely dependent on the availability of new apple shoot growth, the extent of Australian households growing backyard apple trees, and the willingness of suburban gardeners to adequately control pests and diseases on their apple trees.</li> <li>Climatic limits and the number and distribution of apple trees, including crab apple trees, in suburban backyards can affect the establishment or spread of ALCM. Because ALCM can fly short distances unaided, is particularly attracted to young apple</li> </ul>

<sup>32</sup> PPES = partial probability of establishment or spread.

leaf growth and could survive a short time on discarded apple fruit in backyard compost heaps, it was considered that ALCM could spread within Australia following establishment in exposed household and garden plants.

**Wild and amenity plants**

**Low**

- Even though ALCM is capable of short flight, wild apple trees are not as prevalent across the country as apple trees in a commercial or household situation. Therefore, ALCM will require some assistance to spread from one wild plant to another.

## Assessment of consequences

Impact scores allocated for the direct and indirect criteria are shown in Table 42. Available supporting evidence is provided in the text below.

**Table 42 Impact scores for apple leafcurling midge**

Direct impact	Impact scores
Plant life or health	D
Human life or health	A
Any other aspects of the environment	A
Indirect impact	
Control or eradication	D
Domestic trade or industry	D
International trade	D
Environment	B
Communities	A

### Direct impact

**Plant life or health – D**

Consequences affecting plant life or health are unlikely to be discernable at the national level and of minor significance at the regional level. A rating of ‘D’ was assigned to this criterion.

- Smith and Chapman (1995) conducted a survey of 30 apple orchards in the Nelson area for the ranking of the most important arthropod pest and perception of the importance of ALCM. The results indicated that 33 per cent growers ranked ALCM alone, 17 per cent ranked ALCM and mites together, and 17 per cent ranked ALCM, leafroller and mites altogether as the most serious arthropod pest, and the perception of 63 per cent of the growers surveyed was that ALCM affects plant health.

- ALCM is a specialist herbivore restricted to apple trees. It affects crown formation of young apple trees in the first stages of development, but mature trees are able to tolerate normal population levels.
- ALCM spread rapidly in New Zealand after its introduction.
- Surveys of ALCM have shown it is a serious pest in most apple growing regions of New Zealand (Smith and Chapman, 1995; Tomkins *et al.*, 1994). Smith and Chapman (1997) and Wilton (1994) report large increases in populations.
- ALCM is capable of 4–7 overlapping generations in a growing season, resulting in rapid population build up.
- New Zealand organic growers rate ALCM as only a minor problem in mature orchards.

**Human life or health – A**

There are no known direct impacts of ALCM on human life or health and the rating assigned to this criterion was therefore ‘A’.

**Any other aspects of environmental effects – A**

There is no known direct impact of ALCM on any other aspects of the environment, and a rating of ‘A’ was assigned to this criterion.

**Indirect impact**

**Control or eradication – D**

The indirect impact on new or modified eradication, control, surveillance/monitoring and compensation strategies is unlikely to be discernable at the national level and of minor significance at the regional level. A rating of ‘D’ was assigned to this criterion.

Indirect consequences of the eradication or control as a result of the introduction of ALCM:

- an increase in the use of insecticides for control of ALCM because of difficulties estimating the optimum time for insecticide application,
- disruption to IPM programs because of the need to re-introduce or increase the use of organophosphate insecticides,
- subsequent increase in cost of production to producers,
- damage to young leaves would provide entry opportunities for the entry of plant pathogens,
- increased costs for crop monitoring and consultant’s advice to the producer.

**Domestic trade or industry – D**

The indirect consequences on domestic trade are unlikely to be discernable at a national level and would be of minor significance at the regional level. A rating of ‘D’ was assigned to this criterion.

The presence of ALCM on commercial apple crops could result in:

- trade restrictions in the sale or movement of fruit within that district and region and between States,
- fruit with skin distorted by bumps (Tomkins, 1998) caused by high populations of ALCM affecting developing fruitlets,

- consumer expectations and aesthetics ranging from the acceptance of fruit that is slightly affected to outright rejection of imperfect fruit.

**International trade – D** The indirect consequences on international trade are unlikely to be discernable at a national level and would be of minor significance at the regional level. A rating of ‘**D**’ was assigned to this criterion.

- In the case of New Zealand, ALCM larvae and pupae found on harvested fruit can lead to the rejection of fruit for pre-clearance export to countries such as Japan (Lowe, 1993) or treatment on-arrival in California (Anonymous, 2002b).
- If ALCM became established in Australia, our trading partners such as Japan would reject consignments of apples infested with ALCM.

**Environment – B** The indirect consequences on the environment would not be discernable at the national level and would be of minor significance at the local level, and a rating of ‘**B**’ was assigned to this criterion.

Control measures can be broadly classified into two categories: chemical control or biological control.

- Increased insecticide use could cause undesired effects on the environment.
- The introduction of new biocontrol agents could affect existing biological control programs.
- The only hosts of ALCM are apples. These are mainly grown under intensive cultivation in orchards or backyards, so there would be little effect on designated environmentally sensitive or protected areas because few apple trees grow or are allowed to continue to grow in such areas.

**Communities – A** • The presence of ALCM would have limited social effects, if any, and a rating of ‘**A**’ was assigned to this criterion.

### ***Conclusion—consequences***

Based on the decision rule described in the method section, i.e. where the consequences of a pest with respect to one or more criteria are ‘**D**’, the overall consequences are considered to be ‘low’. Therefore the overall consequences of ALCM are **low**.

### **Unrestricted annual risk**

Unrestricted annual risk is the results of combining annual probability of entry, establishment or spread with the outcome of overall consequences. Probabilities and consequences are combined using the ‘rules’ shown in the risk estimation matrix in the method section. The unrestricted annual risk estimation for ALCM is shown in Table 43.

**Table 43 Risk estimation for apple leafcurling midge**

Overall probability of entry, establishment or spread <sup>33</sup>	<b>Moderate</b>
Consequences	<b>Low</b>
Unrestricted annual risk	<b>Low</b>

As indicated in Table 43, the unrestricted annual risk for ALCM is low, which is above Australia's appropriate level of protection (ALOP) of very low. Therefore, risk management would be required for this pest.

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<sup>33</sup> Calculated by @ risk.

## **Garden featherfoot**

### **Biology**

The garden featherfoot (GFF), *Stathmopoda horticola* Dugdale, has four life stages: adult, egg, larva (or caterpillar) and pupa.

Mature larvae are approximately 8 mm in length and are a dark purplish brown in colour, with a dark reddish brown head and paler intersegmental divisions. The cocoon is often attached to the surface of the fruit (Landcare Research, 1999).

Very little has been published on the life history of this species but on orchard trees the larvae are known to feed on the surface of fruit from a silken shelter under the dying calyxes (Landcare Research, 1999).

Other information relevant in the (Thomson, 1992b; Hale *et al.*, 1996b)biology of GFF is available in the datasheet in Appendix 3 of Part B.

### **Risk scenario**

The risk scenario of concern for GFF in this IRA is the larvae and pupae on surface of fruit.



## Probability of importation

The initiating step for the importation scenario for apple fruit is the sourcing of apples from orchards in New Zealand, whereas the end-point is the release of imported apples from the port of entry. The importation scenario is divided into eight steps and the likelihood of GFF being present at each step is summarised in Figure 19. The available evidence supporting the likelihood assessments is provided in the text below.

**Figure 19 The importation steps and the likelihood of the garden featherfoot being present at each step**



**Importation step 1  
(Imp1)**

**Very low**

The likelihood that GFF is present in the source orchards in New Zealand: **Very low**.

- Garden featherfoot is a native New Zealand moth that is generally distributed throughout the country (HortResearch, 1999b).
- There is no reference to GFF in HortResearch's internet BugKEY (HortResearch, 1999b), although unidentified species of *Stathmopoda* caterpillars (probably including GFF) are mentioned as occasional pests of apples in the north of New Zealand and they may be found feeding at the calyx or stem-end of apples.
- The fruits of kiwifruit and stone fruits are more often attacked by garden featherfoot (HortResearch, 1999b).

**Importation step 2  
(Imp2)**

**Extremely low**

The likelihood that picked apple fruit is infested with GFF: **Extremely low**.

- Larvae feed on the surface of fruit from within a silken shelter at the dying calyx while pupation occurs in a white silken cocoon, often attached to the surface of the fruit (Landcare Research, 1999).
- *Stathmopoda* species are occasional pests of apples in the north of New Zealand (HortResearch, 1999b).

**Importation step 3  
(Imp3)**

**Very low**

The likelihood that clean fruit is contaminated by GFF during harvesting and transport of apples to the packing house: **Very low**.

- Fruit are picked into harvesting bags and then transferred into bins kept on the ground in the orchard prior to transportation to the packing house.
- Garden featherfoot is only an occasional pest of apples in the North Island of New Zealand (HortResearch, 1999b).
- Larvae are occasionally found underneath a silken shelter in the calyx or stem-end of apples (HortResearch, 1999b) suggesting that the larvae would not be dislodged during harvesting.

**Importation step 4  
(Imp4)**

**Very low**

The likelihood that GFF survives routine processing procedures in the packing house: **Very low**.

The following packing house operations may influence the survival of GFF.

*Washing*

- Landcare Research (1999) indicate that pupa is in a white silken cocoon on surface of the fruit or the larva feeds on the surface of fruit from a silken shelter under the dying calyx. High volume/high pressure wash would be able to remove some pupae or larvae.

*Brushing*

- Pupae or larvae on surface of the fruit can be brushed off.

*Waxing*

- Any remaining larva and pupa would be able to survive the waxing.

*Sorting and grading*

- Pupae in silken cocoons and the silken shelters of larvae are highly visible, and are likely to be noticed and discarded during the sorting and grading process.

*Packaging*

- Packaging would have little affect on the viability of the remaining pupae and larvae. In most cases the packaging of apples is designed to maximise heat discharge from the fruit while minimising loss of moisture.

*Cold Storage*

- Landcare Research (1999) state that larvae diapause over winter in a cocoon and pupate in spring. This suggests that larvae are able to survive cold storage prior to transportation.

*Summary*

Washing, sorting and grading would remove pupae or larvae on surface of the fruit.

**Importation step 5  
(Imp5)**

**Negligible**

The likelihood that clean fruit is contaminated by GFF during processing in the packing house: **Negligible**.

- Larvae or pupae dislodged during processing would not contaminate more clean fruit.

**Importation step 6  
(Imp6)**

**High**

The likelihood that GFF survives palletisation, quality inspection, containerisation and transportation to Australia: **High**.

- The fact that larvae diapause over winter in a cocoon suggests that they are able to survive the cold conditions during transportation.

**Importation step 7  
(Imp7)**

**Negligible**

The likelihood that clean fruit is contaminated by GFF during palletisation, quality inspection, containerisation and transportation: **Negligible**.

- Larvae that have spun their cocoons on apple fruit for pupation would not leave that fruit to contaminate other apple fruit.
- Any pupae dislodged during quality inspection would be unable to attach to other fruit.

**Importation step 8  
(Imp8)**

**High**

The likelihood that GFF survives and remains with fruit after on-arrival minimum border procedures: **High**.

- The minimum border procedures as described in the method section would not be effective in detecting the larvae or pupae of GFF.

***Conclusions—probability of importation***

When the above likelihoods were inserted into the simulation model, the probability of importation of GFF from one year of trade was found to be **extremely low**.

**Probability of distribution**

The initiating step for the distribution scenario is the release of imported apples from the port of entry, while the last step is the pest being distributed (as a result of the processing, sale or disposal of these apple fruit) in a viable state to an endangered area and subsequently being exposed to a suitable host.

In order to assess the probability of distribution, the distribution scenario is addressed in the three subheadings below. First is a brief description of sequences of events leading to a successful exposure of the pest from infested/infected apple to a susceptible host plant. Second is the assessment of partial probability of distribution of the pest in relation to each of the exposure groups. Third is the conclusion for the probability of distribution.

***Sequence of events for successful exposure***

The sequence of events that has to be completed for a successful exposure of a susceptible host to the pest is summarised below.

The insect stage associated with the apple is the larvae or pupae on the surface of fruit. The only means for GFF to leave fruit or packaging and enter the environment of exposure groups are as adult flight after emergence from pupae. If mature larvae or pupae survive cold storage, adults would need to emerge from the pupal stage after the apples have been taken out of storage. The emergence could occur at unpacking and repacking facilities or retailers (utility

points), on discarded fruit in waste, at landfills where the waste is disposed, and during transportation of purchased apples from retailers to households.

Both the adult male and female have wings and are able to fly. Successful mating between a male and a female must occur before eggs are produced.

A successful exposure of GFF from infested fruit to the host means that the larvae would need to pupate, adult emerges from pupa and female mate with a male and lay her eggs on a susceptible host plant.

### ***Partial probability of distribution***

The partial probability of distribution (PPD) was estimated separately for each of the four exposure groups: commercial fruit crops; nursery plants; household and garden plants; and, wild and amenity plants.

The details and the method of calculation for the PPD of the four exposure groups are explained in the method section and the results are presented in a series of tables and figures below. The information from these tables and figures was used to assess the probability of distribution of GFF to all the exposure groups.

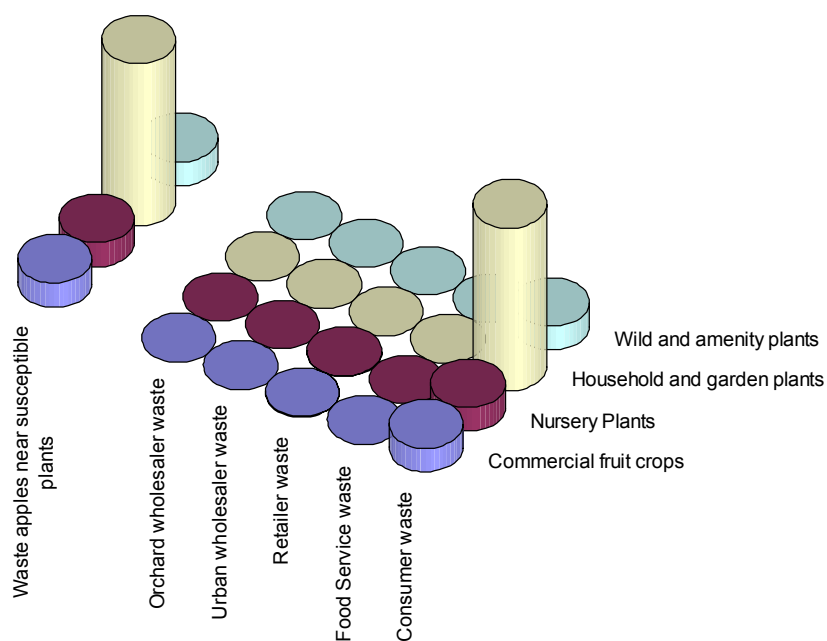
Table 44 indicates the proportions of the five utility points near each of the exposure groups of GFF. Apple, kiwifruit and stone fruits have been reported as the hosts for GFF. This species is probably polyphagous.

**Table 44 The proportions of utility points near host plants susceptible to garden featherfoot in the four exposure groups**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Proximity</b> Orchard wholesalers	Certain	Extremely Low	Extremely Low	Extremely Low
<b>Proximity</b> Urban wholesalers	Extremely Low	Extremely Low	Extremely Low	Extremely Low
<b>Proximity</b> Retailers	Very Low	Very Low	Extremely Low	Extremely Low
<b>Proximity</b> Food services	Extremely Low	Extremely Low	Extremely Low	Extremely Low
<b>Proximity</b> Consumers	Very Low	Very Low	Low	Very Low

Figure 20 gives a pictorial representation of the relative amounts of infested/infected apples, an escaped pest or contaminated packaging material discharged or discarded from different utility points near each of the exposure groups of garden featherfoot.

**Figure 20 Pictorial representation of the relative amounts of infested/infected apple waste<sup>34</sup> from utility points to near exposure groups of garden featherfoot**



<sup>34</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or an escaped pest, or contaminated packaging material.

Table 45 is the summary of the probability that exposure of the host plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points. Evidence is provided in the text below under different exposure groups.

**Table 45 The probability of exposure of susceptible host plants of garden featherfoot from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Exp</b> Orchard <sup>35</sup> wholesaler waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Urban wholesaler waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Retailer waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Food service waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Consumer waste	Negligible	Negligible	Negligible	Negligible

#### *Commercial fruit crops*

##### *Commercial fruit crops near utility points*

The proportions of the five utility points near commercial fruit crops of GFF are shown in Table 44. It was estimated that commercial fruit crops are certain to be located near all orchard wholesalers, very unlikely to be near retailers and consumers, and extremely unlikely to be near urban wholesalers and food service as most of these are in metropolitan areas.

The relative amounts of infested/infected apples, or pests, or contaminated packaging material discharged or discarded from different utility points to near commercial fruit crops susceptible to garden featherfoot is indicated in Figure 20.

##### *Exposure to host*

The commercial crops of GFF are apple, kiwifruit and stone fruits.

A successful exposure from garden featherfoot from infested fruit means that mature larvae need to pupate, pupa need to develop to become adults, and adult females need to locate a male to mate with, and to lay their eggs on a susceptible host plant. The chance for this to happen depends on several factors, including mortality of larvae and pupae, level of

<sup>35</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or an escaped pest, or contaminated packaging material.

infestation/infection and number of apples in the same utility points, availability and susceptibility of hosts and life span of the pest.

As shown in Table 45, it is considered that the probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** commercial fruit crops  
from orchard wholesaler waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**.

- Host plants such as apple, kiwifruit and stone fruit trees are readily available in commercial orchards.

**Exp** commercial fruit crops  
from urban wholesaler waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**.

- Commercial fruit crops are not located in urban areas.
- Urban wholesaler waste is disposed into bins and taken to landfills. Commercial fruit crops are unlikely to be near these sites.

**Exp** commercial fruit crops  
from retailer waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**.

- Most retailers are located in urban areas not close to commercial fruit crops.
- Retailer waste may be used for composting in rural areas and some of these sites may be near commercial orchards.

**Exp** commercial fruit crops  
from food service waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**.

- Most food services are located in urban areas not close to commercial fruit crops.
- Food service industry waste is disposed into bins and taken to landfills. Commercial fruit crops are unlikely to be near these sites.

**Exp** commercial fruit crops  
from consumer waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**.

- The majority of consumers are located in metropolitan and suburban areas. Waste produced by people in metropolitan areas and some in urban areas is generally disposed into landfills. Commercial fruit crops would usually not be near



these sites.

- Households and population densities around commercial orchards are very low.
- Some consumer waste in suburban and rural areas may be utilised for composting. Commercial fruit crops can be present close to compost heaps.

### *Nursery plants*

#### *Nursery plants near utility points*

The proportions of the five utility points near nursery plants of GFF are shown in Table 44. It was estimated that nursery plants are very unlikely to be near orchard wholesalers, retailers and consumers, and extremely unlikely to be near urban wholesalers and food services.

The relative amounts of infested/infected apples, or pests, or contaminated packaging material discharged or discarded from different utility points to near nursery plants susceptible to garden featherfoot is indicated in Figure 20.

#### *Exposure to host*

The nursery plants susceptible to GFF are apple, kiwifruit and stone fruits.

A successful exposure from garden featherfoot from infested fruit means that mature larvae need to pupate, pupa need to develop to become adults, and adult females need to locate a male to mate with, and to lay their eggs on a susceptible host plant. The chance for this to happen depends on several factors, including mortality of larvae and pupae, level of infestation/infection and number of apples in the same utility points, availability and susceptibility of hosts and life span of the pest.

As shown in Table 45, it is considered that the probability that exposure of nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** nursery plants from  
orchard wholesaler waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**.

- Nurseries would be located near wholesaler waste disposal sites.

**Exp** nursery plants from urban  
wholesaler waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**.

- There are rare instances of nurseries being located near to urban waste dumps.

**Exp** nursery plants from retailer  
waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**.

- Apple, kiwifruit and stone fruit nursery plants are for sale in major retail outlets.
- Host plants such as apple and stone fruits are common plants in nurseries in the temperate regions of Australia, particularly during the dormant period over winter and to a limited extent during the spring and summer months.
- Retail garden nurseries have a high density of a range of plant materials in a small area. They often maintain a high hygienic standard, usually fogging with insecticide, to prevent insect attacks.
- A number of fresh food markets will have nursery plants near apple fruit. However, there are a limited number of nurseries associated with fresh food markets that also maintain or store actively growing apple or stone fruit trees.

**Exp** nursery plants from food  
service waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**.

- Most food service industries are located in urban areas. There are instances of nurseries being located near food services.
- However, food service industry waste is disposed into bins and taken to landfills. Nursery plants are unlikely to be near these sites.

**Exp** nursery plants from  
consumer waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**.

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. Nurseries are generally not located near these sites.

### *Household and garden plants*

#### *Household and garden plants near utility points*

The proportions of the five utility points near household and garden plants of GFF are shown in Table 44. It was estimated that household and garden plants are unlikely to be near consumers, very unlikely to be near orchard wholesalers, and extremely unlikely to be near urban wholesalers, retailers and food services.

The relative amounts of infested/infected apples, or pests, or contaminated packaging material discharged or discarded from different utility points to near garden plants susceptible to garden featherfoot is indicated in Figure 20.

*Exposure to host*

The household or garden plants susceptible to GFF are apple, kiwifruit and stone fruits.

A successful exposure from garden featherfoot from infested fruit means that mature larvae need to pupate, pupa need to develop to become adults, and adult females need to locate a male to mate with, and to lay their eggs on a susceptible host plant. The chance for this to happen depends on several factors, including mortality of larvae and pupae, level of infestation/infection and number of apples in the same utility points, availability and susceptibility of hosts and life span of the pest.

As shown in Table 45, it is considered that the probability that exposure of household and garden plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** household and garden  
plants from orchard wholesaler  
waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**.

- Orchard wholesaler waste sites are mostly located within the orchard premises and are not located near household and garden plants.

**Exp** household and garden  
plants from urban wholesaler waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**.

- Urban wholesaler waste is disposed into landfill sites that are generally not near residential properties.

**Exp** household and garden  
plants from retailer waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**.

- Retailer waste would be disposed to landfills that are generally not near residential properties.

**Exp** household and garden  
plants from food service waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**.

- Food services industries are unlikely to have host plants susceptible to GFF within their premises.
- Waste from food services is disposed into landfill sites.

**Exp** household and garden  
plants from consumer waste  
**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**.

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. However, local authorities are now encouraging composting of food waste in suburban backyards rather than disposing of all waste into landfill.
- Utilisation of waste to make compost is becoming a common practice in some suburban and rural households.
- Most consumers in metropolitan and suburban areas dispose of their waste to landfills that are generally not near household and garden plants.
- Apple is commonly grown as a garden plant in the temperate regions of Australia. Several hosts of GFF are commonly found in backyard gardens in the temperate regions of Australia.

*Wild and amenity plants*

*Wild and amenity plants near utility points*

The proportions of the five utility points near wild and amenity plants of GFF are shown in Table 44. It was estimated that wild and amenity plants are unlikely to be near consumers, very unlikely to be near orchard wholesalers, and extremely unlikely to be near urban wholesalers, retailers and food services.

The relative amounts of infested/infected apples, an escaped pest, or contaminated packaging material discharged or discarded from different utility points to near wild and amenity plants susceptible to garden featherfoot is indicated in Figure 20.

*Exposure to host*

Wild and amenity plants susceptible to GFF are apple, kiwifruit and stone fruits.

A successful exposure from garden featherfoot from infested fruit means that mature larvae need to pupate, pupa need to develop to become adults, and adult females need to locate a male to mate with, and to lay their eggs on a susceptible host plant. The chance for this to happen depends on several factors, including mortality of larvae and pupae, level of infestation/infection and number of apples in the same utility points, availability and susceptibility of hosts and life span of the pest.

As shown in Table 45, it is considered that the probability that exposure of amenity plants would result from discharge or discard of either a single infested/infected apple, pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** wild and amenity plants  
from orchard wholesaler waste  
**Negligible**

The probability that exposure of susceptible wild and amenity plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**.

- Orchard wholesaler waste sites are mostly located within the orchard premises and are not located near wild and amenity plants.
- Susceptible feral plants (e.g. volunteer apple seedlings, etc.) may be present near orchard wholesaler's waste disposal sites.

**Exp** wild and amenity plants  
from urban wholesaler waste  
**Negligible**

The probability that exposure of susceptible wild and amenity plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**.

- Urban wholesale waste is disposed at landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds (e.g. apple seedlings).

**Exp** wild and amenity plants  
from retailer waste  
**Negligible**

The probability that exposure of susceptible wild and amenity plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**.

- Retailer waste would be disposed to landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds (e.g. apple seedlings).

**Exp** wild and amenity plants  
from food service waste  
**Negligible**

The probability that exposure of susceptible wild and amenity plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**.

- Food services would dispose their waste into landfills. Seedlings originating from seeds dispersed by birds would be present.

**Exp** wild and amenity plants  
from consumer waste  
**Negligible**

The probability that exposure of susceptible wild and amenity plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**.

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds (e.g. apple seedlings).
- Consumers discard apple cores into the environment or into bins in parks. Bins for waste in parks may not be removed on a daily basis and these would provide a sheltered environment for the insect to emerge before the fruit desiccates or decays.
- Seedlings and apple and other hosts could establish from discarded spoilt fruit or core as waste. However, population densities of susceptible wild and amenity apple plants in parks,

near recreational facilities and along roadsides may be low.

- Consumers who consider apple cores to be biodegradable may indiscriminately discard them into the environment. Spoilt apples or cores discarded into the wild are likely to be isolated.

### **Conclusion—probability of distribution**

The partial probability of distribution from each of the utility points to each of the exposure groups is summarised in Table 46. These were calculated by the simulation model using @risk. The quantitative model evaluated the effect of the ‘volume of trade’ during a specified period when calculating the partial probability of distribution.

**Table 46 Partial probabilities of distribution (PPD)<sup>36</sup> for garden featherfoot**

UTILITY POINTS	PPD			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Orchard wholesalers</b>	Negligible	Negligible	Negligible	Negligible
<b>Urban wholesalers</b>	Negligible	Negligible	Negligible	Negligible
<b>Retailers</b>	Extremely low	Extremely low	Negligible	Negligible
<b>Food services</b>	Negligible	Negligible	Negligible	Negligible
<b>Consumers</b>	Very low	Very low	Very low	Very low
<b>Overall PPD</b>	Very low	Very low	Very low	Very low

### **Probability of establishment or spread**

The assessment for the probability of establishment or spread is carried out in the following manner. Firstly, partial probability for establishment and for spread was assessed separately based on the relevant available scientific information. Secondly, the conclusions for the combined partial probability of establishment or spread for each of the four exposure groups are provided at the end of this section. The relevant information for the assessment for the probability of establishment or spread is presented below against the factors listed in ISPM 11, Rev. 1.

<sup>36</sup> Partial probability of distribution is actually referring to the probability of entry and was estimated by @risk.

***Partial probability of establishment***

ISPM 11 factor	Relevant information
<b>Availability of suitable hosts, alternate hosts and vectors in the PRA area</b>	<ul style="list-style-type: none"> <li>• Apple, kiwifruit and stone fruits are the only known hosts of GFF but it is probably polyphagous.</li> <li>• Commercial crops such as apples are grown in all States and Territories in Australia, except in the northern tropical regions. Apples are also found and grown in suburban backyards in temperate Australia.</li> </ul>
<b>Suitability of the environment</b>	<ul style="list-style-type: none"> <li>• GFF is native to New Zealand where climatic conditions are similar to those in Australia.</li> <li>• Apples are not grown in protected environments such as in glasshouses.</li> </ul>
<b>The potential for adaptation of the pest</b>	<ul style="list-style-type: none"> <li>• The potential for adaptation of the pest is not known. However, host plants are present in Australia.</li> </ul>
<b>The reproductive strategy of the pest</b>	<ul style="list-style-type: none"> <li>• There is limited information on the biology of GFF.</li> <li>• Successful mating between a male and a female must occur before eggs are produced.</li> </ul>
<b>Minimum population needed for establishment</b>	<ul style="list-style-type: none"> <li>• A population can be established from eggs laid by a mated female.</li> </ul>
<b>Cultural practices and control measures</b>	<ul style="list-style-type: none"> <li>• Integrated Pest Management (IPM) programs are utilised in the production of apples in Australia.</li> </ul>

***Conclusion—partial probability of establishment***

Based on the above evidence, partial probability of establishment for each of the exposure groups is assessed as follows.

Partial probability of establishment for commercial fruit crops: **High**.

Partial probability of establishment for nursery plants: **High**

Partial probability of establishment for household and garden plants: **High**

Partial probability of establishment for wild and amenity plants: **High**

***Partial probability of spread***

ISPM 11 factor	Relevant information
<b>Suitability of natural and/or managed environment</b>	<ul style="list-style-type: none"> <li>• GFF is a native New Zealand moth that is generally distributed throughout the country (HortResearch, 1999b). There are similar environments in Australia that would be suitable for its spread.</li> </ul>

ISPM 11 factor	Relevant information
<b>Presence of natural barriers</b>	<ul style="list-style-type: none"> <li>The main Australian commercial apple, kiwifruit and stone fruit orchards are located in six States of Australia with natural barriers including arid areas, climatic differentials and long distances existing between these areas. It would be difficult for the adults to disperse from one area to another unaided.</li> <li>Other host plants available between the commercial apple orchards in different areas would help the spread of GFF.</li> <li>Both the adult male and female are winged and are capable of flight.</li> </ul>
<b>Potential for movement with commodities or conveyances</b>	<ul style="list-style-type: none"> <li>A mixture of adult flight and the transportation of infested apple trees have probably aided the movement of GFF within orchards.</li> <li>The dispersal would result from the movement of larvae or pupae on the surface of the fruit.</li> <li>Existing interstate quarantine control on the movement of nursery stock would reduce the scope for spread of GFF.</li> </ul>
<b>Intended use of the commodity</b>	<ul style="list-style-type: none"> <li>Apples would be used mostly for consumption by humans and would be widely distributed around the States.</li> <li>If larvae or pupae have contaminated the fruit, they will be distributed with the commodity around the country.</li> </ul>
<b>Potential vectors of the pest</b>	<ul style="list-style-type: none"> <li>GFF does not require a vector for its spread since it is capable of independent flight.</li> </ul>
<b>Potential natural enemies</b>	<ul style="list-style-type: none"> <li>The relevance of potential natural enemies in Australia is not known.</li> </ul>

*Conclusion—partial probability of spread*

Based on the above evidence, partial probability of spread for each of the exposure groups is assessed as follows.

Partial probability of spread for commercial fruit crops: **High**.

Partial probability of spread for nursery plants: **High**.

Partial probability of spread for household and garden plants: **High**.

Partial probability of spread for wild and amenity plants: **High**.

***Combined partial probability of establishment or spread***

The combined partial probability of establishment or spread was determined by combining probabilities of establishment and probabilities of spread using the matrix of 'rules' for combining descriptive likelihoods as presented in the method section. The results are indicated in Table 47.



**Table 47 Combined partial probabilities of establishment or spread of garden featherfoot**

	<b>Commercial fruit crops</b>	<b>Nursery plants</b>	<b>Household and garden plants</b>	<b>Wild and amenity plants</b>
<b>Establishment</b>	High	High	High	High
<b>Spread</b>	High	High	High	High
<b>PPES<sup>37</sup></b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>High</b>

Additional evidence to support the combined partial probability of establishment or spread for specific exposure groups is provided in the text below.

<b>Commercial fruit crops</b> <b>High</b>	<ul style="list-style-type: none"> <li>Commercial apple, kiwifruit and stone fruit are grown in many parts of Australia.</li> </ul>
<b>Nursery plants</b> <b>High</b>	<ul style="list-style-type: none"> <li>Apple, kiwifruit and stone fruits are known hosts of GFF.</li> <li>A mixture of adult flight and the transportation of infested apple trees have probably aided the movement of GFF within orchards.</li> </ul>
<b>Household and garden plants</b> <b>High</b>	<ul style="list-style-type: none"> <li>The establishment of GFF in susceptible household and garden plants will be largely dependent on: (1) the availability of a limited number of hosts plants; (2) the extent of Australian households growing backyard apple trees and other host plants; and, (3) the willingness of suburban gardeners to adequately control pests and diseases on their apple trees.</li> <li>Climatic limits and the extent of apple trees, including crab apple trees, in suburban backyards can have an effect on the establishment or spread of GFF. GFF can fly short distances unaided, but is endemic to New Zealand and has not spread any further. It was considered that GFF could spread within Australia following establishment in exposed household and garden plants.</li> </ul>
<b>Wild and amenity plants</b> <b>High</b>	<ul style="list-style-type: none"> <li>Since GFF is a temperate insect, climatic factors would affect its establishment or spread.</li> <li>Even though GFF is capable of short flight, wild host plants trees are not as prevalent across the country as apple or stone fruit trees in a commercial or household situation. This means that GFF will require some assistance to spread from one wild plant to another.</li> </ul>

<sup>37</sup> PPES = partial probability of establishment or spread.

## Assessment of consequences

Impact scores allocated for the direct and indirect criteria are shown in Table 48. Available supporting evidence is provided in the text below.

**Table 48 Impact scores for garden featherfoot**

Direct impact	Impact scores
Plant life or health	D
Human life or health	A
Any other aspects of environment	A
Indirect impact	
Control or eradication	D
Domestic trade or industry	D
International trade	D
Environment	B
Communities	A

### Direct impact

- Plant life or health – D** Consequences affecting plant life or health are unlikely to be discernible at the national level and of minor significance at the regional level. A rating of ‘D’ was assigned to this criterion.
- GFF attacks commercial crops such as apple, kiwifruit and stone fruits.
- Human life or health – A** There are no known direct impacts of GFF on human life or health and the rating assigned to this criterion was therefore ‘A’.
- Any other aspects of environmental effects – A** There is no known direct impact of GFF on any other aspects of the environment and a rating of ‘A’ was assigned to this criterion.

### Indirect impact

- Control or eradication – D** The indirect impact on new or modified eradication, control, surveillance/monitoring and compensation strategies is unlikely to be discernible at the national level and of minor significance at the regional level. A rating of ‘D’ was assigned to this criterion.
- An increase in the use of insecticides for its control because of difficulties estimating the optimum time for insecticide application.
  - Disruption to IPM programs because of the need to re-introduce or increase the use of organophosphate insecticides.

	<ul style="list-style-type: none"> <li>• Subsequent increase in cost of production to producers.</li> <li>• Damage to leaves would provide entry courts for the entry of plant pathogens.</li> <li>• Increased costs for crop monitoring and consultant's advice to the producer.</li> </ul>
<b>Domestic trade or industry – D</b>	<p>The indirect consequences on domestic trade are unlikely to be discernible at a national level and would be of minor significance at the regional level. A rating of 'D' was assigned to this criterion.</p> <p>The presence of GFF on commercial apple crops could result in:</p> <ul style="list-style-type: none"> <li>• trade restrictions in the sale or movement of fruit within that district and region and between States; and,</li> <li>• consumer expectations and aesthetics ranging from the acceptance of fruit that is slightly affected to outright rejection of imperfect fruit.</li> </ul>
<b>International trade – D</b>	<p>The indirect consequences on international trade are unlikely to be discernible at a national level and would be of minor significance at the regional level. A rating of 'D' was assigned to this criterion.</p> <ul style="list-style-type: none"> <li>• If GFF became established in Australia, our trading partners such as Japan would reject consignments of apples infested with GFF.</li> </ul>
<b>Environment – B</b>	<p>The indirect consequences on the environment would not be discernible at the national level and would be of minor significance at the local level and a rating of 'B' was assigned to this criterion.</p> <ul style="list-style-type: none"> <li>• Increased insecticide use could cause undesired effects on the environment.</li> <li>• The introduction of new biocontrol agents could affect existing biological control programs.</li> <li>• Host plants of the GFF are apples, kiwifruit and stone fruits. Commercial apples are grown in six States in Australia under intensive cultivation, so there would be little effect on designated environmentally sensitive or protected areas because few apple trees grow or are allowed to continue to grow in such areas.</li> </ul>
<b>Communities – A</b>	<ul style="list-style-type: none"> <li>• The presence of GFF would have limited social effects, if any, and a rating of 'A' was assigned to this criterion.</li> </ul>

### ***Conclusion—consequences***

Based on the decision rule described in the method section, i.e. where the consequences of a pest with respect to one or more criteria are 'D', the overall consequences are considered to be 'low'. Therefore the overall consequences of GFF are **low**.

### **Unrestricted annual risk**

Unrestricted annual risk is the results of combining annual probability of entry, establishment or spread with the outcome of overall consequences. Probabilities and consequences are

combined using the ‘rules’ shown in the risk estimation matrix in the method section. The unrestricted annual risk estimation for GFF is shown in Table 49.

**Table 49 Risk estimation for garden featherfoot**

Overall probability of entry, establishment or spread <sup>38</sup>	<b>Very low</b>
Consequences	<b>Low</b>
Unrestricted annual risk	<b>Negligible</b>

As indicated in Table 49, the unrestricted annual risk for garden featherfoot is negligible, which is below Australia’s appropriate level of protection (ALOP) of very low. Therefore, risk management would not be required for this pest.

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<sup>38</sup> Calculated by @ risk.

## **Grey-brown cutworm**

### **Biology**

The grey-brown cutworm (GBC), *Graphania mutans* Walker, has four life stages: adult, egg, larva (or caterpillar) and pupa.

Eggs are cream to yellow in colour and are laid in batches on leaves or sometimes under the calyxes of apple fruit. The hatching caterpillars disperse to feed on the foliage for a short time before descending to the orchard understorey. Egg batches are also sometimes laid on the fruit close to harvest (HortResearch, 1999b).

Newly hatched larvae are pale yellow in colour with distinct black spots and covered in stiff, erect hairs. Larvae continue to feed on foliage of host trees until fully grown (Landcare Research, 1999). However, HortResearch (1999b) states that most of the young caterpillars of *G. mutans* descend from the trees to the ground cover of the orchard after a short time, where they feed on a variety of pasture plants. *G. mutans* caterpillars, which were artificially prevented from their normal behaviour of descending to the orchard understorey, cause considerable damage to the surface of apple fruit (HortResearch, 1999b). Mature larvae are approximately 25 mm long, light to dark brown in colour with a broken, white longitudinal stripe down each side (Landcare Research, 1999).

Other information relevant in the biology of GBC is available in the datasheet in Appendix 3 in Part B.

### **Risk scenario**

The risk scenario of concern for GBC in this IRA are firstly that its eggs can be laid on the fruit and secondly larvae can feed on the surface of fruit.

## Probability of importation

The initiating step for the importation scenario for apple fruit is the sourcing of apples from orchards in New Zealand, while the end-point is the release of imported apples from the port of entry. The importation scenario is divided into eight steps and the likelihood of the GBC being present at each step is summarised in Figure 21. The available evidence supporting the likelihood assessments is provided in the text below.

**Figure 21 The importation steps and the likelihood of the grey-brown cutworm being present at each step**



# Importation step 1 (Imp1)

Low

The likelihood that the GBC is present in the source orchards in New Zealand: **Low**.

- Larval damage and egg deposition of GBC occurs in all New Zealand's apple growing regions, with varying frequency (Burnip *et al.*, 1995).
- Orchards surrounded by diverse land uses other than pasture land particularly irrigated pasture have the lowest incidence of GBC (Burnip *et al.*, 1995).
- This pest is primarily a pasture species, but sometimes it can also attack apple (HortResearch, 1999b).
- In a comparison of three fruit production systems: organic production (OP), integrated fruit production (IFP) and biological fruit production (BFP), no significant difference in the overall level of damage (3-6 %) was found (Wearing, 1996).
- Research from the late 1980's indicates that noctuid larval feeding damage immediately post-flowering accounted for 3-7% of fruit rejected at harvest in Canterbury, Nelson and Hawke's Bay (Burnip *et al.*, 1995).
- In a research project comparing three different fruit production systems (OP, IFP, BFP) in a central Otago research orchard some cultivars had more noctuid moth damage than others (Wearing, 1996).
- Noctuid larval feeding can typically damage 2-6% of young fruitlets from late bloom in export orchards and this damage can increase to more than 10% when fruitlets are left unprotected for long periods in early summer (Wearing *et al.*, 1994).

## Summary

Based on the above information that GBC occurs in all New Zealand's apple growing regions and overall damage was 3-6 %, the likelihood for Imp1 was assessed as low.

# Importation step 2 (Imp2)

Very low

The likelihood that picked apple fruit is infested with GBC: **Very low**.

- Egg batches are laid on leaves and the hatching larvae disperse to feed on foliage for a short time in spring. Most of the young caterpillars then descend from the trees to the orchard understorey where they feed on a variety of ground cover plants.
- Eggs can be laid on any convenient object in the orchard and sometimes on the fruits close to harvest, particularly under the calyx. HortResearch (1999b) and Wearing *et al.* (1994) state that 'Presence of eggs on the fruits at harvest is a potential quarantine problem for export of organic apples, although the incidence appears to be rare.'

- Larval damage to the fruit is considerable, unmistakable (HortResearch, 1999b).

*Summary*

- Based on the above information that the incidence of eggs on the fruits at harvest is rare, the likelihood for Imp2 was assessed as very low.

**Importation step 3  
(Imp3)**

**Extremely low**

The likelihood that clean fruit is contaminated by GBC during harvesting and transport of apples to the pack house: **Extremely low.**

- Fruit are picked into harvesting bags and then transferred into bins kept on the ground in the orchard prior to transportation to the pack house.
- Since noctuid larvae are only on the apple tree for a short time post flowering before descending to the orchard understorey to complete their development, clean fruit picked at harvest would rarely be contaminated with larvae.
- Eggs would not be able to contaminate clean fruit.

*Summary*

Based on the above information,, the likelihood for Imp3 was assessed as extremely low.

**Importation step 4  
(Imp4)**

**Very low**

The likelihood that GBC survives routine processing procedures in the pack house: **Very low.**

The following pack house operations may influence the viability of GBC.

*Washing*

- The larvae only feed on the surface of the fruit and would be washed off in the water dump and/or by the high-volume/high pressure washing.
- Most eggs would be washed off but some eggs would survive the washing if they are in the calyx.

*Brushing*

- Egg batches under the calyx are not likely to be brushed off.

*Waxing*

- Any remaining eggs would be able to survive the waxing.

*Sorting and grading*

- Larval damage to the fruit is considerable and unmistakable (HortResearch, 1999b). Damaged fruit would be noticed and discarded.
- Egg batches under the calyx of apple can escape detection.



### *Packaging*

- Packaging would have little affect on the viability of the remaining eggs. In most cases the packaging of apples is designed to maximise heat discharge from the fruit while minimising loss of moisture.

### *Cold Storage*

- There is no data available on the impact of cold storage on the viability of the eggs on apple fruit. However, Burnip *et al.* (1995) indicate that the interception of noctuid egg batches on fruit by quarantine inspectors has been of greater importance to the apple industry since this can result in the rejection of export consignments, implying that the eggs, if present on the apple fruit, can survive the packing house process including cold storage.

### *Summary*

Based on the above information that the packing house procedure would remove larvae and most eggs, the likelihood for Imp4 was assessed as very low.

#### **Importation step 5 (Imp5)**

**Negligible**

The likelihood that clean fruit is contaminated by GBC during processing in the pack house: **Negligible**

- The large size of larvae remaining on the fruit suggests they will be dislodged during processing and will attempt to escape the water to find a drier place.
- Eggs dislodged during pack house operations will not reattach to other clean fruit, as they are not capable of movement.

### *Summary*

Based on the above information, the likelihood for Imp5 was assessed as negligible.

#### **Importation step 6 (Imp6)**

**High**

The likelihood that GBC survives palletisation, quality inspection, containerisation and transportation to Australia: **High**.

- Palletisation, quality inspection and containerisation can have little impact on any egg batches although quality inspection would be able to detect the damaged fruit.
- During the 1992-93 season, noctuid egg batches were detected on export fruit to USA from both Hawke's Bay and Nelson (Burnip *et al.*, 1995).
- This species has been detected during preclearance of NZ apples to USA (MAFNZ, 2003b) at a rate of 0.37 per million fruit inspected.
- U.S. Department of Agriculture interception data (USDA-APHIS, 2003) suggest that at least some noctuid eggs have escaped detection.
- There is no data available on the impact of cold storage during

transportation on the viability of GBC eggs on apple fruit.

#### *Summary*

Based on the above information that the species was detected at preclearance or port of entry, the likelihood for Imp6 was assessed as high.

**Importation step 7  
(Imp7)  
Negligible**

The likelihood that clean fruit is contaminated by GBC during palletisation, quality inspection, containerisation and transportation: **Negligible**

- Remaining eggs are not likely to hatch at transportation temperature so are unable to contaminate clean fruit.

**Importation step 8  
(Imp8)  
High**

The likelihood that GBC survives and remains with fruit after on-arrival minimum border procedures: **High**.

- The minimum border procedures as described in the method section would not effective in detecting the eggs.

#### ***Conclusions—probability of importation***

When the above likelihoods were inserted into the simulation model, the probability of importation of GBC from one year of trade was found to be **Extremely low**.

#### **Probability of distribution**

The initiating step for the distribution scenario is the release of imported apples from the port of entry, while the last step is the pest being distributed (as a result of the processing, sale or disposal of these apple fruit) in a viable state to an endangered area and subsequently being exposed to a suitable host.

In order to assess the probability of distribution, the distribution scenario is addressed in three subheadings below. First is a brief description of sequences of events leading to a successful exposure of the pest from infested/infected apple to a susceptible host plant. Second is the assessment of partial probability of distribution of the pest in relation to each of the exposure groups. Third is the conclusion for the probability of distribution.

#### ***Sequence of events for successful exposure***

The sequence of events that has to be completed for a successful exposure of a susceptible host to the pest is summarised below.

The insect stages associated with the apple fruit are eggs laid under the fruit calyx. When imported apples are taken out of storage the only means for GBC to leave fruit or packaging and enter the environment of exposure groups are as larvae hatching from eggs. The handling and consumption of the apple fruit would increase the mortality of the eggs. If they survive the handling and consumption process, the eggs need to hatch. GBC would be able to enter the environment whenever larvae hatch from eggs: during packing or unpacking of the fruit, from repacking facilities or retailers, from discarded fruit in waste, and from landfills where the waste is disposed. To survive, the larvae must find suitable host plant foliage to feed on, though they can feed on the surface of apple fruit under artificial conditions. In the field, recently hatched larvae normally feed on foliage for a short time in spring (HortResearch,

1999b) before descending from the trees to the ground cover of the orchard, where they feed on a variety of pasture plants before pupating within a cell in the soil. In retailer premises and on waste, larvae would find it very difficult to find a suitable host to complete their development.

A successful exposure of GBC to the host means that the hatched larvae would need to move onto a susceptible host plant by crawling.

### ***Partial probability of distribution***

The partial probability of distribution (PPD) was estimated separately for each of the four exposure groups: commercial fruit crops; nursery plants; household and garden plants; and, wild and amenity plants.

The details and the method of calculation for the PPD of the four exposure groups are explained in the method section and the results are presented in a series of tables and figures below. The information from these tables and figures was used to assess the probability of distribution of GBC to all the exposure groups.

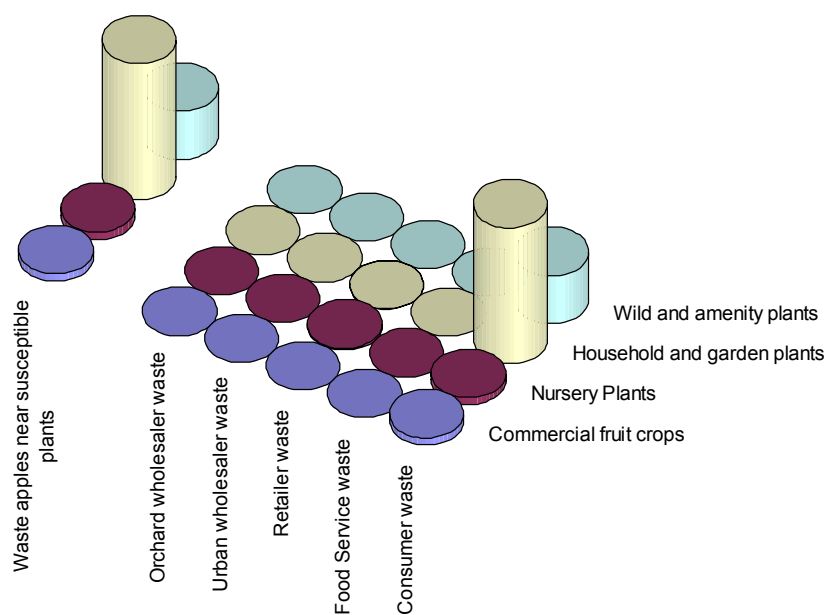
Table 50 indicates the proportions of the five utility points near each of the exposure groups of GBC. Apple and wheat are the main commercial hosts, but GBC also attacks garden pea and plantain (*Plantago* spp.), and is polyphagous on a wide range of dicotyledonous herbaceous plants, but rarely on grasses.

**Table 50 The proportions of utility points near host plants susceptible to grey-brown cutworm in the four exposure groups**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Proximity</b> Orchard wholesalers	Certain	Very Low	Very Low	Very Low
<b>Proximity</b> Urban wholesalers	Extremely Low	Extremely Low	Extremely Low	Extremely Low
<b>Proximity</b> Retailers	Very Low	Low	Very Low	Very Low
<b>Proximity</b> Food services	Extremely Low	Extremely Low	Extremely Low	Extremely Low
<b>Proximity</b> Consumers	Very Low	Very Low	Moderate	Low

Figure 22 gives a pictorial representation of the relative amounts of infested/infected apples, an escaped pest or contaminated packaging material discharged or discarded from different utility points near each of the exposure groups of GBC.

**Figure 22 Pictorial representation of the relative amounts of infested/infected apple waste<sup>39</sup> from utility points to near exposure groups of grey-brown cutworm**



<sup>39</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or an escaped pest, or contaminated packaging material.

Table 51 is the summary of the probability that exposure of the host plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points. Evidence is provided in the text below under different exposure groups.

**Table 51 The probability of exposure of susceptible host plants of grey-brown cutworm from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Exp</b> Orchard <sup>40</sup> wholesaler waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Urban wholesaler waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Retailer waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Food service waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Consumer waste	Negligible	Negligible	Negligible	Negligible

### *Commercial fruit crops*

#### *Commercial fruit crops near utility points*

The proportions of the five utility points near commercial fruit crops of GBC are shown in Table 50. It was estimated that commercial fruit crops are certain to be located near all orchard wholesalers, very unlikely to be near retailers and consumers, and extremely unlikely to be near urban wholesalers and food service as most of these are in metropolitan areas.

The relative amounts of infested/infected apples, or pests, or the amount of contaminated packaging material discharged or discarded from different utility points near commercial fruit crops susceptible to GBC is indicated in Figure 22.

#### *Exposure to host*

The commercial crops of GBC include apple and wheat.

A successful exposure to susceptible hosts requires hatched larvae to crawl onto a susceptible host plant. The chance for this to happen depends on several factors, including mortality of larvae, level of infestation/infection and number of apples in the same utility points, availability and susceptibility of hosts and life span of the pest.

<sup>40</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or an escaped pest, or contaminated packaging material.

As shown in Table 51, it was considered that the probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** commercial fruit crops  
from orchard wholesaler waste

**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Host plants such as apple and wheat are readily available as commercial crops in Australia.

**Exp** commercial fruit crops  
from urban wholesaler waste

**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

- Commercial fruit crops are not located in urban areas.
- Urban wholesaler waste is disposed into bins and taken to landfills. Commercial fruit crops are unlikely to be near these sites.

**Exp** commercial fruit crops  
from retailer waste

**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Most retailers are located in urban areas and are not close to commercial fruit crops.
- Retailer waste may be used for composting in rural areas and some of these sites may be near commercial orchards.

**Exp** commercial fruit crops  
from food service waste

**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Most food service industries are located in urban areas and are not close to commercial fruit crops.
- Food service industry waste is disposed into bins and taken to landfills. Commercial fruit crops are unlikely to be near these sites.

**Exp** commercial fruit crops  
from consumer waste

**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- The majority of consumers are located in metropolitan and suburban areas. Waste produced by people in metropolitan areas and some in urban areas is generally disposed into landfills. Commercial fruit crops would usually not be near these sites.
- Households and population densities around commercial

orchards are very low.

- Some consumer waste in suburban and rural areas may be utilised for composting. Commercial fruit crops can be present close to compost heaps.

### *Nursery plants*

#### *Nursery plants near utility points*

The proportions of the five utility points near nursery plants of GBC are shown in Table 50. It was estimated that nursery plants are unlikely to be near retailers, very unlikely to be near orchard wholesalers and consumers, and extremely unlikely to be near urban wholesalers and food service.

The relative amounts of waste apples discharged or discarded near nursery plants susceptible to GBC is indicated in Figure 22.

#### *Exposure to host*

The nursery plants of GBC include garden pea and plantain (*Plantago* spp.).

A successful exposure to susceptible hosts requires hatched larvae to crawl onto a susceptible host plant. The chance for this to happen depends on several factors, including mortality of larvae, level of infestation/infection and number of apples in the same utility points, availability and susceptibility of hosts and life span of the pest.

As shown in Table 51, it was considered that the probability that exposure of nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** nursery plants from  
orchard wholesaler waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Nurseries would not be located near wholesaler waste disposal sites.

**Exp** nursery plants from urban  
wholesaler waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

- There are rare instances of nurseries being located near to urban waste dumps.

**Exp** nursery plants from retailer  
waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Apple, plantain and garden pea nursery plants are for sale in major retail outlets.
- Host plants such as apple is a common plant in nurseries in the temperate regions of Australia, particularly during the dormant

period over winter and to a limited extent during the spring and summer months. Other host plants such as garden pea and plantain are common nursery plants.

- Retail garden nurseries have a high density of a range of plant materials in a small area. They often maintain a high hygienic standard, usually fogging with insecticide, to prevent insect attacks.
- A number of fresh food markets will have nursery plants near apple fruit. However, there are a limited number of nurseries associated with fresh food markets that also maintain or store actively growing apple trees.

**Exp** nursery plants from food  
service waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Most food service industries are located in urban areas. There are instances of nurseries being located near food services.
- However, food service industry waste is disposed into bins and taken to landfills. Nursery plants are unlikely to be near these sites.

**Exp** nursery plants from  
consumer waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. Nurseries are generally not located near these sites.

### *Household and garden plants*

#### *Household and garden plants near utility points*

The proportions of the five utility points near household and garden plants of GBC are shown in Table 50. It was estimated that household and garden plants are moderately likely to be near consumers, very unlikely to be near orchard wholesalers and retailers, and extremely unlikely to be near urban wholesalers and food services.

The relative amount of waste apples discharged or discarded near household and garden plants susceptible to GBC is indicated in Figure 22.



*Exposure to host*

The household and garden plants of GBC include garden pea and plantain (*Plantago* spp.).

A successful exposure to susceptible hosts requires hatched larvae to crawl onto a susceptible host plant. The chance for this to happen depends on several factors, including mortality of larvae, level of infestation/infection and number of apples in the same utility points, availability and susceptibility of hosts and life span of the pest.

As shown in Table 51, it was considered that the probability that exposure of household and garden plants would result from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

<p><b>Exp</b> household and garden plants from orchard wholesaler waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Orchard wholesaler waste sites are mostly located within the orchard premises and are not located near household and garden plants.</li> </ul>
<p><b>Exp</b> household and garden plants from urban wholesaler waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Urban wholesaler waste is disposed into landfill sites that are generally not near residential properties.</li> </ul>
<p><b>Exp</b> household and garden plants from retailer waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Retailer waste would be disposed to landfills that are generally not near residential properties.</li> </ul>
<p><b>Exp</b> household and garden plants from food service waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from food services: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Food service industries are unlikely to have host plants susceptible to GBC within their premises.</li> <li>Waste from food services is disposed into landfills sites.</li> </ul>
<p><b>Exp</b> household and garden plants from consumer waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. However, local authorities are now encouraging composting of food waste in</li> </ul>

suburban backyards rather than disposing of all waste into landfill.

- Utilisation of waste to make compost is becoming a common practice in some suburban and rural households.
- Most consumers in metropolitan and suburban areas dispose of their waste to landfills which are generally not near household and garden plants.
- Apple is commonly grown as a garden plant in the temperate regions of Australia. Host plants such as wheat are grown throughout Australia as a major commercial crop.
- Several hosts of GBC are commonly found in backyard gardens in the temperate regions of Australia.
- Household apple trees would be exposed to GBC from household apples, for example, an infected apple core that is composted in a garden.

#### *Wild and amenity plants*

##### *Wild and amenity plants near utility points*

The proportions of the five utility points near wild and amenity plants of GBC are shown in Table 50. It was estimated that wild and amenity plants are unlikely to be near consumers, very unlikely to be near orchard wholesalers and retailers, and extremely unlikely to be near urban wholesalers and food services.

The relative amount of waste apples discharged or discarded near wild and amenity plants susceptible to GBC is indicated in Figure 22.

##### *Exposure to host*

The wild and amenity plants of GBC are not known, though it is polyphagous on a wide range of dicotyledonous herbaceous plants, but rarely grasses.

A successful exposure to susceptible hosts requires hatched larvae to crawl onto a susceptible host plant. The chance for this to happen depends on several factors, including mortality of larvae, level of infestation/infection and number of apples in the same utility points, availability and susceptibility of hosts and life span of the pest.

As shown in Table 51, it was considered that the probability that exposure of wild and amenity plants would result from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** wild and amenity plants  
from orchard wholesaler waste

**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Orchard wholesaler waste sites are mostly located within the orchard premises and are not located near wild and amenity plants.
- Susceptible feral plants (e.g. volunteer apple seedlings,

dicotyledonous herbaceous plants, etc.) may be present near orchard wholesaler's waste disposal sites.

**Exp** wild and amenity plants  
from urban wholesaler waste

**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

- Urban wholesaler waste is disposed at landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds (e.g. apple seedlings, dicotyledonous herbaceous plants).

**Exp** wild and amenity plants  
from retailer waste

**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Retailer waste would be disposed to landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds (e.g. apple seedlings, dicotyledonous herbaceous plants).

**Exp** wild and amenity plants  
from food service waste

**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Food service waste is disposed into bins and taken to landfills. Seedlings originating from seeds dispersed by birds could be present.

**Exp** wild and amenity plants  
from consumer waste

**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds (e.g. apple seedlings, dicotyledonous herbaceous plants).
- Consumers discard apple cores in the environment or into bins in parks. Bins for waste in parks may not be removed on a daily basis and these would provide a sheltered environment for the eggs to hatch before the fruit desiccates or decays.
- Apple seedlings can establish from discarded apple cores. However, population densities of susceptible wild and amenity apple plants in parks, near recreational facilities and along roadsides may be low.
- Consumers who consider apple cores to be biodegradable indiscriminately discard them into the environment. Spoilt apples or cores discarded into the wild are likely to be isolated.

**Conclusion—probability of distribution**

The partial probability of distribution from each of the utility points to each of the exposure groups is summarised in Table 52. These were based on the data and assessment provided above and calculated by the simulation model using the @risk. The quantitative model evaluated the effect of the ‘volume of trade’ during a specified period when calculating the partial probability of distribution.

**Table 52 Partial probabilities of distribution (PPD)<sup>41</sup> for grey-brown cutworm**

UTILITY POINTS	PPD			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Orchard wholesalers</b>	Negligible	Negligible	Negligible	Negligible
<b>Urban wholesalers</b>	Negligible	Negligible	Negligible	Negligible
<b>Retailers</b>	Extremely low	Extremely low	Extremely low	Extremely low
<b>Food services</b>	Negligible	Negligible	Negligible	Negligible
<b>Consumers</b>	Extremely low	Extremely low	Very low	Very low
<b>Overall PPD</b>	<b>Extremely low</b>	<b>Extremely low</b>	<b>Very low</b>	<b>Very low</b>

**Probability of establishment or spread**

The assessment for the probability of establishment or spread is carried out in the following manner. Firstly, partial probability for establishment and for spread was assessed separately based on the relevant available scientific information. Secondly, the conclusions for the combined partial probability of establishment or spread for each of the four exposure groups are provided at the end of this section. The relevant information for the assessment for the probability of establishment or spread is presented below against the factors listed in ISPM 11, Rev. 1.

**Partial probability of establishment**

ISPM 11 factor	Relevant information
<b>Availability of suitable hosts, alternate hosts and vectors in the PRA area</b>	<ul style="list-style-type: none"> <li>GBC attacks apples, garden pea, plantain (<i>Plantago</i> spp.), wheat and is polyphagous on a wide range of dicotyledonous herbaceous plants but rarely on grasses (HortResearch, 1999b).</li> <li>Commercial crops such as apples and wheat are grown in all States and Territories in Australia, except in the northern tropical regions. Apples are also found and grown in suburban</li> </ul>

<sup>41</sup> Partial probability of distribution is actually referring to the probability of entry and was estimated by @risk.

ISPM 11 factor	Relevant information
<b>Suitability of the environment</b>	backyards in temperate Australia. <ul style="list-style-type: none"> <li>GBC is found in New Zealand where climatic conditions are similar to those in Australia.</li> <li>Apples and wheat are not grown in protected environments such as in glasshouses.</li> </ul>
<b>The potential for adaptation of the pest</b>	<ul style="list-style-type: none"> <li>The potential for adaptation of the pest is not known. However, GBC is polyphagous and host plants are present in Australia.</li> </ul>
<b>The reproductive strategy of the pest</b>	<ul style="list-style-type: none"> <li>GBC only reproduces sexually.</li> <li>Successful mating between a male and a female must occur before eggs are produced.</li> </ul>
<b>Minimum population needed for establishment</b>	<ul style="list-style-type: none"> <li>When the larvae hatched from eggs find a host, they need to develop, pupate and become adults and mate before laying their eggs to establish a new population.</li> </ul>
<b>Cultural practices and control measures</b>	<ul style="list-style-type: none"> <li>Integrated Pest Management (IPM) programs are utilised in the production of apples in Australia.</li> </ul>

*Conclusion—partial probability of establishment*

Based on the above evidence, partial probability of establishment for each of the exposure groups are as follow:

Partial probability of establishment for commercial fruit crops: **High**

Partial probability of establishment for nursery plants: **High**.

Partial probability of establishment for household and garden plants: **High**

Partial probability of establishment for wild and amenity plants: **High**

***Partial probability of spread***

ISPM 11 factor	Relevant information
<b>Suitability of natural and/or managed environment</b>	<ul style="list-style-type: none"> <li>GBC is present in New Zealand. There are similar environments in Australia that would be suitable for its spread.</li> </ul>
<b>Presence of natural barriers</b>	<ul style="list-style-type: none"> <li>Both the adult male and female are winged and are capable of flight.</li> <li>The main commercial fruit crops of GBC including apple and wheat crops are located in six States of Australia, with natural barriers including arid areas, climatic differentials and long distances existing between these areas. It would be difficult for the adults to disperse from one area to another unaided.</li> <li>Other host plants available between the commercial apple orchards in different areas would help the spread of GBC.</li> <li>GBC does not require a vector for its dispersal.</li> </ul>

ISPM 11 factor	Relevant information
<b>Potential for movement with commodities or conveyances</b>	<ul style="list-style-type: none"> <li>• A mixture of adult flight and the transportation of infested apple trees have probably aided the movement of GBC within orchards.</li> <li>• The means of dispersal would include as eggs on fruit or crawling larvae.</li> <li>• Existing interstate quarantine control on the movement of nursery stock would reduce the scope for the spread.</li> </ul>
<b>Intended use of the commodity</b>	<ul style="list-style-type: none"> <li>• Apples would be used mostly for consumption by humans and would be widely distributed around the States.</li> <li>• Eggs contaminating the fruit would be distributed with the commodity around the country.</li> </ul>
<b>Potential vectors of the pest</b>	<ul style="list-style-type: none"> <li>• GBC does not require a vector for its spread since it is capable of independent flight.</li> </ul>
<b>Potential natural enemies</b>	<ul style="list-style-type: none"> <li>• The relevance of potential natural enemies in Australia is not known.</li> </ul>

*Conclusion—partial probability of spread*

Based on the above evidence, partial probability of spread for each of the exposure groups is as follows:

Partial probability of spread for commercial fruit crops: **High**

Partial probability of spread for nursery plants: **Moderate**.

Partial probability of spread for household and garden plants: **High**

Partial probability of spread for wild and amenity plants: **Moderate**

***Combined partial probability of establishment or spread***

The combined partial probability of establishment or spread was determined by combining probabilities of establishment and probabilities of spread using the matrix of ‘rules’ for combining descriptive likelihoods as presented in the method section. The results are indicated in Table 53.

**Table 53 Combined partial probabilities of establishment or spread of grey-brown cutworm**

	<b>Commercial fruit crops</b>	<b>Nursery plants</b>	<b>Household and garden plants</b>	<b>Wild and amenity plants</b>
<b>Establishment</b>	High	High	High	High
<b>Spread</b>	High	Moderate	High	Moderate
<b>PPES<sup>42</sup></b>	<b>High</b>	<b>Moderate</b>	<b>High</b>	<b>Moderate</b>

Additional evidence to support the combined partial probability of establishment or spread for specific exposure groups is provided in the text below.

<b>Commercial fruit crops</b>	<ul style="list-style-type: none"> <li>Commercial fruit crops of GBC include apple, wheat and pea and they are located in all states.</li> </ul>
<b>High</b>	<ul style="list-style-type: none"> <li>Other host plants available between the commercial apple orchards in different areas would help the spread of GBC.</li> </ul>
<b>Nursery plants</b>	<ul style="list-style-type: none"> <li>GBC attacks apples, garden pea, and plantain (<i>Plantago</i> spp.) and is polyphagous on a wide range of dicotyledonous herbaceous plants but rarely on grasses (HortResearch, 1999b).</li> </ul>
<b>Moderate</b>	
<b>Household and garden plants</b>	<ul style="list-style-type: none"> <li>The establishment of GBC in susceptible household and garden plants will be largely dependent on (1) the availability of a limited number of host plants; (2) the extent of Australian households growing backyard apple trees and other host plants; and, (3) the willingness of suburban gardeners to adequately control pests and diseases on their apple trees.</li> <li>Climatic limits and the extent of apple trees and other host plants grown in suburban backyards can have an effect on the establishment or spread of GBC. GBC can fly short distances unaided, but is endemic to New Zealand and has not spread any further. It was considered that GBC could spread within Australia following establishment in exposed household and garden plants.</li> </ul>
<b>High</b>	
<b>Wild and amenity plants</b>	<ul style="list-style-type: none"> <li>Grey-brown cutworm is a temperate insect, climatic factors in many parts of Australia would be suitable for its establishment or spread.</li> <li>Even though GBC is capable of short flight, wild host plants are present across the country.</li> </ul>
<b>Moderate</b>	

### Assessment of consequences

Impact scores allocated for the direct and indirect criteria are shown in Table 54. Available supporting evidence is provided in the text below.

<sup>42</sup> PPES = partial probability of establishment or spread

**Table 54 Impact scores for grey-brown cutworm**

<b>Direct impact</b>	<b>Impact scores</b>
Plant life or health	D
Human life or health	A
Any other aspects of environment	A
<b>Indirect impact</b>	
Control or eradication	D
Domestic trade or industry	D
International trade	D
Environment	B
Communities	A

**Direct impact**

- Plant life or health – D** Consequences affecting plant life or health are unlikely to be discernible at the national level and of minor significance at the regional level. A rating of ‘**D**’ was assigned to this criterion.
- Grey-brown cutworm attacks commercial crops such as apples and wheat, both of these are very important economic crops in Australia. Hosts also include garden pea, plantain (*Plantago* spp.) and is polyphagous on a wide range of dicotyledonous herbaceous plants but rarely on grasses (HortResearch, 1999b).
- Human life or health – A** There are no known direct impacts of GBC on human life or health and the rating assigned to this criterion was therefore ‘**A**’.
- Any other aspects of environmental effects – A** There is no known direct impact of GBC on any other aspects of the environment and a rating of ‘**A**’ was assigned to this criterion.

**Indirect impact**

- Control or eradication – D** The indirect impact on new or modified eradication, control, surveillance/monitoring and compensation strategies is unlikely to be discernible at the national level and of minor significance at the regional level. A rating of ‘**D**’ was assigned to this criterion.
- An increase in the use of insecticides for its control because of difficulties estimating the optimum time for insecticide application.
  - Subsequent increase in cost of production to producers.
  - Increased costs for crop monitoring and consultant’s advice to the producer.



<b>Domestic trade or industry – D</b>	<p>The indirect consequences on domestic trade are unlikely to be discernible at a national level and would be of minor significance at a regional level. A rating of ‘<b>D</b>’ was assigned to this criterion.</p> <p>The presence of GBC on commercial apple or wheat crops could result in:</p> <ul style="list-style-type: none"> <li>• trade restrictions in the sale or movement of fruit and wheat within that district and region and between States and between different districts;</li> </ul>
<b>International trade – D</b>	<p>The indirect consequences on international trade are unlikely to be discernible at a national level and would be of minor significance at the regional level. A rating of ‘<b>D</b>’ was assigned to this criterion.</p> <ul style="list-style-type: none"> <li>• If GBC became established in Australia, our trading partners such as Japan would reject consignments of apples infested with GBC.</li> </ul>
<b>Environment – B</b>	<p>The indirect consequences on the environment would not be discernible at the national level and would be of minor significance at the local level and a rating of ‘<b>B</b>’ was assigned to this criterion.</p> <ul style="list-style-type: none"> <li>• Increased insecticide use could cause undesired effects on the environment.</li> <li>• The introduction of new biocontrol agents could affect existing biological control programs.</li> </ul>
<b>Communities – A</b>	<ul style="list-style-type: none"> <li>• The presence of GBC would have limited social effects, if any, and a rating of ‘<b>A</b>’ was assigned to this criterion.</li> </ul>

### ***Conclusion—consequences***

Based on the decision rule described in the methodology, i.e. where the consequences of a pest with respect to one or more criteria are ‘**D**’, the overall consequences are considered to be ‘low’. Therefore the overall consequences of GBC are **low**.

### **Unrestricted annual risk**

Unrestricted annual risk is the result of combining annual probability of entry, establishment or spread with the outcome of overall consequences. Probabilities and consequences are combined using the ‘rules’ shown in the risk estimation matrix in the method section. The unrestricted annual risk estimation for GBC is shown in Table 55.

**Table 55 Risk estimation for grey-brown cutworm**

Overall probability of entry, establishment or spread <sup>43</sup>	<b>Very low</b>
Consequences	<b>Low</b>
Unrestricted annual risk	<b>Negligible</b>

As indicated in Table 55, the unrestricted annual risk for grey-brown cutworm is negligible, which is below Australia's appropriate level of protection (ALOP) of very low. Therefore, risk management would not be required for this pest.

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<sup>43</sup> Calculated by @ risk.

## **Leafrollers**

This assessment relates to four species of leafrollers:

Brownheaded leafroller (BHLR), *Ctenopseustis herana* (Felder and Rogenhofer);

Brownheaded leafroller (BHLR), *C. obliquana* (Walker);

Greenheaded leafroller (GHLR), *Planotortrix excessana* (Walker); and,

Greenheaded leafroller (GHLR), *P. octo* Dugdale.

These four species were assessed together because they have very similar biologies and are all of 'primary' economic importance (Wearing *et al.*, 1991).

## **Biology**

These leafrollers are moths with four life stages: adult, egg, larva (or caterpillar), and pupa.

At rest only the forewings of all four leafrollers are visible, one overlapping the other to form a bell-shaped outline.

The body length of BHLRs ranges from 8–12 mm for females and 8–11 mm for males. Wingspan of female BHLRs ranges from 20–28 mm while that of the males ranges from 17–24 mm. Adult BHLRs are extremely variable in colour and forewing pattern. In both sexes the forewings vary from dark brown (almost black) to a pale fawn. Females have a characteristic darker oblique mark halfway down the edge of each forewing as do males which also have a characteristic dark, transverse stripe (often black) across the front part of the folded wings.

Adult GHLR moths have a body length ranging from 8–14 mm for females and 7–12 mm for males, and a wingspan of 22–30 mm for females and 18–25 mm for males. Females are normally pale to dark brown, often with a series of broad, darker brown, variable zig-zag markings on the forewing and a prominent, subapical dark brown spot. The forewings of the male are a uniform medium to dark coppery brown, sometimes with a distinct greyish surface sheen. Adults are not readily distinguishable from other, closely related leafroller moths.

Eggs of all leafroller species are laid in flat oval rafts or batches of 2–170, usually on the upper surface of host plant leaves. The eggs are flat, and with a pebbled surface. They overlap each other within the raft to form a smooth mass. This makes it difficult to distinguish the eggs from the surrounding leaf surface. The GHLR egg batch is densely coated with characteristic white particles deposited during egg laying and this makes it difficult to see individual eggs. Eggs of GHLR are approximately  $1.3 \times 1$  mm. They are initially blue-green and change to a paler yellow-green as they develop. Eggs of BHLR are approximately  $0.7 \times 1.0$  mm and the batches have a sparse coating of particles over the surface. They are initially pale green and change to a more yellow-green as they develop. Before hatching, the dark head of the developing caterpillar is visible through the egg wall, giving the egg batches a blotchy or speckled appearance (Anonymous, 1983; HortResearch, 1998).

Larvae are very similar and are difficult to distinguish from each other when occurring together in the same habitat.

The first larval instar of BHLR is about 1.5–2.0 mm long, has a pale brown head with a dark mark on each side, and the body is often pale green. The head becomes strikingly black in the

second instar, and changes again, through subsequent instars, from dark brown to reddish or pale brown. Body colour varies. The mature larva may have faint red or red-brown stripes on its head, and is up to 20 mm long. The two species of BHLR are identical in appearance at all stages.

The first larval instar of GHLR is about 1.5–2.0 mm long and has a pale brown head with a dark mark on each side. During development, the head and the plate behind it become paler and almost transparent. The full-grown mature larva is about 25 mm in length and the head and the plate behind it are shining green. The body is pale bluish-green with diffuse, white longitudinal bands.

The pupa (chrysalis) of all four leafrollers is at first green, but soon becomes brown after rapidly hardening, and then darkens during development. The pupa is typically found in a thin-walled silken cocoon between two leaves webbed together, and is usually 10-15 mm long; the female pupae are larger than those of the male. At the end of the abdomen, two prominent broad-based laterally projecting spines and a number of hooks support the pupa in its cocoon. Each abdominal segment also has a series of short, backward-projecting spines that are used by the pupa to move partially out of its cocoon prior to moth emergence (HortResearch, 1999b).

### **Risk scenario**

The risk scenario of concern for these leafrollers in this IRA is the larvae either on or inside the calyx or inside the apple fruit.

## Probability of importation

The initiating step for the importation scenario for apple fruit is the sourcing of apples from orchards in New Zealand, while the end-point is the release of imported apples from the port of entry. The importation scenario is divided into eight steps and the likelihood of the brownheaded and greenheaded leafrollers being present at each step are summarised in Figure 23. The available evidence supporting the likelihood assessments is provided in the text below.

**Figure 23 The importation steps and the likelihood of the brownheaded and greenheaded leafrollers being present at each step**



**Importation step 1  
(Imp1)**

**High**

The likelihood that leafrollers are present in the source orchards in New Zealand: **High**

- Brownheaded leafrollers, *Ctenopseustis obliquana* and *C. herana* and greenheaded Leafrollers, *Planotortrix excessana* and *P. octo* occur only in New Zealand, including some offshore islands (Thomas, 1998).
- *Ctenopseustis obliquana* is found in both the North and South Islands but is less frequent on the east coast of the South Island where it may be replaced by *C. herana* (HortResearch, 1999b).
- *C. obliquana* is a major pest of apples in Hawke's Bay, Gisborne, Waikato, and Nelson.
- *Ctenopseustis herana* is found throughout the South Island and the provinces of Northland and Waikato of the North Island.
- *C. herana* is a pest species in apple orchards mainly in Nelson, Canterbury and Waikato (HortResearch, 1999b).
- The apple cultivars 'Liberty' and 'Red Delicious' are particularly prone to damage from *Ctenopseustis obliquana*, while the cultivar 'Prima' is resistant (Wearing *et al.*, 2003).
- GHLRs inhabit most lowland forest margins and horticultural areas (Thomas, 1998).
- *Planotortrix excessana* is rare or infrequent in the eastern regions of the country and it is a major pest of apples in Nelson and the Waikato (HortResearch, 1999b).
- *Planotortrix octo* is found in both the North and South Islands and is particularly important in the eastern apple growing regions of Poverty Bay, Hawke's Bay, Marlborough, Canterbury, and Central Otago. It is also a pest in the Waikato (HortResearch, 1999b).
- Wearing (1995b) states that extensive research in Central Otago over five years has shown that *Planotortrix octo* is the most important species damaging the apple crop, especially in the Dumbarton district.
- Early instar caterpillars settle mainly on the lower surfaces of leaves where they construct silken shelters and feed near the main veins or in shoot tips.
- In the Auckland area there are four to six overlapping generations annually and every stage of the life cycle is present throughout the year (Green, 1998).
- Re-invasion of apple trees by the overwintering generation takes place during October-December (HortResearch, 1999b).
- Walker *et al.* (1996) found leafroller larvae on HortResearch samples taken from seven of the eight blocks selected from Hawke's Bay and Nelson orchards.
- Walker *et al.* (1996) found the incidence of leafrollers ranged from nine larvae from 1200 shoots (cv Braeburn) to three

larvae from 1200 shoots (cv Fuji) at Twyford (Walker *et al.*, 1996).

- However no leafrollers were detected within the Havelock North blocks (Walker *et al.*, 1996).

#### Summary

Based on above evidence that leafrollers are major pests in apple orchards in some areas of New Zealand, the likelihood for Imp1 was assessed as high.

#### Importation step 2 (Imp2)

Very low

The likelihood that picked apple fruit is infested with leafrollers: **Very low**

- Occasionally young larvae invade the calyx and progress to feeding internally on the apple fruit and show no sign of external damage (HortResearch, 1999b; Thomas, 1998).
- Young and mature larvae web leaves to the fruit where they superficially damage the surface of the fruit.
- Internal damage to apple fruits caused by greenheaded leafrollers is much less common than surface damage (HortResearch, 1999b).

#### Summary

Based on above evidence that leafrollers rarely cause internal damage to apples, the likelihood for Imp2 was assessed as very low.

#### Importation step 3 (Imp3)

Very Low

The likelihood that clean fruit is contaminated by leafrollers during harvesting and transport of apples to the packing house: **Very low**

- Egg-masses of greenheaded leafrollers are laid together on leaves while their larvae feed mainly on leaves by forming a protective shelter by spinning them together with silk (HortResearch, 1999b).
- If disturbed during the day adults make a short flight or escape 'jump' into ground vegetation and immediately 'freeze' (Thomas, 1998).
- Larvae feeding internally would not move into other fruit; they would remain in the fruit they are already feeding in.
- Some larvae that have been dislodged could be residual contaminants in the bins or containers used to transport apples to the packing house.

#### Summary

Based on above evidence that larvae feed mainly on leaves and adults move away from fruit when disturbed, the likelihood for Imp3 was assessed as very low.

#### Importation step 4 (Imp4)

High

The likelihood that leafrollers survive routine processing procedures in the packing house: **High**

The following packing house operations may influence the viability of leafrollers.

*Washing*

- Larvae feeding internally within the apple would not be removed by external high-volume/high pressure washing. However, larvae feeding externally in protective silken shelters between an apple fruit and a leaf would be removed by such a cleaning method.

*Brushing*

- Larvae feeding externally in a protective silken shelter between the fruit and a leaf would be removed from brushing.

*Waxing*

- Larvae protected inside apple fruit would be able to survive the waxing process.

*Sorting and Grading*

- Sorting and grading would remove some fruit that are contaminated with larvae since surface damaged fruit, or remaining frass (droppings) outside the fruit or protective shelter formed by a leaf attached to an apple fruit (Thomas, 1998) would be noticeable.
- If external frass were absent, there would also be entry or exit holes present on fruit.

*Packaging*

- Packaging would have little affect on the survival of leafrollers. In most cases the packaging of apples is designed to maximise heat discharge from the fruit while minimising loss of moisture.

*Cold Storage*

- Larvae of greenheaded leafrollers overwinter as late instars in the Canterbury region of the South Island of New Zealand (Thomas, 1998) suggesting that they are able to survive cold conditions.
- Larvae inside apple fruit would almost certainly be able to survive storage prior to transportation since they are able to feed in the fruit or alternatively survive as a resting stage in cool storage.

*Summary*

- Based on above information that leafrollers be present inside the fruit and are able to survive packing and cold storage, the likelihood for Imp4 was assessed as high.

**Importation step 5  
(Imp5)**

**Extremely low**

The likelihood that clean fruit is contaminated by leafrollers during processing in the packing house: **Extremely low**

- Larvae feeding internally in apple fruit (HortResearch, 1999b) would not move about to attach to other fruit.
- Externally occurring larvae that have survived the packing house processes to this point would be able to move amongst the apples. However, the number of larvae would remain the



same.

### Summary

Based on above information that the number of externally feeding leafrollers in the packing house would remain the same, the likelihood for Imp5 was assessed as extremely low.

**Importation step 6  
(Imp6)  
High**

The likelihood that leafrollers survive palletisation, quality inspection, containerisation and transportation to Australia: **High**

- Greenheaded leafroller larvae should be able to survive the cold conditions experienced during refrigerated transport since larvae overwinter as late instars in the Canterbury region of the South Island of New Zealand (Thomas, 1998).
- Larvae inside the apple fruit would be provided with some protection from the cold and they would be able to survive by feeding internally on the fruit.
- *Planotortrix excessana* has been intercepted on fresh avocados exported from New Zealand to Australia indicating that larvae can survive cold storage during transportation (DAFF-PDI, 2002).
- Brownheaded leafroller larvae have been detected several times on imported fresh apricots, peaches, nectarines, cherries and avocados indicating that larvae can survive cold storage (DAFF-PDI, 2002).

### Summary

Based on above evidence that leafrollers can survive cold conditions and have been intercepted on avocados exported from New Zealand, the likelihood for Imp6 was assessed as high.

**Importation step 7  
(Imp7)  
Negligible**

The likelihood that clean fruit is contaminated by leafrollers during palletisation, quality inspection and transportation: **Negligible**

- Larvae of leafrollers remaining inside apple fruit would not leave that fruit to contaminate other apple fruit. However, the number of larvae would remain the same.

**Importation step 8  
(Imp8)  
High**

The likelihood that these leafrollers survive and remain with fruit after on-arrival minimum border procedures: **High**

- The minimum border procedures as described in the method section would not be effective in detecting leafrollers.

### Conclusions—probability of importation

When the above likelihoods were inserted into the simulation model, the probability of importation for brownheaded and greenheaded leafrollers on apples from one year of trade was found to be **very low**.

## **Probability of distribution**

The initiating step for the distribution scenario is the release of imported apples from the port of entry, while the last step is the pest being distributed (as a result of the processing, sale or disposal of these apple fruit) in a viable state to an endangered area and subsequently being transferred to a suitable host.

In order to assess the probability of distribution, the distribution scenario is addressed in three subheadings below. First is a brief description of sequences of events leading to a successful exposure of the pest from infested/infected apple to a susceptible host plant. Second is the assessment of partial probability of distribution of the pest in relation to each of the exposure groups. Third is the conclusion for the probability of distribution.

### ***Sequence of events for successful exposure***

The sequence of events that has to be completed for a successful exposure of a susceptible host to the pest is summarised below.

The insect stage associated with the apple is the larvae. If the larvae survive cold storage and mature after the apples have been taken out of cold storage, they could leave the fruit and find a site to pupate. In the field situation, most larvae leave their feeding sites and spin new rolls for pupation. Mature leafroller larvae are also able to pupate on ground-cover plants or in leaf litter (HortResearch, 1999b; McLaren *et al.*, 1999). There would be mortality during the larva's search for the pupating site. The emerged adults would be able to enter the environment after they emerge from pupae i.e. during packing or unpacking of the fruit, from repacking facilities or retailers (utility points), from discarded fruit in waste, and from landfills where the waste is disposed.

Both adult males and females are winged and most are able to fly about 100m, with a maximum of 400m. Sexual reproduction is essential in brownheaded and greenheaded leafrollers. Female pheromones are released in the evening and night, but particularly around dusk, and attract males for mating.

A successful exposure of leafrollers from infested fruit to its hosts means that mature larvae need to leave their feeding sites to pupate, pupae need to develop to become adults, and adult females would need to locate a male to mate with and lay its eggs on a susceptible host plant.

### ***Partial probability of distribution***

The partial probability of distribution (PPD) was estimated separately for each of the four exposure groups: commercial fruit crops, nursery plants, household and garden plants, and wild and amenity plants.

The details and the method of calculation for the PPD of the four exposure groups are explained in the method section and the results are presented in a series of tables and figures below. The information from these tables and figures was used to assess the probability of distribution of leafrollers to all the exposure groups.

Table 56 indicates the proportions of the five utility points near each of the exposure groups of leafrollers. Greenheaded and brownheaded leafrollers are highly polyphagous and many

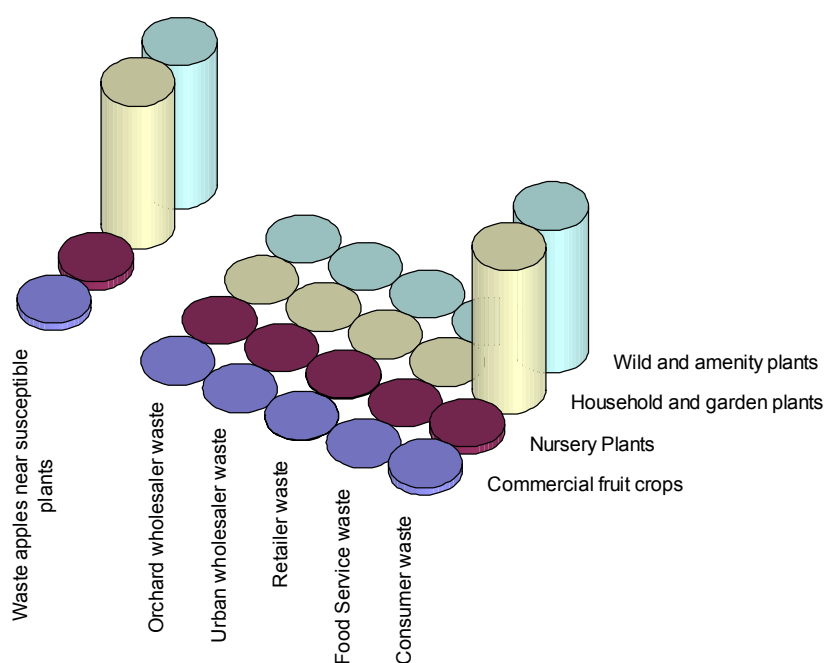
hosts are widely available in Australia. These leafrollers have been recorded on over 200 host plants.

**Table 56 The proportions of utility points near host plants susceptible to leafrollers in the four exposure groups**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Proximity</b> Orchard wholesalers	Certain	Very low	Very low	Very low
<b>Proximity</b> Urban wholesalers	Extremely low	Extremely low	Extremely low	Extremely low
<b>Proximity</b> Retailers	Very low	Low	Very low	Very low
<b>Proximity</b> Food services	Extremely low	Extremely low	Extremely low	Extremely low
<b>Proximity</b> Consumers	Very low	Very low	Moderate	Moderate

Figure 24 gives a pictorial representation of the relative amounts of infested/infected apples, an escaped pest or contaminated packaging material discharged or discarded from different utility points near each of the exposure groups of leafrollers.

**Figure 24 Pictorial representation of the relative amounts of infested/infected apple waste<sup>44</sup> from utility points to near exposure groups of leafrollers**



<sup>44</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or an escaped pest, or contaminated packaging material.

Table 57 is the summary of the probability that exposure of the host plants would result from discharge or discard of a single infested/infected apple, or an escaped pest, or contaminated packaging material from different utility points. Evidence is provided in the text below under different exposure groups.

**Table 57 The probability of exposure of susceptible host plants of leafrollers from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Exp</b> Orchard <sup>45</sup> wholesaler waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Urban wholesaler waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Retailer waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Food service waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Consumer waste	Negligible	Negligible	Negligible	Negligible

#### *Commercial fruit crops*

##### *Commercial fruit crops near utility points*

The proportions of the five utility points near commercial fruit crops of leafrollers are shown in Table 56. It was estimated that commercial fruit crops are certain to be located near all orchard wholesalers, very unlikely to be near retailers and consumers, and extremely unlikely to be near urban wholesalers and food service as most of these are in metropolitan areas.

The number of infested/infected apples, an escaped pest, or contaminated packaging material discharged or discarded from different utility points to near commercial fruit crops susceptible to leafrollers is indicated in Figure 24.

##### *Exposure to host*

The commercial fruit crops of leafrollers include apples, pears, stonefruit, citrus, grapes and berries.

A successful exposure of leafrollers from infested fruit to their hosts means that mature larvae need to leave their feeding sites to pupate, pupae need to develop to become adults, and adult females would need to locate a male to mate with and lay its eggs on a susceptible host plant. The chance for this to happen depends on several factors, including the mortality caused by the handling and consumption of fruit and mortality during the larva's search for a pupating

<sup>45</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or escaped pest, or contaminated packaging material.

site, the level of infestation/infection and number of apples in the same utility points, reproductive strategy, life span of the pest and availability and susceptibility of hosts.

As shown in Table 57, it is considered that the probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** commercial fruit crops  
from orchard wholesaler waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Host plants such as pomefruit and stonefruit are common in commercial orchards.
- Handling of fruit in orchard wholesalers would increase mortality of leafrollers.

**Exp** commercial fruit crops  
from urban wholesaler waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

- Commercial fruit crops are not located in urban areas.
- Urban wholesaler waste is disposed into bins and taken to landfills. Commercial fruit crops are unlikely to be located adjoining these sites.

**Exp** commercial fruit crops  
from retailer waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Most retailers are located in urban areas not closed to commercial fruit crops.
- Retailer waste may be used for composting in rural areas and some of these sites may be near commercial orchards.

**Exp** commercial fruit crops  
from food service waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Most food service providers are located in metropolitan and suburban areas. Waste produced by people in metropolitan areas and some in urban areas is generally disposed into landfills. Commercial fruit crops would usually not be present adjoining these sites.
- Population densities around commercial orchards are very low.
- Some food service waste in suburban and rural areas may be utilised for composting. Commercial fruit crops can be present close to compost heaps.

**Exp** commercial fruit crops

from consumer waste

**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Majority of consumers are located in metropolitan and suburban areas. Waste produced by people in metropolitan areas and some in urban areas is generally disposed into landfills. Commercial fruit crops would usually not be present adjoining these sites.
- Households and population densities around commercial orchards are very low.
- Some consumer waste in suburban and rural areas may be utilised for composting. Commercial fruit crops can be present close to compost heaps.

*Nursery plants**Nursery plants near utility points*

The proportions of the five utility points near nursery plants of leafrollers are shown in Table 56. It was estimated that nursery plants are unlikely to be near retailers, very unlikely to be near orchard wholesalers and consumers, and extremely unlikely to be near urban wholesalers and food services.

The relative amounts of waste apples discharged or discarded near nursery plants susceptible to leafrollers is indicated in Figure 24.

*Exposure to host*

Nursery hosts of leafrollers include apples, pears, stonefruit, citrus, walnuts, camellias, eucalypts, roses and conifers.

A successful exposure of leafrollers from infested fruit to their hosts means that mature larvae need to leave their feeding sites to pupate, pupae need to develop to become adults, and adult females would need to locate a male to mate with and lay its eggs on a susceptible host plant. The chance for this to happen depends on several factors, including the mortality caused by the handling and consumption of fruit and mortality during the larva's search for a pupating site, the level of infestation/infection and number of apples in the same utility points, reproductive strategy, life span of the pest and availability and susceptibility of hosts.

As shown in Table 57, it is considered that the probability that exposure of nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** nursery plants from  
orchard wholesaler waste**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Host plants such as stonefruit and citrus are common in nurseries.
- Retail garden nurseries have a high density of a range of plant

materials in a small area. They often maintain a high hygienic standard, usually fogging with insecticide, to prevent insect attacks.

- There are rare instances of nurseries being located near to orchard wholesaler waste.

**Exp** nursery plants from urban  
wholesaler waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

- There are rare instances of nurseries being located near to urban waste dumps.
- Host plants such as stonefruit and citrus are common in nurseries.

**Exp** nursery plants from retailer  
waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Suitable nursery plants are common in nurseries in the temperate regions of Australia, year round.
- Retail garden nurseries have a high density of a range of plant materials in a small area. They often maintain a high hygienic standard, usually fogging with insecticide, to prevent insect attacks.

**Exp** nursery plants from food  
service waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Most food services are in metropolitan and suburban areas and their waste is disposed into landfills. Nurseries are generally not located near these sites.

**Exp** nursery plants from  
consumer waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. Nurseries are generally not located near these sites.

### *Household and garden plants*

#### *Household and garden plants near utility points*

The proportions of the five utility points near household and garden plants of leafrollers are shown in Table 56. It was estimated that household and garden plants are moderately likely to be near consumers, very unlikely to be near orchard wholesalers and retailers and extremely unlikely to be near urban wholesalers and food services.



The relative amounts of waste apples discharged or discarded near household and garden plants susceptible to leafrollers are indicated in Figure 24.

### *Exposure to host*

Household and garden plant hosts of leafrollers include apples, pears, stonefruit, citrus, camellias, ivy, oaks, roses and conifers.

A successful exposure of leafrollers from infested fruit to their hosts means that mature larvae need to leave their feeding sites to pupate, pupae need to develop to become adults, and adult females would need to locate a male to mate with and lay its eggs on a susceptible host plant. The chance for this to happen depends on several factors, including the mortality caused by the handling and consumption of fruit and mortality during the larva's search for a pupating site, the level of infestation/infection and number of apples in the same utility points, reproductive strategy, life span of the pest and availability and susceptibility of hosts.

As shown in Table 57, it is considered that the probability that exposure of household and garden plants would result from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** household and garden  
plants from orchard wholesaler  
waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Orchard wholesale waste sites are mostly located within the orchard premises and are not located near household and garden plants.

**Exp** household and garden  
plants from urban wholesaler waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible.**

- Urban wholesaler waste is disposed into landfill sites, which are generally not near residential properties.

**Exp** household and garden  
plants from retailer waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Retailer waste would be disposed to landfills, which are generally not near residential properties.

**Exp** household and garden  
plants from food service waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Food service waste would be disposed to landfills, which are generally not near residential properties.

**Exp** household and garden  
plants from consumer waste  
**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Most consumers in metropolitan and suburban areas dispose of their waste to landfills, which are generally not near household and garden plants.
- However, utilisation of waste to make compost is becoming a common practice in some suburban and rural households.
- Host of leafrollers, including fruit trees and ornamental plants such as camellias are commonly grown as garden plants in the temperate regions of Australia.
- Host plants would be exposed to leafrollers from household apples such as an infected apple core that is composted in a garden. However, females would need to locate a male to mate with and lay her eggs on a susceptible host plant within 1-4 days of emergence.

*Wild and amenity plants*

*Wild and amenity plants near utility points*

The proportions of the five utility points near wild and amenity plants of leafrollers are shown in Table 56. It was estimated that wild and amenity plants are moderately likely to be near consumers, very unlikely to be near orchard wholesalers and retailers and extremely unlikely to be near urban wholesalers and food services.

The relative amounts of waste apples discharged or discarded near wild and amenity plants susceptible to leafrollers is indicated in Figure 24.

*Exposure to host*

Wild and amenity host plants of leafrollers include apples, pears, stonefruit, berries, oaks, conifers, cotoneaster and ivy.

A successful exposure of leafrollers from infested fruit to their hosts means that mature larvae need to leave their feeding sites to pupate, pupae need to develop to become adults, and adult females would need to locate a male to mate with and lay its eggs on a susceptible host plant. The chance for this to happen depends on several factors, including the mortality caused by the handling and consumption of fruit and mortality during the larva's search for a pupating site, the level of infestation/infection and number of apples in the same utility points, reproductive strategy, life span of the pest and availability and susceptibility of hosts.

As shown in Table 57, it is considered that the probability that exposure of wild and amenity plants would result from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** wild and amenity plants  
from orchard wholesaler waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

<p><b>Exp</b> wild and amenity plants from urban wholesaler waste <b>Negligible</b></p>	<ul style="list-style-type: none"> <li>Orchard wholesale waste sites are mostly located within the orchard premises and are not located near wild and amenity plants.</li> <li>Susceptible feral plants e.g. <i>Cotoneaster</i> may be present near orchard wholesalers waste disposal sites.</li> </ul> <p>The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Urban wholesale waste is disposed at landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. <i>Cotoneaster</i>, apple seedlings.</li> </ul>
<p><b>Exp</b> wild and amenity plants from retailer waste <b>Negligible</b></p>	<p>The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Retailer waste would be disposed to landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. <i>Cotoneaster</i>, apple seedlings.</li> </ul>
<p><b>Exp</b> wild and amenity plants from food service waste <b>Negligible</b></p>	<p>The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Food service waste would be disposed to landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. <i>Cotoneaster</i>, apple seedlings.</li> </ul>
<p><b>Exp</b> wild and amenity plants from consumer waste <b>Negligible</b></p>	<p>The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. <i>Cotoneaster</i>, apple seedlings.</li> <li>Consumers discard apple cores in the environment or in bins in parks. Bins for waste in parks that may not be removed on a daily basis and these would provide a sheltered environment for the insect to emerge before the fruit desiccates or decays.</li> <li>Apple seedlings can establish from discarded apple cores. Susceptible wild and amenity plants, such as oaks may be present in parks, near recreational facilities and along roadsides. However, females would need to locate a male to mate with and lay her eggs on a susceptible host plant.</li> <li>Consumers who consider apple cores to be biodegradable indiscriminately discard them in the environment. Spoilt apples or cores discarded into the wild are likely to be isolated.</li> </ul>

**Conclusion—probability of distribution**

The partial probability of distribution from each of the utility points to each of the exposure groups is summarised in Table 58. These were based on the data and assessment provided above and calculated by the simulation model using the @risk. The quantitative model evaluated the effect of the ‘volume of trade’ during a specified period when calculating the partial probability of distribution.

**Table 58 Partial probabilities of distribution (PPD)<sup>46</sup> for leafrollers**

UTILITY POINTS	PPD			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Orchard wholesalers</b>	Extremely low	Extremely low	Extremely low	Extremely low
<b>Urban wholesalers</b>	Negligible	Negligible	Negligible	Negligible
<b>Retailers</b>	Very low	Very low	Very low	Very low
<b>Food services</b>	Extremely low	Extremely low	Extremely low	Extremely low
<b>Consumers</b>	Low	Low	High	High
<b>Overall PPD</b>	Low	Low	High	High

**Probability of establishment or spread**

The assessment for the probability of establishment or spread is carried out in the following manner. Firstly, partial probability for establishment and for spread was assessed separately based on the relevant available scientific information. Secondly, the conclusions for the combined partial probability of establishment or spread for each of the four exposure groups are provided at the end of this section. The relevant information for the assessment for the probability of establishment or spread is presented below against the factors listed in ISPM 11, Rev. 1.

**Partial probability of establishment**

ISPM 11 factor	Relevant information
<b>Availability of suitable hosts, alternate hosts and vectors in the PRA area</b>	<ul style="list-style-type: none"> <li>Caterpillars of greenheaded and brownheaded leafrollers have been recorded on more than 200 plant species in 71 families. While many of these are true host plants, which enable the insect to complete its full life cycle, others may be only temporary hosts for the caterpillars, which move off onto other host plants (HortResearch, 1999b).</li> </ul>

<sup>46</sup> Partial probability of distribution is actually referring to the probability of entry and was estimated by @risk.

ISPM 11 factor	Relevant information
<b>Suitability of the environment</b>	<ul style="list-style-type: none"> <li>Some of the more important and common hosts of leafrollers are: apples, pears, grapes, citrus, stonefruits, kiwifruit, feijoa, berryfruits, walnut, lupin, tree lupin, ivy, camellia, laurel, hebe, polyanthus, coprosma and young conifers (HortResearch, 1999b).</li> <li>Other host plants include pohutakawa, karaka, mahoe, poroporo, willow, honeysuckle, privet, poplar, Eucalyptus, cyclamen, orchids, roses, and clover.</li> <li>Many shelterbelt species (eg. willow, poplar, alders) are also excellent hosts for larval development.</li> <li>Many of these host plants are widely available in Australia</li> <li>Brownheaded and greenheaded leafrollers are found throughout New Zealand and some offshore islands where climatic conditions are similar to those of Australia.</li> <li>The environment (e.g. suitability of climate, soil, pest and host competition) in Australia would therefore be suitable for the establishment of these leafrollers.</li> </ul>
<b>The potential for adaptation of the pest</b>	<ul style="list-style-type: none"> <li>The genetic adaptability of brownheaded and greenheaded leafrollers is not known. However, they would have no problem to adapt to the climatic conditions in Australian environment considering they occur throughout all climatic zones of New Zealand (HortResearch, 1999b).</li> <li><i>Planotortrix octo</i> has developed resistance to the organophosphate insecticide azinphos-methyl and cross resistance to several other insecticides in Central Otago (Wearing, 1995a) and Hawke's Bay (Lo <i>et al.</i>, 1997; Lo, 2003).</li> <li><i>Ctenopseustis obliquana</i> has developed resistance to the organophosphate insecticide azinphos-methyl and cross-resistance to the Insect Growth Regulator Mimic™ in Hawke's Bay and resistance to a pyrethroid in Bay of Plenty (Lo, 2003).</li> </ul>
<b>The reproductive strategy of the pest</b>	<ul style="list-style-type: none"> <li>These leafrollers can only reproduce sexually and produce from two to six overlapping generations a year depending on latitude and climate.</li> <li>Development is temperature driven with the threshold temperature for development determined to be 4.8°C for BHLR and 6.1°C for GHLR and larval development is slowed considerably during the winter (HortResearch, 1999b).</li> <li>In the central New Zealand region there is no winter resting stage (HortResearch, 1999b).</li> <li>Development for GHLR from egg to adult can be completed in 4-6 weeks in summer (Landcare Research, 1999).</li> <li>GHLR and BHLR produce distinct female sex pheromones that are released in the evening and night, but particularly around dusk, to attract males over long distances.</li> </ul>

ISPM 11 factor	Relevant information
	<ul style="list-style-type: none"> <li>Females are normally mated once, although both sexes are capable of mating more often. Most mating occurs 1-4 days after adult emergence.</li> <li>Fecundity is highly variable between individual females and in one study ranged from 52–282 eggs/female for GHLR and from 58–429 eggs/female for BHLR when larvae were fed on apple foliage. Variation in fecundity is determined primarily by weather conditions, and probably the quality and succession of host plants.</li> <li>Egg infertility in New Zealand under natural conditions is rare at less than 1% and inviability (failure to hatch) averaging only 2% of eggs (HortResearch, 1999b).</li> <li>Successful mating between a male and a female must occur within the limited lifespan of the adult.</li> </ul>
<b>Minimum population needed for establishment</b>	<ul style="list-style-type: none"> <li>Population can start from a single mated female which lay 2-170 eggs.</li> </ul>
<b>Cultural practices and control measures</b>	<ul style="list-style-type: none"> <li>Pest control programs are similar between New Zealand and Australia. Integrated Pest Management (IPM) and Integrated Fruit Production (IFP) programmes are utilised in the production of Australian apples (APAL, 2003). Similarly New Zealand orchardists employ IFP in the production of their fruit (ENZA, 2003; Anonymous, 2002b).</li> <li>Mating disruption is also being used for resistance management of these leafrollers in New Zealand (HortResearch, 1999b) and the bacterial spray <i>Bacillus thuringiensis</i> is frequently used for organic control of leafrollers (HortResearch, 1999b).</li> <li>Some parasitoids introduced from Australia for the control of light brown apple moth in New Zealand have also attacked these leafrollers and are now found in their populations (HortResearch, 1999b).</li> </ul>

*Conclusion—partial probability of establishment*

Based on the above evidence, partial probability of establishment for each of the exposure groups is assessed as follows.

Partial probability of establishment for commercial fruit crops: **High**.

Partial probability of establishment for nursery plants: **High**.

Partial probability of establishment for household and garden plants: **High**.

Partial probability of establishment for wild and amenity plants: **High**.

***Partial probability of spread***

<b>ISPM 11 factor</b>	<b>Relevant information</b>
<b>Suitability of natural and/or managed environment</b>	<ul style="list-style-type: none"> <li>These species have been reported from all over New Zealand. There are similar environments in Australia that would be suitable for their spread.</li> </ul>
<b>Presence of natural barriers</b>	<ul style="list-style-type: none"> <li>There is little information on the ability of these leafrollers to spread beyond natural barriers. The long distances existing between the main Australian commercial orchards would make it difficult for these leafrollers to disperse directly from one area to another unaided.</li> <li>However the highly polyphagous nature of these species should enable them to locate suitable hosts in the intervening areas.</li> <li>In the Auckland area the lower threshold temperature for flight has been estimated at 10–12°C (HortResearch, 1999b).</li> </ul>
<b>Potential for movement with commodities or conveyances</b>	<ul style="list-style-type: none"> <li>Larvae that are in the calyx or feeding internally would be distributed through the wholesale or retail trade of apples.</li> </ul>
<b>Intended use of the commodity</b>	<ul style="list-style-type: none"> <li>Apples would be used mostly for human and are not intended for propagation purposes.</li> </ul>
<b>Potential natural enemies</b>	<ul style="list-style-type: none"> <li>Some parasitoids present in Australia would be able to attack these leafrollers because several species (such as <i>Goniozus jacintae</i>, <i>Glavidorsum stokesii</i>, <i>Xanthopimpla rhopaloceros</i> and <i>Trigonospila brevifacies</i>) have actually been introduced from Australia for the control of light brown apple moth in New Zealand (HortResearch, 1999b) and have shown to also attack these leafrollers.</li> </ul>

***Conclusion—partial probability of spread***

Based on the above evidence, partial probability of spread for each of the exposure groups is assessed as follows.

Partial probability of spread for commercial fruit crops: **High**.

Partial probability of spread for nursery plants: **High**.

Partial probability of spread for household and garden plants: **High**.

Partial probability of spread for wild and amenity plants: **High**.

***Combined partial probability of establishment or spread***

The combined partial probability of establishment or spread was determined by combining probabilities of establishment and probabilities of spread using the matrix of ‘rules’ for combining descriptive likelihoods as presented in the method section. The results are indicated in Table 59.

**Table 59 Combined partial probabilities of establishment or spread of leafrollers**

	<b>Commercial fruit crops</b>	<b>Nursery plants</b>	<b>Household and garden plants</b>	<b>Wild and amenity plants</b>
<b>Establishment</b>	High	High	High	High
<b>Spread</b>	High	High	High	High
<b>PPES<sup>47</sup></b>	High	High	High	High

Additional evidence to support the combined partial probability of establishment or spread for specific exposure groups is provided in the text below.

<b>Commercial fruit crops</b> <b>High</b>	<ul style="list-style-type: none"> <li>The leafrollers attack a wide range of hosts such as apples, pears, grapes, citrus, stonefruits, kiwifruit, feijoa, berryfruits, walnut, and lupin. Commercial crops of these hosts are widely distributed in Australia.</li> </ul>
<b>Nursery plants</b> <b>High</b>	<ul style="list-style-type: none"> <li>The most important factor for establishment or spread in nursery plants is the availability of several plant species commonly sold in nurseries that are available as alternate hosts. Australian nurseries carry a wide range of host evergreen garden shrubs and trees for example, species of <i>Acacia</i>, <i>Boronia</i>, <i>Buddleia</i>, camellia, <i>Citrus</i>, <i>Daphne</i>, <i>Escallonia</i>, <i>Eucalyptus</i>, fuchsia, geranium, holly, ivy, <i>Jasminium</i>, magnolia, <i>Photinia</i>, <i>Pinus</i>, privet, <i>Rhododendron</i>, and rose.</li> </ul>
<b>Household and garden plants</b> <b>High</b>	<ul style="list-style-type: none"> <li>Many of the host plants listed for these leafrollers are grown in Australian household gardens as ornamentals so there are numerous hosts available.</li> </ul>
<b>Wild and amenity plants</b> <b>High</b>	<ul style="list-style-type: none"> <li>Many host plants of brownheaded and greenheaded leafrollers are found growing wild in Australia such as species of <i>Acacia</i>, <i>Eucalyptus</i>, <i>Leptospermum</i>, poplars, willows and blackberry that could provide suitable hosts.</li> <li>Existing control programmes with broad spectrum insecticides are not normally applied to wild and amenity plants.</li> <li>GHLR and BHLR caterpillars often disperse into apple orchards from surrounding shelterbelt host plants in New Zealand (HortResearch, 1999b).</li> </ul>

## Assessment of consequences

Impact scores allocated for the direct and indirect criteria are shown in Table 60. Available supporting evidence is provided in the text below.

<sup>47</sup> PPES = partial probability of establishment or spread.



**Table 60 Impact scores for leafrollers**

<b>Direct impact</b>	<b>Impact scores</b>
Plant life or health	D
Human life or Health	A
Any other aspects of environment	A
<b>Indirect impact</b>	
Control or eradication	D
Domestic trade or industry	D
International trade	D
Environment	B
Communities	A

**Direct impact**

- Plant life or health – D** Consequences affecting plant life or health are unlikely to be discernible at national level and of minor significance at the regional level. Thus a rating of ‘D’ was assigned for this criterion.
- Wearing *et al.* (1991) rated these leafrollers as primary economic pests in New Zealand where they damage the leaves, buds and fruit of their hosts.
  - These leafrollers are pests of apples, pears, stonefruit, berries, oaks, conifers, cotoneaster and ivy.
  - These species are highly polyphagous feeding on over 200 species of plant both economic (such as fruit trees, vines as well as apples) and non-economic in 71 families (HortResearch, 1999b).
  - All four species cause similar damage to foliage and fruits and there is no way of distinguishing the damage of different species.
  - Hatching caterpillars settle mainly on the lower surfaces of leaves where they feed near the main veins typically creating small windows. Other young larvae are commonly found on the shoot tips or areas of new growth, where they web the leaves together with silk or they settle in the calyx of fruits such as apple. Later instar larvae migrate from these settlement positions to construct feeding niches between adjacent leaves, between a leaf and a fruit, in a developing bud, or on a single leaf, where the leaf roll develops.
  - Leaf feeding and shoot damage often include leaf folding and rolling and shoot distortion.
  - Buds of deciduous host plants are especially vulnerable to

attack in the winter and early spring, when the interior of the buds may be eaten.

- Leaves are webbed to the fruit and feeding injury takes place under the protection of the leaf; or larvae spin up between fruits of a cluster.
- Surface fruit damage is common in short-stemmed apple varieties such as Cox's Orange Pippin, Sturmer Pippin, which form compact fruit clusters.
- Young larvae biting through the skin cause small, circular 'stings'.
- In crops such as kiwifruit, plum, grapefruit, and apple, the maturing fruit produces a layer of corky tissue over the damage by leafrollers.
- The fruit surface is eaten and some caterpillars bore into the fruit, particularly through the calyx. Internal damage to apple, and pear fruits is much less common than surface damage. They can also cause internal damage to apricots, peaches, and walnuts.
- Faecal pellets (frass) are often found with damage. Leafroller damage is characterised by silken webbing on both fruits and foliage, and even bud damage in winter/spring.
- On *Pinus*, GHLR web needles together and form them into a tube that kills the needles, which then turn brown and hard.
- Greenheaded leafroller larvae feed on foliage, stems, growing points, flowers and green cones and in winter buds and stems are attacked resulting in malformation and retardation of growth of young stems (Anonymous, 1983).
- All life stages are present throughout the year especially in the warmer regions around Waikato and Auckland. Two to four overlapping generations occur annually depending on latitude and host plant.

**Human life or health – A**

There are no known direct impacts of GHLR and BHLR on human life or health and the rating assigned to this criterion was therefore 'A'.

**Any other aspects of environmental effects – A**

There are no known direct impacts of the leafrollers on any other aspects of the environment and a rating of 'A' was assigned to this criterion.

**Indirect impact**

**Control or eradication – D**

The indirect impact on new or modified eradication, control, surveillance/monitoring and compensation strategies is unlikely to be discernable at national level and of minor significance at the regional level. A rating of 'D' was assigned to this criterion.

- In New Zealand these species are kept under control by the application of organophosphate insecticides and insect growth

regulators that are also used for the control of other pests such as apple leafcurling midge and other leafrollers, in particular light brown apple moth (HortResearch, 1999b).

- *Planotortrix octo* and *Ctenopseustis obliquana* have already developed resistance and cross-resistance to various organophosphates and insect growth regulators in New Zealand (Wearing, 1995a; Lo *et al.*, 1997; Lo, 2003). Thus it would be difficult to eradicate these pests using chemical sprays alone. The extremely wide range of host species for these species would also make it difficult to completely eradicate them from the natural environment.
- In organic orchards, control of leafrollers is difficult.
- Mating disruption, *Bacillus thuringiensis* and pyrethrum are being investigated but are not widely used (McLaren and Fraser, 1994). Despite the activity of natural enemies they are inadequate for commercial leafroller control (McLaren and Fraser, 1994).
- Although the New Zealand native pest leafrollers have been reasonably well studied in New Zealand it would be essential to provide resources to study the pest under Australian conditions should they become established in Australia.

#### Domestic trade or industry – D

The indirect consequences on domestic trade are unlikely to be discernable at national level and of minor significance at the regional level. A rating of ‘D’ was assigned to this criterion.

- The presence of any species of these leafrollers in Australia could result in trade restrictions in the movement of fruit within that district and region and between states.
- It can also restrict in the sale of fruit because damaged fruit would not meet consumer’s expectations. BHLR and GHLR cause superficial fruit damage on apple and stone fruits. Stone fruits ‘bleed’ considerable amounts of sap or jelly, on which secondary diseases may develop, while in kiwifruit, plum, grapefruit and apple the maturing fruit produces a layer of corky tissue over the damage, helping to prevent secondary infections (Thomas, 1998).

#### International trade – D

The indirect consequences on international trade are unlikely to be discernable at national level and of minor significance at the regional level. A rating of ‘D’ was assigned to this criterion.

- In the case of New Zealand, when the presence of leafrollers on harvested fruit exceed a maximum pest limit as defined by importing countries it can lead to the rejection of the cargo or subsequent fumigation on-arrival (Jamieson *et al.*, 2000).
- If these leafrollers become established in Australia our trading partners would require the same treatment as the ones applied to New Zealand.
- Consumers in the European Community (including the UK) expect the production of food to be based on environmentally

friendly techniques that promote sustainable methods with minimal impact on the environment and reduced use of pesticides (Batchelor *et al.*, 1997; Lo *et al.*, 1997). The establishment of these leafrollers in Australia would result in an increase in the use of pesticides for their control that would result in consumers in the premium European markets rejecting Australian produce on the basis of environmentally unsustainable practices.

#### Environment – B

The indirect consequences on environment would not be discernible at the national level and of minor significance at the local level and a rating of ‘B’ was assigned to this criterion.

The impact on environment by these leafrollers can result from chemical control, biological control and feeding damage on native plants.

- Increased insecticide use can cause undesired effects on the environment;
- *Planotortrix octo* has developed resistance to the organophosphate insecticide azinphos-methyl and cross resistance to several other insecticides in Central Otago (Wearing, 1995a) and Hawke’s Bay (Lo *et al.*, 1997; Lo, 2003). *Ctenopseustis obliquana* has developed resistance to the organophosphate insecticide azinphos-methyl and cross-resistance to the Insect Growth Regulator Mimic™ in Hawke’s Bay and resistance to a pyrethroid in Bay of Plenty (Lo, 2003). Insecticide use would increase if the leafrollers become established in Australia and this would have undesirable impact on the environment.
- Control of greenheaded leafrollers and brownheaded leafrollers is primarily dependent on the application of broad-spectrum insecticides such as organophosphates, carbamates, and to a limited extent, synthetic pyrethroids, that are applied against other key apple pests in conventional New Zealand orchards. These highly toxic products have provided very effective control of leafrollers and other pests but they have had the disadvantage of wider toxicity to many natural enemies.
- Recently, the chemical industry has developed effective insect growth regulator compounds, which combine high toxicity to leafrollers with safety to many important beneficial species.
- The introduction of other biocontrol agents can affect existing biological control programmes of other leafrollers particularly light brown apple moth.
- The introduction of new biocontrol agents of these leafrollers would affect the simplified orchard ecosystem as well as native ecosystems in the vicinity of orchards in the first instance, particularly if the biocontrol agents turn out to be not host specific in the wild.
- A wide range of beneficial predators, and parasitoids attack

greenheaded and brownheaded leafrollers but these have never been the primary method of control in commercial orchards.

- An increase in organic production of apples means the natural enemies of greenheaded and other leafrollers have become more important.
- However, parasitoids introduced for control of light brown apple moth (an Australian species) have been found parasitising GHLR and BHLR. These include *Goniozus jacintae* and *Glabridorsum stokesii*, *Trigonospila brevifacies*, and *Xanthopimpla rhopaloceros* from Australia. These are contributing to reducing pest populations of GHLR and BHLR not only in orchards but also on their many host plants in the surrounding environment. This could minimise immigration of moths into orchards and reduce the need for chemical control (HortResearch, 1999b).
- Another biological method of controlling greenheaded and brownheaded leafrollers is mating disruption, which uses high concentrations of the appropriate insect pheromone to prevent mating (HortResearch, 1999b).
- Insect pathogens, such as bacteria (eg. *Bacillus thuringiensis*) and viruses, offer an alternative method of biological control (HortResearch, 1999b).
- Native plant communities as well as crop species would be affected following the introduction of these leafrollers given the wide host range of these species that includes genera such as *Acacia*, *Acmena*, *Boronia*, *Eucalyptus* and *Leptospermum*, which are such dominant representatives of the Australian flora.
- The establishment or spread of greenheaded or brownheaded leafrollers in native vegetation would result in a cost for environmental restoration associated with an eradication program.

#### **Communities – A**

There are no recorded social effects resulting from the presence of brownheaded or greenheaded leafrollers and a rating of ‘A’ was assigned to this criterion.

#### **Conclusion—consequences**

Based on the decision rule described in the method section, i.e. where the consequences of a pest with respect to one or more criteria are ‘D’, the overall consequences are considered to be ‘low’. Therefore the overall consequences of brownheaded and greenheaded leafrollers are **low**.

#### **Unrestricted annual risk**

Unrestricted annual risk is the result of combining annual probability of entry, establishment or spread with the outcome of overall consequences. Probabilities and consequences are

combined using the ‘rules’ shown in the risk estimation matrix in the method section. The unrestricted annual risk estimation for leafrollers is shown in Table 61.

**Table 61 Risk estimation for leafrollers**

Overall probability of entry, establishment or spread <sup>48</sup>	<b>High</b>
Consequences	<b>Low</b>
Unrestricted annual risk	<b>Low</b>

As indicated in Table 61, the unrestricted risk for brownheaded and greenheaded leafrollers is low, which is above Australia’s appropriate level of protection (ALOP) of very low. Therefore, risk management would be required for these pests.

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<sup>48</sup> Calculated by @ risk.

**Native leafroller****Biology**

The Native leafroller (NLR), *Pyrgotis plagiatana* Walker, has the following life stages: adult, egg, larva (or caterpillar) and pupa.

There is no published study on the biology of this species. Native leafroller is occasionally found attacking apples and pears, particularly in Otago (HortResearch, 1999b). From the illustration provided in Dugdale (1971) the larvae of NLR are 10–11 mm long.

**Risk scenario**

The risk scenario of concern for NLR is the probable feeding and contamination by larvae on apple fruit.

## Probability of importation

The initiating step for the importation scenario for apple fruit is the sourcing of apples from orchards in New Zealand, while the end-point is the release of imported apples from the port of entry. The importation scenario is divided into eight steps and the likelihood of the NLR being present at each step is summarised in Figure 25. The available evidence supporting the likelihood assessments is provided in the text below.

**Figure 25 The importation steps and the likelihood of the native leafroller being present at each step**





<p><b>Importation step 1 (Imp1)</b></p> <p><b>Very low</b></p>	<p>The likelihood that NLR is present in the source orchards in New Zealand: <b>Very low</b></p> <ul style="list-style-type: none"> <li>• Native leafroller is widespread in New Zealand and has been recorded from both North and South Islands along with some offshore islands (Dugdale, 1971; Dugdale, 1988).</li> <li>• Native leafroller feeds on many native New Zealand host plants.</li> <li>• Native leafroller is associated principally with Myrtacea and conifers (Dugdale, 1971).</li> <li>• This native leafroller species is occasionally found attacking apples and pears, particularly in Otago (HortResearch, 1999b).</li> </ul>
<p><b>Importation step 2 (Imp2)</b></p> <p><b>Very low</b></p>	<p>The likelihood that picked apple fruit is infested with NLR: <b>Very low</b></p> <ul style="list-style-type: none"> <li>• There is no report available about which parts of the apple tree this species attacks.</li> <li>• Native leafroller is only an occasional or incidental pest species on apple (Wearing <i>et al.</i>, 1991; HortResearch, 1999b).</li> </ul>
<p><b>Importation step 3 (Imp3)</b></p> <p><b>Extremely Low</b></p>	<p>The likelihood that clean fruit is contaminated by NLR during harvesting and transport of apples to the packing house: <b>Extremely low</b></p> <ul style="list-style-type: none"> <li>• Fruit are picked into harvesting bags and then transferred into bins kept on the ground in the orchard prior to transportation to the packing house.</li> <li>• Native leafroller is only an occasional or incidental pest of apple particularly in Otago and therefore it is extremely unlikely that NLR will contaminate clean fruit.</li> </ul>
<p><b>Importation step 4 (Imp4)</b></p> <p><b>High</b></p>	<p>The likelihood that NLR survives routine processing procedures in the packing house: <b>High</b></p> <p>The following packing house operations may influence the survival of NLR.</p> <p><i>Washing</i></p> <ul style="list-style-type: none"> <li>• It is not known if NLR feeds on apple fruit. If it does and only feeds on the surface of the fruit, the caterpillars would be washed off in the water dump or by high-volume/high pressure washing. However, if it can feed internally, washing would not be effective in removing the larvae.</li> </ul> <p><i>Brushing</i></p> <ul style="list-style-type: none"> <li>• The size of the larvae ranging from 10-11 mm indicates they are likely to be brushed off the surface of fruit.</li> </ul>

#### *Waxing*

- There is no evidence indicating that the larvae would not be able to survive waxing.

#### *Sorting and grading*

- The relatively large size of the larvae (10-11 mm) would ensure that they would be detected during sorting and grading.

#### *Packaging*

- Packaging would have little effect on the survival of the native leafroller. In most cases the packaging of apples is designed to maximise heat discharge from the fruit while minimising loss of moisture.

#### *Cold Storage*

- There is no data available on the impact of cold storage on the survival of NLR larvae on apple fruit.

#### *Summary*

It is not known if this species attacks or even develops inside apple fruit. However, native leafroller has been detected during preclearance of NZ apples to the USA (0.007 per million pre-cleared fruit) (MAFNZ, 2003b) indicating that some NLR larvae survive packing house procedures. Based on this evidence the likelihood for Imp4 was assessed as **high**.

#### **Importation step 5 (Imp5)**

**Negligible**

The likelihood that NLR clean fruit is contaminated by NLR during processing in the packing house: **Negligible**

- The fact that NLR only occasionally attacks apple indicates that it is not very prevalent in orchards in New Zealand and is rarely encountered on apple fruit.
- Any larvae remaining on the fruit will not contaminate any more fruit than are already contaminated even if they are dislodged from fruit during packing house processes.

#### **Importation step 6 (Imp6)**

**High**

The likelihood that NLR survives palletisation, quality inspection, containerisation and transportation to Australia: **High**

- There is a lack of information on this species' ability to survive cold conditions and therefore it is difficult to assess whether or not the species can survive transportation and cold storage.
- Packaging would have little affect on the viability of the remaining larvae. In most cases the packaging of apples is designed to maximise heat discharge from the fruit while minimising loss of moisture providing ideal conditions for any surviving caterpillars.

**Importation step 7  
(Imp7)****Negligible**

The likelihood that clean fruit is contaminated by NLR during palletisation, quality inspection, containerisation and transportation: **Negligible**

- The fact that NLR only occasionally attacks apple indicates that it is not very prevalent in orchards in New Zealand and is rarely encountered on apple fruit.
- Any larvae remaining on the fruit will not contaminate any more fruit than are already contaminated even if they are dislodged from fruit.

**Importation step 8  
(Imp8)****High**

The likelihood that native leafroller survives and remains with fruit after on-arrival minimum border procedures: **High**

- The minimum on-arrival border procedures as described in the method section would not be effective in detecting the larvae.

***Conclusions—probability of importation***

When the above likelihoods were inserted into the simulation model, the probability of importation for native leafroller on apples from one year of trade was found to be **extremely low**.

**Probability of distribution**

The initiating step for the distribution scenario is the release of imported apples from the port of entry, while the last step is the pest being distributed (as a result of the processing, sale or disposal of these apple fruit) in a viable state to an endangered area and subsequently being transferred to a suitable host.

In order to assess the probability of distribution, the distribution scenario is addressed in three subheadings below. First is a brief description of sequences of events leading to a successful exposure of the pest from infested/infected apple to a susceptible host plant. Second is the assessment of partial probability of distribution of the pest in relation to each of the exposure groups. Third is the conclusion for the probability of distribution.

***Sequence of events for successful exposure***

The sequence of events that has to be completed for a successful exposure of a susceptible host to the pest is summarised below.

The insect stage associated with the apple would be the larva. If the larvae survive cold storage and mature after the apples have been taken out of cold storage, they could leave the fruit and find a site to pupate. There would be mortality during the larva's search for a pupating site. The emerged adults would be able to enter the environment after they emerge from pupae i.e. during packing or unpacking of the fruit, from repacking facilities or retailers (utility points), from discarded fruit in waste, and from landfills where the waste is disposed.

Both adult males and females are winged and most are able to fly. Sexual reproduction is essential in native leafroller.

A successful exposure of native leafroller from infested fruit to its hosts means that mature larvae need to leave fruit to pupate, pupae need to develop to become adults, and adult females would need to locate a male to mate with and lay its eggs on a susceptible host plant.

### ***Partial probability of distribution***

The partial probability of distribution (PPD) was estimated separately for each of the four exposure groups: commercial fruit crops, nursery plants, household and garden plants, and wild and amenity plants.

The details and the method of calculation for the PPD of the four exposure groups are explained in the method section and the results are presented in a series of tables and figures below. The information from these tables and figures was used to assess the probability of distribution of NLR to all the exposure groups.

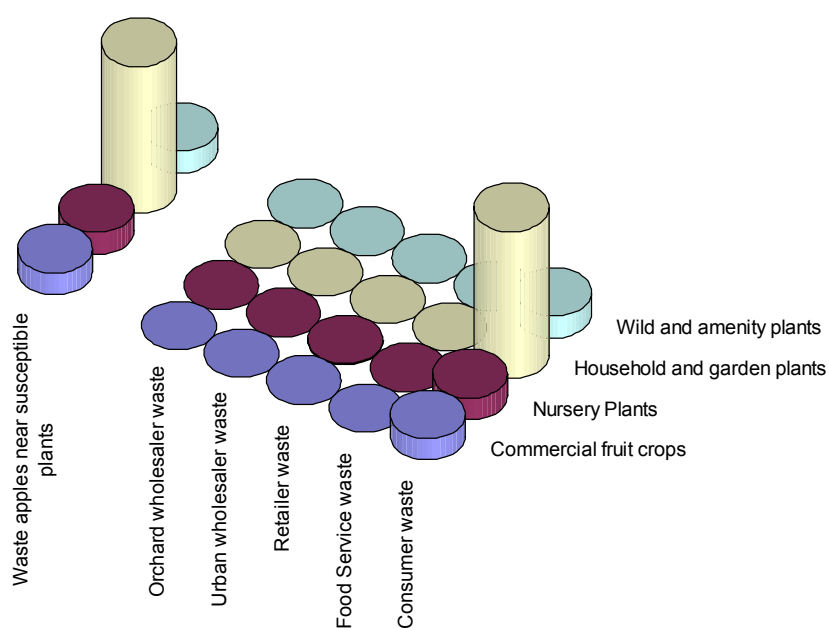
Table 62 indicates the proportions of the five utility points near each of the exposure groups of NLR. Native leafrollers are polyphagous feeding on species of *Cassinia*, *Coprosma*, *Dacrydium*, *Hebe*, *Pittosporum*, *Pleurophyllum*, *Podocarpus* as well as apple and pear; several of these hosts are available in Australia.

**Table 62 The proportions of utility points near host plants susceptible to native leafroller in the four exposure groups**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Proximity</b> Orchard wholesalers	Certain	Very low	Very low	Very low
<b>Proximity</b> Urban wholesalers	Extremely low	Extremely low	Extremely low	Extremely low
<b>Proximity</b> Retailers	Very low	Very low	Extremely low	Extremely low
<b>Proximity</b> Food services	Extremely low	Extremely low	Extremely low	Extremely low
<b>Proximity</b> Consumers	Very low	Very low	Low	Very low

Figure 26 gives a pictorial representation of the relative amounts of infested/infected apples, an escaped pest or contaminated packaging material discharged or discarded from different utility points near each of the exposure groups of native leafroller.

**Figure 26 Pictorial representation of the relative amounts of infested/infected apple waste<sup>49</sup> from utility points to near exposure groups of native leafroller**



<sup>49</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or an escaped pest, or contaminated packaging material.

Table 63 is the summary of the probability that exposure of the host plants would result from discharge or discard of a single infested/infected apple, or an escaped pest, or contaminated packaging material from different utility points. Evidence is provided in the text below under different exposure groups.

**Table 63 The probability of exposure of susceptible host plants of native leafroller from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Exp</b> Orchard <sup>50</sup> wholesaler waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Urban wholesaler waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Retailer waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Food service waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Consumer waste	Negligible	Negligible	Negligible	Negligible

#### *Commercial fruit crops*

##### *Commercial fruit crops near utility points*

The proportions of the five utility points near commercial fruit crops of native leafroller are shown in Table 62. It was estimated that commercial fruit crops are certain to be located near orchard wholesalers, very unlikely to be near retailers and consumers, and extremely unlikely to be near urban wholesalers and food service as most of these are in metropolitan areas.

The relative amounts of infested/infected apples, an escaped pest, or contaminated packaging material discharged or discarded from different utility points to near commercial fruit crops susceptible to native leafroller is indicated in Figure 26.

##### *Exposure to host*

The commercial fruit crops of native leafroller include only apples and pears.

A successful exposure of native leafroller from infested fruit to its hosts means that mature larvae need to leave fruit to pupate, pupae need to develop to become adults, and adult females would need to locate a male to mate with and lay its eggs on a susceptible host plant. The chance for this to happen depends on several factors, including the mortality caused by

<sup>50</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or escaped pest, or contaminated packaging material.

the handling and consumption of fruit and mortality during the larva's search for a pupating site, the level of infestation/infection and number of apples in the same utility points, reproductive strategy, life span of the pest and availability and susceptibility of hosts.

As shown in Table 63, it is considered that the probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

<p><b>Exp</b> commercial fruit crops from orchard wholesaler waste <b>Negligible</b></p>	<p>The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>• Pomefruit hosts are common in commercial orchards.</li> <li>• Handling of fruit in orchard wholesalers would increase mortality of native leafroller.</li> </ul>
<p><b>Exp</b> commercial fruit crops from urban wholesaler waste <b>Negligible</b></p>	<p>The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>• Commercial fruit crops are not located in urban areas.</li> <li>• Urban wholesaler waste is disposed into bins and taken to landfills. Commercial fruit crops are unlikely to be located adjoining these sites.</li> </ul>
<p><b>Exp</b> commercial fruit crops from retailer waste <b>Negligible</b></p>	<p>The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>• Most retailers are located in urban areas not closed to commercial fruit crops.</li> <li>• Retailer waste may be used for composting in rural areas and some of these sites may be near commercial orchards.</li> </ul>
<p><b>Exp</b> commercial fruit crops from food service waste <b>Negligible</b></p>	<p>The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>• Most food service providers are located in metropolitan and suburban areas. Waste produced by people in metropolitan areas and some in urban areas is generally disposed into landfills. Commercial fruit crops would usually not be present adjoining these sites.</li> <li>• Population densities around commercial orchards are very low.</li> <li>• Some food service waste in suburban and rural areas may be utilised for composting. Commercial fruit crops can be present close to compost heaps.</li> </ul>

**Exp** commercial fruit crops  
from consumer waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Majority of consumers are located in metropolitan and suburban areas. Waste produced by people in metropolitan areas and some in urban areas is generally disposed into landfills. Commercial fruit crops would usually not be present adjoining these sites.
- Households and population densities around commercial orchards are very low.
- Some consumer waste in suburban and rural areas may be utilised for composting. Commercial fruit crops can be present close to compost heaps.

### *Nursery plants*

#### *Nursery plants near utility points*

The proportions of the five utility points near nursery plants of native leafroller are shown in Table 62. It was estimated that nursery plants are unlikely to be near retailers, very unlikely to be near orchard wholesalers, retailers and consumers, and extremely unlikely to be near urban wholesalers and food services.

The relative amounts of waste apples discharged or discarded near nursery plants susceptible to native leafroller are indicated in Figure 26.

#### *Exposure to host*

Nursery hosts of native leafroller include apples, pears, *Cassinia*, *Coprosma*, *Hebe*, and *Pittosporum*.

A successful exposure of native leafroller from infested fruit to its hosts means that mature larvae need to leave fruit to pupate, pupae need to develop to become adults, and adult females would need to locate a male to mate with and lay its eggs on a susceptible host plant. The chance for this to happen depends on several factors, including the mortality caused by the handling and consumption of fruit and casualties during the larva's search for a pupating site, the level of infestation/infection and number of apples in the same utility points, reproductive strategy, life span of the pest and availability and susceptibility of hosts.

As shown in Table 63, it is considered that the probability that exposure of nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** nursery plants from  
orchard wholesaler waste  
**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Host plants such as apple, pear, *Cassinia*, *Coprosma*, *Hebe*, and *Pittosporum* are common in nurseries.
- Retail garden nurseries have a high density of a range of plant



materials in a small area. They often maintain a high hygienic standard, usually fogging with insecticide, to prevent insect attacks.

- There are rare instances of nurseries being located near to orchard wholesaler waste.

**Exp** nursery plants from urban  
wholesaler waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

- There are rare instances of nurseries being located near to urban waste dumps.
- Host plants such as apple, pear, *Cassinia*, *Coprosma*, *Hebe*, and *Pittosporum* are common in nurseries.

**Exp** nursery plants from retailer  
waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Suitable nursery plants are common in nurseries in the temperate regions of Australia, year round.
- Retail garden nurseries have a high density of a range of plant materials in a small area. They often maintain a high hygienic standard, usually fogging with insecticide, to prevent insect attacks.

**Exp** nursery plants from food  
service waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Most food services are in metropolitan and suburban areas and their waste is disposed into landfills. Nurseries are generally not located near these sites.

**Exp** nursery plants from  
consumer waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. Nurseries are generally not located near these sites.

### *Household and garden plants*

#### *Household and garden plants near utility points*

The proportions of the five utility points near household and garden plants of native leafroller are shown in Table 62. It was estimated that household and garden plants are unlikely to be near consumers, very unlikely to be near orchard wholesalers and extremely unlikely to be near urban wholesalers, retailers and food services.

The relative amounts of waste apples discharged or discarded near household and garden plants susceptible to native leafroller are indicated in Figure 26.

### *Exposure to host*

Household and garden plant hosts of native leafroller include apples, pears, *Cassinia*, *Coprosma*, *Hebe*, and *Pittosporum*.

A successful exposure of native leafroller from infested fruit to its hosts means that mature larvae need to leave fruit to pupate, pupae need to develop to become adults, and adult females would need to locate a male to mate with and lay its eggs on a susceptible host plant. The chance for this to happen depends on several factors, including the mortality caused by the handling and consumption of fruit and casualties during the larva's search for a pupating site, the level of infestation/infection and number of apples in the same utility points, reproductive strategy, life span of the pest and availability and susceptibility of hosts.

As shown in Table 63, it is considered that the probability that exposure of household and garden plants would result from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** household and garden  
plants from orchard wholesaler  
waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Orchard wholesale waste sites are mostly located within the orchard premises and are not located near household and garden plants.

**Exp** household and garden  
plants from urban wholesaler waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible.**

- Urban wholesaler waste is disposed into landfill sites, which are generally not near residential properties.

**Exp** household and garden  
plants from retailer waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Retailer waste would be disposed to landfills, which are generally not near residential properties.

**Exp** household and garden  
plants from food service waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Food service waste would be disposed to landfills, which are generally not near residential properties.

**Exp** household and garden  
plants from consumer waste  
**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Most consumers in metropolitan and suburban areas dispose of their waste to landfills, which are generally not near household and garden plants.
- However, utilisation of waste to make compost is becoming a common practice in some suburban and rural households.
- Hosts of native leafroller, including fruit trees and ornamental plants such as *Cassinia*, *Coprosma*, *Hebe*, and *Pittosporum*, are commonly grown as garden plants in the temperate regions of Australia.
- Host plants would be exposed to native leafroller from household apples such as an infected apple core that is composted in a garden.

*Wild and amenity plants*

*Wild and amenity plants near utility points*

The proportions of the five utility points near wild and amenity plants of native leafroller are shown in Table 62. It was estimated that wild and amenity plants are moderately likely to be near consumers, very unlikely to be near orchard wholesalers and retailers and extremely unlikely to be near urban wholesalers and food services.

The relative amounts of waste apples discharged or discarded near wild and amenity plants susceptible to native leafroller is indicated in Figure 26.

*Exposure to host*

Wild and amenity host plants of native leafroller include apples, pears, *Cassinia*, *Dacrydium*, *Pittosporum* and *Podocarpus*.

A successful exposure of native leafroller from infested fruit to its hosts means that mature larvae need to leave fruit to pupate, pupae need to develop to become adults, and adult females would need to locate a male to mate with and lay its eggs on a susceptible host plant. The chance for this to happen depends on several factors, including the mortality caused by the handling and consumption of fruit and casualties during the larva's search for a pupating site, the level of infestation/infection and number of apples in the same utility points, reproductive strategy, life span of the pest and availability and susceptibility of hosts.

As shown in Table 63, it is considered that the probability that exposure of wild and amenity plants would result from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** wild and amenity plants  
from orchard wholesaler waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Orchard wholesale waste sites are mostly located within the orchard premises and are not located near wild and amenity

plants.

- Susceptible feral plants e.g. *Coprosma* and *Pittosporum* may be present near orchard wholesalers waste disposal sites.

**Exp** wild and amenity plants  
from urban wholesaler waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

- Urban wholesale waste is disposed at landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. apple seedlings.

**Exp** wild and amenity plants  
from retailer waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Retailer waste would be disposed to landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. apple seedlings.

**Exp** wild and amenity plants  
from food service waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Food service waste would be disposed to landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. apple seedlings.

**Exp** wild and amenity plants  
from consumer waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. apple seedlings.
- Consumers discard apple cores in the environment or in bins in parks. Bins for waste in parks that may not be removed on a daily basis and these would provide a sheltered environment for the insect to emerge before the fruit desiccates or decays.
- Apple seedlings can establish from discarded apple cores. Susceptible wild and amenity plants, such as oaks may be present in parks, near recreational facilities and along roadsides. However, females would need to locate a male to mate with and lay her eggs on a susceptible host plant.
- Consumers who consider apple cores to be biodegradable indiscriminately discard them in the environment. Spoilt apples or cores discarded into the wild are likely to be isolated.

**Conclusion—probability of distribution**

The partial probability of distribution from each of the utility points to each of the exposure groups is summarised in Table 64. These were based on the data and assessment provided above and calculated by the simulation model using the @risk. The quantitative model evaluated the effect of the ‘volume of trade’ during a specified period when calculating the partial probability of distribution

**Table 64 Partial probabilities of distribution (PPD)<sup>51</sup> for native leafroller**

UTILITY POINTS	PPD			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Orchard wholesalers</b>	Negligible	Negligible	Negligible	Negligible
<b>Urban wholesalers</b>	Negligible	Negligible	Negligible	Negligible
<b>Retailers</b>	Extremely low	Extremely low	Negligible	Negligible
<b>Food services</b>	Negligible	Negligible	Negligible	Negligible
<b>Consumers</b>	Very low	Very low	Very low	Very low
<b>Overall PPD</b>	<b>Very low</b>	<b>Very low</b>	<b>Very low</b>	<b>Very low</b>

**Probability of establishment or spread**

The assessment for the probability of establishment or spread is carried out in the following manner. Firstly, partial probability for establishment and for spread was assessed separately based on the relevant available scientific information. Secondly, the conclusions for the combined partial probability of establishment or spread for each of the four exposure groups are provided at the end of this section. The relevant information for the assessment for the probability of establishment or spread is presented below against the factors listed in ISPM 11, Rev. 1.

**Partial probability of establishment**

ISPM 11 factor	Relevant information
<b>Availability of suitable hosts, alternate hosts and vectors in the PRA area</b>	<ul style="list-style-type: none"> <li>Caterpillars of native leafroller have been recorded on apple, pear, <i>Cassinia</i>, <i>Coprosma</i>, <i>Hebe</i>, and <i>Pittosporum</i> (HortResearch, 1999b).</li> <li>Many of these host plants are widely available in Australia.</li> </ul>
<b>Suitability of the environment</b>	<ul style="list-style-type: none"> <li>Native leafroller is found throughout New Zealand and some offshore islands where climatic conditions are similar to those</li> </ul>

<sup>51</sup> Partial probability of distribution is actually referring to the probability of entry and was estimated by @risk

ISPM 11 factor	Relevant information
<b>environment</b>	<p>of Australia.</p> <ul style="list-style-type: none"> <li>The environment (e.g. suitability of climate, soil, pest and host competition) in Australia would therefore be suitable for the establishment of native leafroller.</li> <li>Apple and pear are not grown in protected environments such as in glasshouses.</li> </ul>
<b>The potential for adaptation of the pest</b>	<ul style="list-style-type: none"> <li>The genetic adaptability of native leafroller is not known. However, it would have no problem to adapt to the climatic conditions in Australian environment considering they occur throughout all climatic zones of New Zealand (HortResearch, 1999b).</li> </ul>
<b>The reproductive strategy of the pest</b>	<ul style="list-style-type: none"> <li>Native leafroller only reproduces sexually.</li> <li>Successful mating between a male and a female must occur before eggs are produced.</li> </ul>
<b>Minimum population needed for establishment</b>	<ul style="list-style-type: none"> <li>After larvae have hatched from eggs they need to find a host, before they can develop, pupate and become adults and mate prior to laying their eggs to establish a new population.</li> </ul>
<b>Cultural practices and control measures</b>	<ul style="list-style-type: none"> <li>Pest control programs are similar between New Zealand and Australia. Integrated Pest Management (IPM) and Integrated Fruit Production (IFP) programmes are utilised in the production of Australian apples (APAL, 2003). Similarly New Zealand orchardists employ IFP in the production of their fruit (ENZA, 2003; Anonymous, 2002b).</li> </ul>

*Conclusion—partial probability of establishment*

Based on the above evidence, partial probability of establishment for each of the exposure groups is assessed as follows.

Partial probability of establishment for commercial fruit crops: **High**.

Partial probability of establishment for nursery plants: **High**.

Partial probability of establishment for household and garden plants: **High**.

Partial probability of establishment for wild and amenity plants: **High**.

*Partial probability of spread*

ISPM 11 factor	Relevant information
<b>Suitability of natural and/or managed environment</b>	<ul style="list-style-type: none"> <li>Native leafroller is reported from all over New Zealand. There are similar environments in Australia that would be suitable for their spread.</li> </ul>
<b>Presence of natural barriers</b>	<ul style="list-style-type: none"> <li>Both the adult male and female are winged and are capable of flight.</li> <li>The main commercial fruit crops of native leafroller are apple and pear crops that are located in six States of Australia, with natural</li> </ul>

ISPM 11 factor	Relevant information
	barriers including arid areas, climatic differentials and long distances existing between these areas. It would be difficult for the adults to disperse from one area to another unaided.
<b>Potential for movement with commodities or conveyances</b>	<ul style="list-style-type: none"> <li>• Other host plants such as <i>Cassinia</i> and <i>Pittosporum</i> are available between the commercial apple orchards in different areas would help the spread of native leafroller.</li> <li>• A mixture of adult flight and the transportation of infested apple trees would probably aid the movement of native leafroller within orchards.</li> <li>• The means of dispersal would include larvae on fruit.</li> <li>• Existing interstate quarantine control on the movement of nursery stock would reduce the scope for the spread.</li> </ul>
<b>Intended use of the commodity</b>	<ul style="list-style-type: none"> <li>• Apples would be used mostly for consumption by humans and would be widely distributed around the States.</li> <li>• Larvae on the fruit would be distributed with the commodity around the country.</li> </ul>
<b>Potential natural enemies</b>	<ul style="list-style-type: none"> <li>• There is no information of parasitoids of native leafroller and the relevance of potential natural enemies in Australia is not known.</li> </ul>

#### *Conclusion—partial probability of spread*

Based on the above evidence, partial probability of spread for each of the exposure groups is assessed as follows.

Partial probability of spread for commercial fruit crops: **High**.

Partial probability of spread for nursery plants: **High**.

Partial probability of spread for household and garden plants: **High**.

Partial probability of spread for wild and amenity plants: **High**.

#### ***Combined partial probability of establishment or spread***

The combined partial probability of establishment or spread was determined by combining probabilities of establishment and probabilities of spread using the matrix of 'rules' for combining descriptive likelihoods as presented in the method section. The results are indicated in Table 65.

**Table 65 Combined partial probabilities of establishment or spread of native leafroller**

	<b>Commercial fruit crops</b>	<b>Nursery plants</b>	<b>Household and garden plants</b>	<b>Wild and amenity plants</b>
<b>Establishment</b>	High	High	High	High
<b>Spread</b>	High	High	High	High
<b>PPES<sup>52</sup></b>	High	High	High	High

Additional evidence to support the combined partial probability of establishment or spread for specific exposure groups is provided in the text below.

<b>Commercial fruit crops</b> <b>High</b>	<ul style="list-style-type: none"> <li>Native leafroller attacks commercial hosts such as apples, pears. Commercial crops of apples and pears are widely distributed in Australia.</li> <li>Other host plants available between the commercial apple orchards in different areas would help the spread of native leafroller.</li> </ul>
<b>Nursery plants</b> <b>High</b>	<ul style="list-style-type: none"> <li>Native leafroller attacks apple, <i>Cassinia</i>, <i>Coprosma</i>, <i>Hebe</i>, and <i>Pittosporum</i> (HortResearch, 1999b).</li> </ul>
<b>Household and garden plants</b> <b>High</b>	<ul style="list-style-type: none"> <li>Many host plants, such as <i>Coprosma</i>, <i>Hebe</i> and <i>Pittosporum</i>, for native leafroller are grown in Australian household gardens as ornamentals so there are numerous hosts available.</li> </ul>
<b>Wild and amenity plants</b> <b>High</b>	<ul style="list-style-type: none"> <li>Many host plants that could provide suitable hosts for native leafroller, such as <i>Cassinia</i>, <i>Pittosporum</i> and <i>Podocarpus</i>, are found growing wild in Australia.</li> </ul>

## Assessment of consequences

Impact scores allocated for the direct and indirect criteria are shown in Table 66. Available supporting evidence is provided in the text below.

<sup>52</sup> PPES = partial probability of establishment or spread.



**Table 66 Impact scores for native leafroller**

<b>Direct impact</b>	<b>Impact scores</b>
Plant life or health	C
Human life or Health	A
Any other aspects of environment	A
<b>Indirect impact</b>	
Control or eradication	D
Domestic trade or industry	D
International trade	D
Environment	B
Communities	A

**Direct impact**

**Plant life or health – C** Consequences affecting plant life or health are unlikely to be discernible at national level and of minor significance at the district level. Thus a rating of ‘C’ was assigned for this criterion.

- Native leafroller occasionally attacks apples and pears particularly in Otago (HortResearch, 1999b) both of these are very important economic crops in Australia.
- Native leafroller is polyphagous feeding on several species of plant both economic and non-economic (such as *Cassinia*, *Coprosma*, *Hebe*, *Pittosporum* and *Podocarpus*) (HortResearch, 1999b).

**Human life or health – A** There are no known direct impacts of native leafroller on human life or health and the rating assigned to this criterion was therefore ‘A’.

**Any other aspects of environmental effects – A** There are no known direct impacts of native leafroller on any other aspects of the environment and a rating of ‘A’ was assigned to this criterion.

**Indirect impact**

**Control or eradication – D** The indirect impact on new or modified eradication, control, surveillance/monitoring and compensation strategies is unlikely to be discernable at national level and of minor significance at the regional level. A rating of ‘D’ was assigned to this criterion.

- An increase in the use of insecticides for its control because of difficulties estimating the optimum time for insecticide

application.

- Subsequent increase in cost of production to producers.
- Increased costs for crop monitoring and consultant's advice to the producer.

**Domestic trade or industry – D**

The indirect consequences on domestic trade are unlikely to be discernable at national level and of minor significance at the regional level. A rating of 'D' was assigned to this criterion.

- The presence of native leafroller in Australia could result in trade restrictions in the movement of fruit within that district and region and between States.
- It can also restrict in the sale of fruit because damaged fruit would not meet consumer's expectations. Native leafroller causes superficial fruit damage on apple and pear fruits.

**International trade – D**

The indirect consequences on international trade are unlikely to be discernable at national level and of minor significance at the regional level. A rating of 'D' was assigned to this criterion.

- If native leafroller became established in Australia, our trading partners would reject consignments of apples infested with native leafroller.

**Environment – B**

The indirect consequences on environment would not be discernible at the national level and of minor significance at the local level and a rating of 'B' was assigned to this criterion.

- Increased insecticide use could cause undesired effects on the environment.
- The introduction of new biocontrol agents for native leafroller could affect existing biological control programs.
- The establishment or spread of native leafroller in native vegetation would result in a cost for environmental restoration associated with an eradication program.

**Communities – A**

There are no recorded social effects resulting from the presence of native leafroller and a rating of 'A' was assigned to this criterion.

**Conclusion—consequences**

Based on the decision rule described in the method section, i.e. where the consequences of a pest with respect to one or more criteria are 'D', the overall consequences are considered to be 'low'. Therefore the overall consequences of native leafroller is **low**.

**Unrestricted annual risk**

Unrestricted annual risk is the result of combining annual probability of entry, establishment or spread with the outcome of overall consequences. Probabilities and consequences are combined using the 'rules' shown in the risk estimation matrix in the method section. The unrestricted annual risk estimation for native leafroller is shown in Table 67.

**Table 67 Risk estimation for native leafroller**

Overall probability of entry, establishment or spread <sup>53</sup>	<b>Very low</b>
Consequences	<b>Low</b>
Unrestricted annual risk	<b>Negligible</b>

As indicated in Table 67, the unrestricted risk for native leafroller is negligible, which is below Australia's appropriate level of protection (ALOP) of very low. Therefore, risk management would not be required for this pest.

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<sup>53</sup> Calculated by @ risk.

## **New Zealand flower thrips**

### **Biology**

New Zealand flower thrips (NZFT), *Thrips obscuratus* (Crawford), has the following life stages: adult, egg, larva, prepupa and pupa.

Adults are variable in size (2-5 mm), and in colour, usually pale to dark brown, but sometimes yellowish. The eggs are kidney-shaped, transparent and are buried in plant tissue. There are two larval stages: The first is tiny and it feeds and grows, and then moults into a second larval stage. The prepupa and pupa both have wing buds, and the antennae on the pupa are folded down. All the immature stages range in colour from white to creamy yellow. Males and females occur throughout the year in the northern part of the North Island, but in regions with colder winters only females over-winter.

In the laboratory, a female completes development from newly laid egg to adult in 21.6 days at a constant temperature of 15°C; the male takes 19.5 days. Another 10.4 days are required for the adult female to commence egg-laying.

### **Risk scenario**

The risk scenario of concern for New Zealand flower thrips is contamination of apple fruit from nearby stone fruit orchards by adult thrips.

## Probability of importation

The initiating step for the importation scenario for apple fruit is the sourcing of apples from orchards in New Zealand, while the end-point is the release of imported apples from the port of entry. The importation scenario is divided into eight steps and the likelihood of the New Zealand flower thrips being present at each step are summarised in Figure 27. The available evidence supporting the likelihood assessments is provided in the text below.

**Figure 27 The importation steps and the likelihood of the New Zealand flower thrips being present at each step**



**Importation step 1  
(Imp1)**

**High**

The likelihood that NZFT is present in the source orchards in New Zealand: **High**

- New Zealand flower thrips is found throughout New Zealand (excluding the Chatham Islands), from alpine regions down to sea level in both introduced and native habitats (HortResearch, 1998).
- It is found on the flowers of a wide range of both native plants, such as New Zealand flax, and introduced plants including kiwifruit, pipfruit, stone fruit, citrus, and commercially grown cut flowers.
- For apple plants, NZFT occurs on apple flowers in spring and is also seen on the foliage (HortResearch, 1999b).

*Summary*

Based on the above evidence that NZFT is found throughout New Zealand and occurs on apple flowers and foliage, the likelihood for Imp1 was assessed as high.

**Importation step 2  
(Imp2)**

**Negligible**

The likelihood that picked apple fruit is infested with NZFT: **Negligible**

- New Zealand flower thrips occurs on apple flowers in spring and is also seen on the foliage (HortResearch, 1999b).
- New Zealand flower thrips is attracted to apple blossom but leaves as soon as the blossom dries off. It is not attracted to apple fruit (MAFNZ, 2003a).

*Summary*

Based on the above information that NZFT is not attracted to apple fruit, the likelihood for Imp2 was assessed as negligible.

**Importation step 3  
(Imp3)**

**Very Low**

The likelihood that clean fruit is contaminated by NZFT during harvesting and transport of apples to the packing house: **Very low**

- Fruit are picked into harvesting bags and then transferred into bins kept on the ground in the orchard prior to transportation to the packing house.
- MAFNZ (2003b) states: 'Records exist of the pest on apple fruit but these are of accidental contamination possibly from nearby stonefruit orchards'.

**Importation step 4  
(Imp4)**

**Extremely low**

The likelihood that NZFT survives routine processing procedures in the packing house: **Extremely low**

The following packing house operations may influence the survival of NZFT.

*Washing*

- New Zealand flower thrips remaining on the fruit would be the

adults and larvae that contaminate the apple fruit. Washing would be effective to remove them from the fruit.

*Brushing*

- Adults and larvae are likely to be brushed off.

*Waxing*

- Waxing would be able to remove some remaining adults and larvae.

*Sorting and grading*

- Sorting and grading would have little impact on the thrips because NZFL would not stay with the fruit.

*Packaging*

- Packaging would have little affect on the viability of the thrips. In most cases the packaging of apples is designed to maximise heat discharge from the fruit while minimising loss of moisture.

*Cold Storage*

- There is no data available on the impact of cold storage on the viability of NZFT on apple fruit. However, female adults of this species overwinter in colder parts of New Zealand and would be able to survive cold storage.

*Summary*

Washing, brushing and waxing together would be able to remove NZFL. The likelihood for Imp4 was assessed as extremely low, this is supported by the fact that New Zealand flower thrips has not been detected at 2002 pre-clearance or in 17 years of trade of New Zealand apples to the US (MAFNZ, 2003b; USDA-APHIS, 2003).

**Importation step 5  
(Imp5)**

**Negligible**

The likelihood that clean fruit is contaminated by NZFT during processing in the packing house: **Negligible**

- New Zealand flower thrips is found on the flowers of a wide range of both native and introduced plants, but it is not attracted to apple fruit (MAFNZ, 2003a).
- New Zealand flower thrips would not be attracted to apple fruit in the packing house.

**Importation step 6  
(Imp6)**

**High**

The likelihood that NZFT survives palletisation, quality inspection, containerisation and transportation to Australia: **High**

- New Zealand flower thrips has been intercepted in Australia many times on other commodities such as apricots, cherries, nectarines and peaches (DAFF-PDI, 2002) suggesting that it would be able to survive this process.

### *Summary*

- Based on the above information that NZFT has survived transportation to Australia on other fruits, the likelihood for Imp6 was assessed as high.

#### **Importation step 7 (Imp7)**

**Negligible**

The likelihood that clean fruit is contaminated by NZFT during palletisation, quality inspection, containerisation and transportation: **Negligible**

- New Zealand flower thrips would not be attracted to apple fruit.

#### **Importation step 8 (Imp8)**

**High**

The likelihood that NZFT survives and remains with fruit after on-arrival minimum border procedures: **High**

- The minimum border procedures as described in the method section would not be effective in detecting the thrips.

### ***Conclusions—probability of importation***

When the above likelihoods were inserted into the simulation model, the probability of importation for the NZFT on apples from one year of trade was found to be **extremely low**.

### **Probability of distribution**

The initiating step for the distribution scenario is the release of imported apples from the port of entry, while the last step is the pest being distributed (as a result of the processing, sale or disposal of these apple fruit) in a viable state to an endangered area and subsequently being transferred to a suitable host.

In order to assess the probability of distribution, the distribution scenario is addressed in three subheadings below. First is a brief description of sequences of events leading to a successful exposure of the pest from infested/infected apple to a susceptible host plant. Second is the assessment of partial probability of distribution of the pest in relation to each of the exposure groups. Third is the conclusion for the probability of distribution.

#### ***Sequence of events for successful exposure***

The sequence of events that has to be completed for a successful exposure of a susceptible host to the pest is summarised below.

New Zealand flower thrips is not attracted to apples fruit and would not usually be present on the fruit (HortResearch, 1998). The thrips are accidental contaminants of apple fruit and are considered to be a post-harvest passenger pest of apple. If contamination occurs the insect stage associated with the apple is the adult that may or may not be mated. Handling and consumption would cause some mortality. If the adults survive cold storage, they could enter the environment by flight from unpacking and repacking facilities or retailers (utility points), on discarded fruit in waste, at landfills where the waste is disposed, and during transportation of purchased apples from retailers to households.

Mated females lay eggs that produce female thrips, whereas eggs from unmated females produce males. A pollen supply is necessary for continuous egg-laying.



A successful exposure of NZFT from infested fruit to its hosts means that adult females would need to lay their eggs on a susceptible host plant.

### ***Partial probability of distribution***

The partial probability of distribution (PPD) was estimated separately for each of the four exposure groups: commercial fruit crops, nursery plants, household and garden plants, and wild and amenity plants.

The details and the method of calculation for the PPD of the four exposure groups are explained in the method section and the results are presented in a series of tables and figures below. The information from these tables and figures was used to assess the probability of distribution of the NZFT to all the exposure groups.

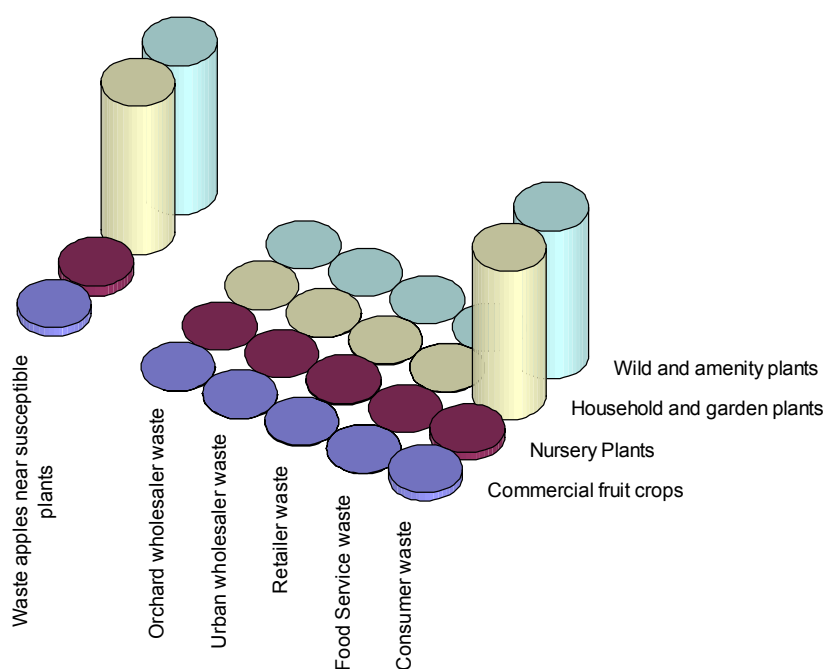
Table 68 indicates the proportions of the five utility points near each of the exposure groups of the NZFT. NZFT are polyphagous and many hosts are widely available in Australia. NZFT have been recorded on at least 225 host plants.

**Table 68 The proportions of utility points near host plants susceptible to New Zealand flower thrips in the four exposure groups**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Proximity</b> Orchard wholesalers	Certain	Very Low	Very Low	Very Low
<b>Proximity</b> Urban wholesalers	Extremely Low	Extremely Low	Extremely Low	Extremely Low
<b>Proximity</b> Retailers	Very Low	Low	Very Low	Very Low
<b>Proximity</b> Food services	Extremely Low	Extremely Low	Extremely Low	Extremely Low
<b>Proximity</b> Consumers	Very Low	Very Low	Moderate	Moderate

Figure 28 gives a pictorial representation of the relative amounts of infested/infected apples, an escaped pest or contaminated packaging material discharged or discarded from different utility points near each of the exposure groups of NZFT.

**Figure 28 Pictorial representation of the relative amounts of infested/infected apple waste<sup>54</sup> from utility points to near exposure groups of New Zealand flower thrips**



<sup>54</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or an escaped pest, or contaminated packaging material.

Table 69 is the summary of the probability that exposure of the host plants would result from discharge or discard of a single infested/infected apple, or an escaped pest, or contaminated packaging material from different utility points. Evidence is provided in the text below under different exposure groups.

**Table 69 The probability of exposure of susceptible host plants of New Zealand flower thrips from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Exp</b> Orchard <sup>55</sup> wholesaler waste	Extremely low	Extremely low	Extremely low	Extremely low
<b>Exp</b> Urban wholesaler waste	Extremely low	Extremely low	Extremely low	Extremely low
<b>Exp</b> Retailer waste	Extremely low	Extremely low	Extremely low	Extremely low
<b>Exp</b> Food service waste	Extremely low	Extremely low	Extremely low	Extremely low
<b>Exp</b> Consumer waste	Extremely low	Extremely low	Extremely low	Extremely low

#### *Commercial fruit crops*

##### *Commercial fruit crops near utility points*

The proportions of the five utility points near commercial fruit crops of NZFT are shown in Table 68. It was estimated that commercial fruit crops are certain to be located near orchard wholesalers, very unlikely to be near retailers and consumers, and extremely unlikely to be near urban wholesalers and food service as most of these are in metropolitan areas.

The relative amounts of infested/infected apples, an escaped pest, or contaminated packaging material discharged or discarded from different utility points to near commercial fruit crops susceptible to NZFT is indicated in Figure 28.

##### *Exposure to host*

The commercial fruit crops of NZFT include apples, pears and stonefruit.

A successful exposure of NZFT from infested fruit to its hosts means that adult females would need to lay their eggs on a susceptible host plant. The chance for this to happen depends on several factors, including the mortality caused by the handling and consumption of fruit, the level of infestation/infection and number of apples in the same utility points, reproductive strategy, life span of the pest and availability and susceptibility of hosts.

<sup>55</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or escaped pest, or contaminated packaging material.

As shown in Table 69, it is considered that the probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be extremely low. Other supporting evidence is provided in the text below.

**Exp** commercial fruit crops  
from orchard wholesaler waste

**Extremely low**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Extremely low**

- Host plants such as pomefruit and stonefruit are common in commercial orchards.

**Exp** commercial fruit crops  
from urban wholesaler waste

**Extremely low**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Extremely low**

- Commercial fruit crops are not located in urban areas.
- Urban wholesaler waste is disposed into bins and taken to landfills. Commercial fruit crops are unlikely to be located adjoining these sites.

**Exp** commercial fruit crops  
from retailer waste

**Extremely low**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Extremely low**

- Most retailers are located in urban areas not closed to commercial fruit crops.
- Retailer waste may be used for composting in rural areas and some of these sites may be near commercial orchards.

**Exp** commercial fruit crops  
from food service waste

**Extremely low**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Extremely low**

- Most food service providers are located in metropolitan and suburban areas. Waste produced by people in metropolitan areas and some in urban areas is generally disposed into landfills. Commercial fruit crops would usually not be present adjoining these sites.
- Population densities around commercial orchards are very low.
- Some food service waste in suburban and rural areas may be utilised for composting. Commercial fruit crops can be present close to compost heaps.

**Exp** commercial fruit crops  
from consumer waste

**Extremely low**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Extremely low**

- Majority of consumers are located in metropolitan and suburban areas. Waste produced by people in metropolitan

areas and some in urban areas is generally disposed into landfills. Commercial fruit crops would usually not be present adjoining these sites.

- Households and population densities around commercial orchards are very low.
- Some consumer waste in suburban and rural areas may be utilised for composting. Commercial fruit crops can be present close to compost heaps.

### *Nursery plants*

#### *Nursery plants near utility points*

The proportions of the five utility points near nursery plants of NZFT are shown in Table 68. It was estimated that nursery plants are unlikely to be near retailers, very unlikely to be near orchard wholesalers and consumers, and extremely unlikely to be near urban wholesalers and food services.

The relative amounts of waste apples discharged or discarded near nursery plants susceptible to NZFT are indicated in Figure 28.

#### *Exposure to host*

Nursery hosts of NZFT include many of the listed host plants as well as apples, pears, stonefruit and roses.

A successful exposure of NZFT from infested fruit to its hosts requires that adult females would need to lay their eggs on a susceptible host plant. The chance for this to happen depends on several factors, including the mortality caused by the handling and consumption of fruit, the level of infestation/infection and number of apples in the same utility points, reproductive strategy, life span of the pest and availability and susceptibility of hosts.

As shown in Table 69, it is considered that the probability that exposure of nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be extremely low. Other supporting evidence is provided in the text below.

**Exp** nursery plants from  
orchard wholesaler waste

**Extremely low**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Extremely low**

- Host plants such as stonefruit and citrus are common in nurseries.
- Retail garden nurseries have a high density of a range of plant materials in a small area. They often maintain a high hygienic standard, usually fogging with insecticide, to prevent insect attacks.
- There are rare instances of nurseries being located near to orchard wholesaler waste.

**Exp** nursery plants from urban  
wholesaler waste

**Extremely low**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban

wholesalers: **Extremely low**

- Nurseries are rarely located near to urban waste dumps.
- Although host plants such as stonefruit and citrus are common in nurseries, nursery plants are unlikely to be flowering.

**Exp** nursery plants from retailer waste

**Extremely low**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Extremely low**

- Suitable nursery plants are common in nurseries in the temperate regions of Australia, all year round, however, nursery plants are unlikely to be flowering.
- Retail garden nurseries have a high density of a range of plant materials in a small area. They often maintain a high hygienic standard, usually fogging with insecticide, to prevent insect attacks.

**Exp** nursery plants from food service waste

**Extremely low**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Extremely low**

- Most food services are in metropolitan and suburban areas and their waste is disposed into landfills. Nurseries are generally not located near these sites.

**Exp** nursery plants from consumer waste

**Extremely low**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Extremely low**

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. Nurseries are generally not located near these sites.

### *Household and garden plants*

#### *Household and garden plants near utility points*

The proportions of the five utility points near household and garden plants of NZFT are shown in Table 68. It was estimated that household and garden plants are moderately likely to be near consumers, very unlikely to be near orchard wholesalers and retailers and extremely unlikely to be near urban wholesalers and food services.

The relative amounts of waste apples discharged or discarded near household and garden plants susceptible to NZFT are indicated in Figure 28.

#### *Exposure to host*

Household and garden plant hosts of NZFT include apples, pears, stonefruit, rosemary, *Buddleia davidii*, broad bean, New Zealand flax, privet, horse chestnut, *Robinia pseudoacacia*, *Choisya ternata* and roses.

A successful exposure of NZFT from infested fruit to its hosts means that adult females would need to lay their eggs on a susceptible host plant. The chance for this to happen depends on several factors, including the mortality caused by the handling and consumption of fruit, the level of infestation/infection and number of apples in the same utility points, reproductive strategy, life span of the pest and availability and susceptibility of hosts.

As shown in Table 69, it is considered that the probability that exposure of household and garden plants would result from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be extremely low. Other supporting evidence is provided in the text below.

**Exp** household and garden plants from orchard wholesaler waste  
**Extremely low**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Extremely low**

- Orchard wholesale waste sites are mostly located within the orchard premises and are not located near household and garden plants.

**Exp** household and garden plants from urban wholesaler waste  
**Extremely low**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Extremely low**.

- Urban wholesaler waste is disposed into landfill sites, which are generally not near residential properties.

**Exp** household and garden plants from retailer waste  
**Extremely low**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Extremely low**

- Retailer waste would be disposed to landfills, which are generally not near residential properties.

**Exp** household and garden plants from food service waste  
**Extremely low**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Extremely low**

- Food service waste would be disposed to landfills, which are generally not near residential properties.

**Exp** household and garden plants from consumer waste  
**Extremely low**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Extremely low**

- Most consumers in metropolitan and suburban areas dispose of their waste to landfills, which are generally not near household and garden plants.
- Utilisation of waste to make compost is becoming a common practice in some suburban and rural households.
- Host of NZFT, including fruit trees and ornamental plants such

as roses are commonly grown as garden plants in the temperate regions of Australia.

- Host plants would be exposed to NZFT from household apples such as an infected apple core that is composted in a garden. However, females would need to lay her eggs on a susceptible host plant.

### *Wild and amenity plants*

#### *Wild and amenity plants near utility points*

The proportions of the five utility points near wild and amenity plants of NZFT are shown in Table 68. It was estimated that wild and amenity plants are moderately likely to be near consumers, very unlikely to be near orchard wholesalers and retailers and extremely unlikely to be near urban wholesalers and food services.

The relative amounts of waste apples discharged or discarded near wild and amenity plants susceptible to NZFT are indicated in Figure 28.

#### *Exposure to host*

Wild and amenity host plants of NZFT include apples, pears, blackberries, broom, *Leptospermum*, viburnum and gorse.

A successful exposure of NZFT from infested fruit to its hosts means that adult females would need to lay their eggs on a susceptible host plant. The chance for this to happen depends on several factors, including the mortality caused by the handling and consumption of fruit, the level of infestation/infection and number of apples in the same utility points, reproductive strategy, life span of the pest and availability and susceptibility of hosts.

As shown in Table 69, it is considered that the probability that exposure of wild and amenity plants would result from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be extremely low. Other supporting evidence is provided in the text below.

**Exp** wild and amenity plants  
from orchard wholesaler waste

**Extremely low**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Extremely low**

- Orchard wholesale waste sites are mostly located within the orchard premises and are not located near wild and amenity plants.
- Susceptible feral plants e.g. apple seedlings may be present near orchard wholesalers waste disposal sites.

**Exp** wild and amenity plants  
from urban wholesaler waste

**Extremely low**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Extremely low**

- Urban wholesale waste is disposed at landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. apple seedlings.



**Exp** wild and amenity plants  
from retailer waste

**Extremely low**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Extremely low**

- Retailer waste would be disposed to landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. apple seedlings.

**Exp** wild and amenity plants  
from food service waste

**Extremely low**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Extremely low**

- Food service waste would be disposed to landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. apple seedlings.

**Exp** wild and amenity plants  
from consumer waste

**Extremely low**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Extremely low**

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. apple seedlings.
- Consumers discard apple cores in the environment or in bins in parks.
- Susceptible wild and amenity plants, such as roses may be present in parks, near recreational facilities and along roadsides. However, females would need to lay her eggs on a susceptible host plant.
- Consumers who consider apple cores to be biodegradable indiscriminately discard them in the environment. Spoilt apples or cores discarded into the wild are likely to be isolated.

### ***Conclusion—probability of distribution***

The partial probability of distribution from each of the utility points to each of the exposure groups is summarised in Table 70. These were based on the data and assessment provided above and calculated by the simulation model using the @risk. The quantitative model evaluated the effect of the ‘volume of trade’ during a specified period when calculating the partial probability of distribution.

**Table 70 Partial probabilities of distribution (PPD)<sup>56</sup> for New Zealand flower thrips**

UTILITY POINTS	PPD			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Orchard wholesalers</b>	Extremely low	Extremely low	Extremely low	Extremely low
<b>Urban wholesalers</b>	Extremely low	Extremely low	Extremely low	Extremely low
<b>Retailers</b>	Very low	Very low	Very low	Very low
<b>Food services</b>	Extremely low	Extremely low	Extremely low	Extremely low
<b>Consumers</b>	Very low	Very low	Moderate	Moderate
<b>Overall PPD</b>	Very low	Very low	Moderate	Moderate

### Probability of establishment or spread

The assessment for the probability of establishment or spread is carried out in the following manner. Firstly, partial probability for establishment and for spread was assessed separately based on the relevant available scientific information. Secondly, the conclusions for the combined partial probability of establishment or spread for each of the four exposure groups are provided at the end of this section. The relevant information for the assessment for the probability of establishment or spread is presented below against the factors listed in ISPM 11, Rev. 1.

#### *Partial probability of establishment*

ISPM 11 factor	Relevant information
<b>Availability of suitable hosts, alternate hosts and vectors in the PRA area</b>	<ul style="list-style-type: none"> <li>NZFT have been recorded on at least 225 plant species from 78 families. While many of these are true host plants, the range of plants used for breeding is not known (HortResearch, 1999b).</li> <li>Some of the more important and common hosts of NZFT in New Zealand are: New Zealand flax, kiwifruit, apples, pears, stonefruits, and citrus (HortResearch, 1999b).</li> <li>Many of these host plants are widely available in Australia.</li> </ul>
<b>Suitability of the environment</b>	<ul style="list-style-type: none"> <li>NZFT is found throughout New Zealand, where climatic conditions are similar to those of Australia.</li> <li>Many Australian environments would be suitable for the</li> </ul>

<sup>56</sup> Partial probability of distribution is actually referring to the probability of entry and was estimated by @risk.

ISPM 11 factor	Relevant information
<b>The potential for adaptation of the pest</b>	<p>thrips' survival and reproduction as this species is noted for its ecological and physiological tolerance (HortResearch, 1999b).</p> <ul style="list-style-type: none"> <li>• However, to date, there have been no signs of this species being established in Australia although it has probably already had many opportunities to reach the Australian environment.</li> <li>• The genetic adaptability of NZFT is not known. However, it would have no problem to adapt to the climatic conditions in Australian environment considering it occurs throughout all climatic zones of New Zealand (HortResearch, 1999b).</li> </ul>
<b>The reproductive strategy of the pest</b>	<ul style="list-style-type: none"> <li>• The species has a special form of reproduction (arrhenotoky) that allows females to reproduce without males (McLaren and Walker, 1998).</li> <li>• Mated females lay eggs that produce female thrips, while unmated females lay eggs that produce male thrips (HortResearch, 1998).</li> <li>• Males and females occur throughout the year in the northern part of the North Island, but in regions with colder winters, the females overwinter.</li> <li>• In Central Otago, development from the egg to the start of the adult stage on tart cherries takes 28 days (HortResearch, 1998).</li> <li>• In the laboratory, a female completes development from newly laid egg to adult in 21.6 days at constant temperature of 15°C, while the male takes 19.5 days. Another 10.4 days are required for the adult female to start egg-laying (HortResearch, 1998).</li> </ul>
<b>Minimum population needed for establishment</b>	<ul style="list-style-type: none"> <li>• A population can start from the eggs laid in plant tissue by a single female.</li> </ul>
<b>Cultural practices and control measures</b>	<ul style="list-style-type: none"> <li>• In conventional orchards NZFT is controlled by the application of organophosphate and carbamate pesticides (McLaren and Fraser, 2001).</li> <li>• Integrated Pest Management (IPM) programs are utilised in the production of apples in Australia.</li> <li>• New Zealand orchardists employ Integrated Fruit Production (IFP) in the production of their fruit (ENZA, 2003) and IFP became a minimum export standard for New Zealand apples in 2000/01 (Anonymous, 2002b).</li> </ul>

*Conclusion—partial probability of establishment*

Based on the above evidence, partial probability of establishment for each of the exposure groups is assessed as follows.

Partial probability of establishment for commercial fruit crops: **Moderate**.

Partial probability of establishment for nursery plants: **Moderate**.

Partial probability of establishment for household and garden plants: **Moderate**.

Partial probability of establishment for wild and amenity plants: **Moderate**.

***Partial probability of spread***

ISPM 11 factor	Relevant information
<b>Suitability of natural and/or managed environment</b>	<ul style="list-style-type: none"> <li>NZFT has been reported from all over New Zealand. There are similar environments in Australia that would be suitable for its spread.</li> </ul>
<b>Presence of natural barriers</b>	<ul style="list-style-type: none"> <li>There is little information on the ability of NZFT to spread beyond natural barriers. The long distances existing between the main Australian commercial orchards would make it difficult for NZFT to disperse directly from one area to another unaided.</li> <li>However the highly polyphagous nature of this species should enable it to locate suitable hosts in the intervening areas.</li> </ul>
<b>Potential for movement with commodities or conveyances</b>	<ul style="list-style-type: none"> <li>NZFT would be transported during movement of commodities or conveyances if it remained on the fruit.</li> </ul>
<b>Intended use of the commodity</b>	<ul style="list-style-type: none"> <li>Apples would be used mostly for human and are not intended for propagation purposes.</li> </ul>
<b>Potential natural enemies</b>	<ul style="list-style-type: none"> <li>The relevance of natural enemies is not known.</li> </ul>

***Conclusion—partial probability of spread***

Based on the above evidence, partial probability of spread for each of the exposure groups is assessed as follows.

Partial probability of spread for commercial fruit crops: **High**.

Partial probability of spread for nursery plants: **High**.

Partial probability of spread for household and garden plants: **High**.

Partial probability of spread for wild and amenity plants: **High**.

***Combined partial probability of establishment or spread***

The combined partial probability of establishment or spread was determined by combining probabilities of establishment and probabilities of spread using the matrix of ‘rules’ for combining descriptive likelihoods as presented in the method section. The results are indicated in Table 71.

**Table 71 Combined partial probabilities of establishment or spread of New Zealand flower thrips**

	<b>Commercial fruit crops</b>	<b>Nursery plants</b>	<b>Household and garden plants</b>	<b>Wild and amenity plants</b>
<b>Establishment</b>	Moderate	Moderate	Moderate	Moderate
<b>Spread</b>	High	High	High	High
<b>PPES<sup>57</sup></b>	Moderate	Moderate	Moderate	Moderate

Additional evidence to support the combined partial probability of establishment or spread for specific exposure groups is provided in the text below.

<b>Commercial fruit crops</b> <b>Moderate</b>	<ul style="list-style-type: none"> <li>NZFT attacks a wide range of hosts such as apples, pears, grapes, citrus, stonefruits, and kiwifruit. Commercial crops of these hosts are widely distributed in Australia.</li> </ul>
<b>Nursery plants</b> <b>Moderate</b>	<ul style="list-style-type: none"> <li>The most important factor for establishment or spread in nursery plants is the availability of several plant species commonly sold in nurseries that are available as alternate hosts. Australian nurseries carry a wide range of host plants for example, species of <i>Citrus</i>, <i>Prunus</i>, <i>Buddleia</i>, <i>Rhododendron</i> and rose.</li> </ul>
<b>Household and garden plants</b> <b>Moderate</b>	<ul style="list-style-type: none"> <li>Many of the host plants listed for NZFT are grown in Australian household gardens as ornamentals so there are numerous hosts available.</li> </ul>
<b>Wild and amenity plants</b> <b>Moderate</b>	<ul style="list-style-type: none"> <li>Many host plants of NZFT are found growing wild in Australia such as clover, blackberries, tea tree, broom and gorse that could provide suitable hosts.</li> </ul>

### Assessment of consequences

Impact scores allocated for the direct and indirect criteria are shown in Table 72. Available supporting evidence is provided in the text below.

<sup>57</sup> PPES = partial probability of establishment or spread.

**Table 72 Impact scores for New Zealand flower thrips**

<b>Direct impact</b>	<b>Impact scores</b>
Plant life or health	C
Human life or Health	A
Any other aspects of environment	A
<b>Indirect impact</b>	
Control or eradication	D
Domestic trade or industry	D
International trade	D
Environment	B
Communities	A

**Direct impact**

- Plant life or health – C** Consequences affecting plant life or health are unlikely to be discernible at a national level and of minor significance at the district level. A rating of ‘C’ was assigned to this criterion.
- These species are highly polyphagous feeding on at least 225 species of plants in 78 families (HortResearch, 1999b).
  - NZFT is a pest of economically important crops such as apples, pears, stonefruit, kiwifruit, citrus and grapes (HortResearch, 1999b).
  - NZFT may feed directly on stonefruit, causing superficial damage. This damage can result in downgrading of the fruit and exclusion from export (HortResearch, 1998).
  - Adults sometimes lay eggs in the surface of stonefruit (HortResearch, 1998).
- Human life or health – A** There are no known direct impacts of NZFT on human life or health and the rating assigned to this criterion was therefore ‘A’.
- Any other aspects of environmental effects – A** There are no known direct impacts of NZFT on any other aspects of the environment and a rating of ‘A’ was assigned to this criterion.

**Indirect impact**

- Control or eradication – D** The indirect impact on new or modified eradication, control, surveillance/monitoring and compensation strategies is unlikely to be discernable at national level and of minor significance at the regional level. A rating of ‘D’ was assigned to this criterion.

	<ul style="list-style-type: none"> <li>Additional programs to minimise the impact of these pests on host plants may be necessary. Existing control programs may be effective for some hosts (e.g. broad spectrum pesticide applications) but not all hosts (e.g. where specific integrated pest management programs are used).</li> </ul>
<b>Domestic trade or industry – D</b>	<p>The indirect consequences on domestic trade are unlikely to be discernable at national level and of minor significance at the regional level. A rating of ‘<b>D</b>’ was assigned to this criterion.</p> <ul style="list-style-type: none"> <li>The presence of NZFT in Australia could result in trade restrictions in the movement of fruit within that district and region and between states.</li> <li>It can also restrict in the sale of fruit because damaged fruit would not meet consumer’s expectations. NZFT causes superficial fruit damage on stone fruits (HortResearch, 1998).</li> </ul>
<b>International trade – D</b>	<p>The indirect consequences on international trade are unlikely to be discernable at national level and of minor significance at the regional level. A rating of ‘<b>D</b>’ was assigned to this criterion.</p> <ul style="list-style-type: none"> <li>If NZFT became established in Australia our trading partners would require the same treatment as the ones applied to New Zealand.</li> </ul>
<b>Environment – B</b>	<p>The indirect consequences on environment would not be discernable at the national level and of minor significance at the local level and a rating of ‘<b>B</b>’ was assigned to this criterion.</p> <ul style="list-style-type: none"> <li>Increased insecticide use can cause undesired effects on the environment.</li> <li>The introduction of other biocontrol agents can affect existing biological control programmes.</li> <li>The introduction of new biocontrol agents of NZFT would affect the simplified orchard ecosystem as well as native ecosystems in the vicinity of orchards in the first instance, particularly if the biocontrol agents turn out to be not host specific in the wild.</li> <li>The establishment or spread of NZFT in native vegetation would result in a cost for environmental restoration associated with an eradication program.</li> </ul>
<b>Communities – A</b>	<p>There are no recorded social effects resulting from the presence of NZFT and a rating of ‘<b>A</b>’ was assigned to this criterion.</p>

### **Conclusion—consequences**

Based on the decision rule described in the method section, i.e. where the consequences of a pest with respect to one or more criteria are ‘**D**’, the overall consequences are considered to be ‘low’. Therefore the overall consequences of NZFT are **low**.

### Unrestricted annual risk

Unrestricted annual risk is the result of combining annual probability of entry, establishment or spread with the outcome of overall consequences. Probabilities and consequences are combined using the ‘rules’ shown in the risk estimation matrix in the method section. The unrestricted annual risk estimation for NZFT is shown in Table 73.

**Table 73 Risk estimation for New Zealand flower thrips**

Overall probability of entry, establishment or spread <sup>58</sup>	<b>Low</b>
Consequences	<b>Low</b>
Unrestricted annual risk	<b>Very low</b>

As indicated in Table 73, the unrestricted risk for New Zealand flower thrips is very low, which meets Australia’s appropriate level of protection (ALOP) of very low. Therefore, risk management would not be required for this pest.

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<sup>58</sup> Calculated by @ risk.



## **PESTS FOR WESTERN AUSTRALIA**

The following risk assessments are for:

- Codling moth
- Oystershell scale
- Oriental fruit moth
- Mealybug
- Citrophilius mealybug
- European red mite

## **Apple scab or black spot**

### **Introduction**

Apple scab (referred to as black spot in New Zealand), caused by the fungus *Venturia inaequalis* is the most economically important disease of apple worldwide (CABI, 2003a). *V. inaequalis* occurs in Australia (APPD, 2003) except in Western Australia where it has been eradicated and is under official control (McKirdy *et al.*, 2001).

According to Keitt (1953), *V. inaequalis* predominantly attacks members of the genus *Malus*, which includes cultivated apple (*Malus × domestica*) and crab apples (*M. coronaria* and *M. iowensis*). *V. inaequalis* has also been recorded on other hosts including arrow-wood (*Viburnum* spp.), *Sarcocephalus esculentus* and loquat (*Eriobotrya japonica*) (MacHardy, 1996; CABI, 2003a).

In pear (*Pyrus* spp.) scab is caused by *Venturia pirina* (Shabi, 1990). Several host specific forms referred to as ‘formae speciales’ of *V. inaequalis* on mountain ash (*Sorbus aucuparia*), hawthorn (*Crataegus oxycantha*) and cotoneaster (*Cotoneaster integerrima*) have been designated (Menon, 1956). Similarly, firethorn (*Pyracantha* spp.) is also infected by another ‘formae speciales’ of *V. inaequalis* (Le-Cam *et al.*, 2002). These ‘formae speciales’ are not known to cause infection on *Malus* spp.

*Venturia inaequalis* attacks leaves, petioles, blossoms, sepals, fruits, pedicels and less frequently, young shoots and bud scales. But the most obvious symptoms occur on leaves and fruit (Biggs, 1990). The fungus produces two distinct types of spores i.e. conidia (asexual) and ascospores (sexual). Ascospores released from overwintered leaves and fruits on the orchard floor are the principal source of inoculum in the spring. The lesions resulting from these infections produce conidia throughout the spring and summer and serve as secondary inoculum. Under favourable conditions, the pathogen attacks the leaves and fruit to cause serious damage. Crop losses have been estimated at around 70 per cent where cool and humid weather conditions occur during spring (Biggs, 1990). Direct losses are caused by the reduction of fruit quality due to scabby growth. Indirect losses are the result of yield reductions that occur as a result of impaired growth vigour caused by repeated defoliation (Biggs, 1990).

The lesions on infected immature fruit that survive abscission enlarge and become brown and corky. Sometimes these lesions may coalesce to form what is referred to as ‘sheet scab’ but commonly discrete lesions are found on fruit. As fruit matures cracks appear on the fruit surface and these may extend into the flesh. Fruit may even become deformed owing to uneven growth of meristematic tissue near the fruit surface (Biggs, 1990).

Apples become more resistant to scab when they mature (Keitt and Jones, 1926). Fruit infected late in the season before harvest is likely to have ‘pin-point’ or ‘pin-head’ lesions that may not be visible at harvest. Such infections may cause ‘storage scab’, after 8–12 weeks in cold storage (MacHardy, 1996). These lesions are typically black and sunken and may either show rupture of the cuticle or have concentric bands.

Other information relevant to the biology and epidemiology of *V. inaequalis* is available (Thomson, 1992b; Hale *et al.*, 1996b) in the datasheet in Appendix 3 in Part B.

**Risk scenario**

The risk scenario of particular relevance to *V. inaequalis* is that associated with scabby growth on the surface of mature fruit and ‘pin-point’ lesions that are not visible. The latter may cause rotting symptoms in cold storage.

Trash is another potential pathway for introduction of *V. inaequalis*. This pathway was not considered, as the scope of this assessment is limited to export from New Zealand of mature apples free from trash.

**Probability of importation**

The initiating step for the importation scenario for apple fruit is the sourcing of apples from orchards in New Zealand, while the end-point is the release of imported apples from the port of entry. The importation scenario is divided into eight steps and the likelihood of *V. inaequalis* being present at each step is summarised in Figure 29. The available evidence supporting the likelihood assessments is provided in the text that follows.

**Figure 29 The importation steps and the likelihood of *V. inaequalis* being present at each step**



**Importation step 1 (Imp1)**  
**High**

The likelihood that *V. inaequalis* is present in the source orchard in New Zealand: **High**.

**Epidemiology**

- Apple scab occurs in all pipfruit production areas in New Zealand (Manktelow and Beresford, 1995). In the main apple production area of Hawke's Bay, more than 20 per cent of growers had problems with scab (Stewart *et al.*, 1993).
- The highest number of infection periods occurred in Auckland followed by Nelson, Hawke's Bay and Canterbury. These areas account for 86 per cent of New Zealand exports (see the

section on Apple Industry in New Zealand). Ascospore release occurs later in the cooler southern regions (Beresford *et al.*, 1989) resulting in a lower incidence of scab. Overall, scab is more prevalent in the orchards in the North Island than it is in the South Island.

- Biology of the pathogen (see datasheet sheet in appendix 3 in Part B) suggests that all orchards would have the disease to some level.

#### *Varietal susceptibility*

- All commercial varieties grown in New Zealand are susceptible to scab (Manktelow and Beresford, 1995). They also showed that the three major commercial cultivars (i.e. Braeburn, Fuji, Gala) grown in Auckland, Hawke's Bay, Nelson, Canterbury and Central Otago and varieties derived from their parentage are susceptible to scab.

#### *Climate and environment*

- Climatic conditions in New Zealand are conducive for the establishment and spread of the pathogen (see the section on Apple Industry in New Zealand).

#### *Orchard management*

- In New Zealand primary inoculum is reduced by application of urea to leaf litter in the autumn (Beresford *et al.*, 2000), and a range of protective fungicides (Percy, 2003). Fungicide applications are done on weather-based infection period monitoring and weather forecasts (Beresford and Spink, 1992) and implementation of the Integrated Fruit Production (IFP) program (Batchelor *et al.*, 1997).

#### *Summary*

Apple scab caused by *V. inaequalis* is present in all pipfruit production areas in New Zealand where commercial varieties are susceptible and environmental conditions are favourable for disease development, the likelihood for Imp1 was assessed as high.

The likelihood that picked fruit is infected/infested with *V. inaequalis*: **Very low**.

#### **Importation step 2 (Imp2)**

**Very low**

#### *Infection of orchard blocks/trees*

- Autumn application of urea as a post harvest spray to leaves on the ground reduced ascospore production in the spring (Beresford *et al.*, 2000). This measure lowers the availability of primary inoculum for scab infection.
- Implementation of the IFP program ensures reduction of fruit infection by scab (Batchelor *et al.*, 1997). The fungicide application in the IFP program was based on monitoring scab infection periods, ascospore counts and scab incidence

(Batchelor *et al.*, 1997). It has lowered scab incidence through better timing of eradicator sprays (Beresford *et al.*, 1989).

- The average number of fungicide applications increased from 11.6 in 1997–1998 to 18.4 in 1998–1999 in orchards converting to organic production in Hawke’s Bay (Tate *et al.*, 2000). Fruit infection was reduced by the application of protective fungicides based on the prediction of infection periods followed by the application of curative sprays based on monitored infection periods (Manktelow *et al.*, 1989; Tate *et al.*, 1996). Application of fungicides in commercial practice would ensure very low levels of fruit infection.

#### *Infection/infestation of mature fruit*

- Mature fruit are less prone to infection (Keitt and Jones, 1926). The fruit infected during the latter part of the season may produce small ‘pin-point’ lesions that are not visible at harvest (Bratley, 1937; MacHardy, 1996). These lesions may not be detected in fruit in the packing house before export.
- Post-harvest fungicides are not used in New Zealand before fruit is cold stored (MAFNZ, 2003a).

#### *Summary*

Scab disease is well managed in New Zealand by employing preventive and curative measures. Several applications of fungicides in the IFP program are based on monitoring scab infection periods, ascospore counts and scab incidence. Mature fruit is less prone to infection. New Zealand maintains a high quality export market. Therefore, only a very low level of infection of mature fruit by *V. inaequalis* is likely to be present so the likelihood for Imp2 was assessed as very low.

#### **Importation step 3 (Imp3)**

**Extremely low**

The likelihood that clean fruit is contaminated by *V. inaequalis* during picking or transport to the packing house: **Extremely low.**

#### *Contamination at picking*

- Conidia are formed on leaf lesions throughout the spring and summer. Leaves are capable of producing up to 100,000 conidia per lesion under high humidity (Biggs, 1990). However, many of the conidia are likely to be killed by fungicides.
- Mature fruit with scabby lesions may have viable conidia but not ascospores (Biggs, 1990).
- Clean fruit is likely to be contaminated by conidia during handling at harvest especially during wet weather. Harvesting bags may contain infected leaves and fruit. Infected leaves are likely sources of infection if they are wet.

#### *Contamination in soil*

- The overwintered pseudothecia on leaves shed in the previous

season would have released ascospores by harvest time in the current season. At this time leaves of the current season have not been shed and pseudothecia have not yet formed. Conidia are unlikely to be present in the soil.

#### *Contamination in bins*

- Storage bins kept on the orchard floor awaiting transportation to the packing house are unlikely to be contaminated by *V. inaequalis* in the soil. However, fruit may be contaminated by conidia splashed from infected leaves in canopies during wet weather. Contamination is unlikely during dry weather.

#### *Contamination during transport*

- Contamination of the fruit is likely to occur if actively sporulating lesions are present on trees at harvest. This would occur during wet weather, if bins were not covered, during transportation to the packing house through the orchard. Contamination would also occur from infected trash during transport, only if wet weather persists.

#### *Summary*

Contamination of fruit may occur if actively sporulating lesions are present in the orchard at time of harvest. Direct contamination from bins and soil would not occur. Scab is a disease that affects fruit quality. The fungicide program to control scab is designed to minimise fruit infection. Therefore, well-managed orchards would have insignificant amount of scab. Based on this information, the likelihood for Imp3 was assessed as extremely low.

#### **Importation step 4 (Imp4)**

**Very low**

The likelihood that *V. inaequalis* survives routine processing procedures in the packing house: **Very low**.

#### *Precooling*

- This treatment would not have any effect on the survival of conidia as they can survive at low temperatures (Biggs, 1990).

#### *Washing*

- Conidia on fruit lesions tend to be easily detached upon wetting (Frey and Keitt, 1925) when the fruit is washed in the dump tank. Infected lesions will remain unaffected. The same effect is likely to occur with the high-pressure high-volume water spray installed in some packing houses.
- In New Zealand, majority of packing houses would use chlorine to disinfest fruit in the dump tank. Chlorine is ineffective unless its concentration is maintained at 100 ppm. Under optimal conditions, chlorine would probably kill conidia present only on the external fruit surfaces. According to MAFNZ (2004) water in the dump tank is replenished regularly (see the section on the Apple Industry in New

Zealand). This measure would reduce the chances for contamination of fruit.

#### *Brushing*

- It is virtually certain that brushing would not dislodge any conidia present within tissues in fruit or leaves. However, the volume of such fruit would be low in export-orientated commercial orchards where scab is well managed.

#### *Waxing*

- Waxing would not dislodge any conidia present within tissues in fruit or leaves.

#### *Sorting and grading*

- During packing house operations scabby, blemished, mis-shapen, split, ripened fruit or those that do not meet the export quality standard would be rejected.
- Fruit infected at maturity is unlikely to show discernable scabby lesions (MacHardy, 1996). These ‘pin-point’ lesions that are not visually detected or tiny scabby lesions that have escaped detection will survive the routine packing house operations.

#### *Packaging*

- Packaging would have little effect on the survival of the pathogen. In most cases the packaging of apples is designed to maximise heat discharge from the fruit while minimising loss of moisture.

#### *Post-harvest fungicides*

- Post-harvest fungicides are not used before storage of fruit in New Zealand (MAFNZ, 2003a).

#### *Cold storage*

- Any internal infections that survive the packing house operations will develop disease symptoms when cold-stored for 8–12 weeks (MacHardy, 1996). The minimum temperatures for conidial germination, sporulation and infection are 0°C, 4°C, 4°C, respectively (MacHardy, 1996; Studt and Weltzien, 1975). This suggests that conidia are able to survive, germinate, sporulate and infect during or after cold storage.

#### *Summary*

Packing house operations would cull blemished and scabby fruit. However, mature fruit infected with ‘pin-point’ lesions may not be detected during routine packing house operations unless they have developed rots in cold storage. The conidia in these lesions can survive cold storage and contaminate other fruit. However, the



**Importation step 5  
(Imp5)**

**Extremely low**

likelihood for Imp4 was assessed as very low because there would be a low level of fruit infection in the orchard as a consequence of good management.

The likelihood that clean fruit is contaminated by *V. inaequalis* during processing in the packing house: **Extremely low**.

- Some of the fruit and trash arriving at the packing house would be infected/infested with conidia. Conidia dislodged in the water dump have the potential to contaminate clean fruit but not if chlorine is present at the right concentration. Replenishment of dump tanks as described (see the Apple Industry in New Zealand) bins would minimise the risk of contamination. Conidia that have contaminated clean fruit surfaces in the water dump are likely to be removed during a high-volume, high-pressure water wash.
- The lesions, which appear as ‘pin-points’ on fruit, are subcuticular and protected by the cuticle. These lesions would not provide inoculum for contamination of clean fruit in the packing house until after cold storage for 8–12 weeks (MacHardy, 1996).
- Ascospore formation occurs in pseudothecia on leaves and fruit, only after a period of development and maturation over winter (Biggs, 1990). Ascospores would not be a source of inoculum for contamination of clean fruit during the packing house operations.

*Summary*

Conidia dislodged in the water dump have the potential to contaminate clean fruit, but not if chlorine is present at the right concentration and water is replenished regularly. Conidia in ‘pin-point’ lesions on fruit would not provide inoculum for contamination of clean fruit in the packing house. Ascospores would not be present. The likelihood for Imp5 was assessed as extremely low.

**Importation step 6  
(Imp6)**

**Moderate**

The likelihood that *V. inaequalis* survives palletisation, quality inspection, containerisation and transportation, and remains undetected: **Moderate**.

- Fruit with ‘pin-point’ scab lesions may develop ‘storage scab’ when cold stored for 8–12 weeks before export (MacHardy, 1996). These fruit will show sunken black lesions, usually on the discoloured fruit surface (often with yellow skin). These are likely to be detected during a quality inspection.
- The pathogen is likely to survive especially on fruit with ‘pin-point’ lesions that have not been cold stored for at least 8–12 weeks (MacHardy, 1996).
- Apple would be transported in refrigerated containers (0–2°C) by sea or air. It takes only a few hours to reach Australia by air and the sea voyage from New Zealand would take about seven to 10 days. Fruit with internal infection not stored for an

adequate period before export has the potential to develop symptoms when cold-stored on-arrival.

*Summary*

If ‘pin-point’ lesions are present on fruit they will not be detected during routine packing house operations and the pathogen is likely to survive if fruit spends only a short time in cold storage. The likelihood for Imp6 was assessed as moderate.

**Importation step 7  
(Imp7)**

**Negligible**

The likelihood that clean fruit is contaminated by *V. inaequalis* during palletisation, quality inspection and transportation to Australia: **Negligible**.

- Fruits that have been sorted, graded and inspected for quality will have few infected fruit.
- Fruit with ‘pin-point’ lesions when cold stored for 8–12 weeks is likely to develop disease symptoms (MacHardy, 1996). These are likely to be discarded at quality inspection. The number of fruit with ‘pin-point’ lesions is likely to be small, as scab disease is managed well in export orchards.

*Summary*

Contamination of fruit would not occur at this step because most of rotting fruit would be rejected before and after cold storage. The likelihood for Imp7 was assessed as negligible.

**Importation step 8  
(Imp8)**

**High**

The likelihood that *V. inaequalis* survives and remains with fruit after on-arrival minimum border procedures: **High**.

- Fruit with ‘pin-point’ lesions in cold storage for more than 8–12 weeks would develop symptoms before export and would be discarded at pre-export inspection.
- Symptoms on fruit infected with ‘pin-point’ lesions, where the fruit is not cold stored for 8–12 weeks (MacHardy, 1996), are unlikely to be detected.
- Fruit with pseudothecia containing developing asci and ascospores are unlikely to be detected.

*Summary*

Fruit with ‘pin-point’ lesions that have not been cold stored for 8–12 weeks and fruit with mature pseudothecia will not be detected by on-arrival minimum border procedures. The likelihood for Imp8 was assessed as high.

**Conclusions—probability of importation**

When the above likelihoods were inserted into the simulation model, the probability of importation of *V. inaequalis* from one year of trade was found to be **Extremely low**.

## Probability of distribution

The initiating step for the distribution scenario is the release of imported apples from the port of entry, while the last step is the pest being distributed (as a result of the processing, sale or disposal of these apple fruit) in a viable state to an endangered area and subsequently being transferred to a suitable host.

In order to assess the probability of distribution, the distribution scenario is addressed in the three subheadings below. First is a brief description of the sequences of events leading to a successful exposure of the pest from infested/infected apple to a susceptible host plant. Second, is the assessment of partial probability of distribution of the pest in relation to each of the exposure groups. Third, is the conclusion for the probability of distribution.

### Sequence of events for successful exposure

The sequence of events that has to be completed for a successful exposure of *V. inaequalis* from either infested or infected apples to a susceptible host is summarised below.

Conidia of *V. inaequalis* will be in 'pin-point' lesions on mature harvested apple fruit that was infected late in the season. These 'pin-point' or 'pin-head' lesions may not be visible at harvest and if fruit is not cold stored for an adequate period before being exported it has the potential to develop symptoms on-arrival in Australia.

On entry, discarded apples and apple cores or peels are most likely to be disposed of in landfills via garbage collection or into backyard compost pits/heaps that may be close to a susceptible host plant. Waste would be colonised rapidly by other micro-organisms or consumed by insects, mammals or birds.

A successful exposure of *V. inaequalis* to a susceptible host means that *V. inaequalis* in fruit waste must be in a viable state. Wind or rain-splash is the most likely method of transfer of *V. inaequalis* to a susceptible host. The susceptible tissue must be near the inoculum source for effective transfer. Successful infection would take place under favourable environmental conditions, provided that each step listed above is completed.

Theoretically, transfer of at least one conidium or ascospore to a susceptible host would be required to initiate an infection. Specific environmental conditions are required for survival and germination of spores. The interacting effects of temperature, wetness and relative humidity have a profound effect on spore germination and infection (Biggs, 1990; Studt and Weltzien, 1975; MacHardy, 1996). Free water and high humidity are required for initiation of ascospore germination (Biggs, 1990). Similarly, conidia require specific temperature, moisture and humidity conditions for germination (Biggs, 1990; MacHardy, 1996; Studt and Weltzien, 1975; Turner *et al.*, 1986). Conidia sporulate over a wide range of temperature 4–28°C (optimum 10–20°C) (Biggs, 1990) but not in dry atmospheric conditions i.e. about 60 per cent relative humidity (Studt and Weltzien, 1975). Detached conidia are vulnerable to dry conditions and are highly unlikely to cause an outbreak of scab at locations far away from the source (Hirst and Stedman, 1961).

From an inoculum source, conidia and ascospores have a limited capacity to spread either by wind or rain splash. Infection is likely to occur only on susceptible tissues. The conidia are confined mostly within the canopy, and ascospores can be disseminated up to a distance of 100 m (CABI, 2003a; Holb, 2002; MacHardy, 1996). The distance of conidial spread will depend on the size of the water droplets and wind speed (Hirst and Stedman, 1961). However,

it is generally accepted that less than 10 per cent of ascospores are released beyond the crop boundary (Gregory, 1973). Insects, birds and feral animals also have the potential to spread the pathogen.

Abundant susceptible tissue (tender shoots, leaves and fruitlets) would be present in spring. New flushes of leaves produced over the summer also would be prone to infection. Young fruits are infected and distinct lesions are formed mainly around the calyx-end during the early part of the season. Fruit infections that occur in late summer or early autumn may not be visible until fruits are in storage (MacHardy, 1996). Mature senescing leaves would be less susceptible to infection (Biggs, 1990). Trees would be devoid of any susceptible tissues during late autumn and winter. Therefore, the period of exposure of the pathogen to susceptible tissue is limited to spring and summer months.

Orchard wholesalers would commonly dispose of their waste in an isolated location in the orchard or near it. However, nearly all urban wholesalers, retailers and food services and a significant amount of consumers dispose of their waste in landfills. Some consumer waste would be utilised either by consumers themselves or composting agencies to prepare compost. In both situations exposure of host plants to waste is possible. Waste in composting bins will have no access to plants as they are covered. Waste in landfills or compost heaps will generate heat (up to 60°C) during the decay process. Under these conditions many pathogenic propagules are likely to be killed. In domestic back garden composting, temperatures may not reach the level required to kill fungal spores or bacterial cells. Landfill sites are constantly covered by soil. This would prevent the access of the pathogen in waste to a susceptible host. In both landfill sites and backyard compost heaps saprophytic microorganisms would decompose the waste.

Infected apple fruit discarded into a waste dump or compost heap would be colonised rapidly by saprophytic micro-organisms, inactivating the pathogen (Boudreau and Andrews, 1987; Cullen *et al.*, 1984; Miedtke and Kennel, 1990; Phillion *et al.*, 1997). The high temperature generated during the decay process may also inactivate the pathogen. Several antagonistic micro-organisms, such as *Aureobasidium pullulans*, *Chaetomium globosum*, *Athelia bomacina*, *Coniothyrium* sp. and *Phoma* sp., that inhibit pseudothecial formation and ascospore production of *V. inaequalis* have been reported (Boudreau and Andrews, 1987; Cullen *et al.*, 1984; Miedtke and Kennel, 1990; Phillion *et al.*, 1997). These organisms are likely to occur in many soils or waste dumps.

### ***Partial probability of distribution***

The partial probability of distribution (PPD) was estimated for each of the exposure groups: commercial fruit crops, nursery plants, household and garden plants, and wild and amenity plants.

The details and the method of calculation for the PPD of the four exposure groups are explained in the method section and the results are presented in a series of tables and figures below. The information from these tables and figures was used to assess the probability of distribution of *V. inaequalis* to all the exposure groups.

Table 74 indicates the proportions of the five utility points near each of the exposure groups of *V. inaequalis*.

**Table 74 The proportions of utility points near host plants susceptible to *V. inaequalis* in the four exposure groups**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Proximity</b> Orchard wholesalers	Certain	Very low	Very low	Very low
<b>Proximity</b> Urban wholesalers	Extremely low	Extremely low	Extremely low	Extremely low
<b>Proximity</b> Retailers	Very low	Very low	Extremely low	Extremely low
<b>Proximity</b> Food services	Extremely low	Extremely low	Extremely low	Extremely low
<b>Proximity</b> Consumers	Very low	Very low	Low	Very Low

Figure 30 provides an estimate of the relative amounts of infested/infected apples discarded from different utility points near each of the exposure groups of *V. inaequalis*.

**Figure 30 Pictorial representation of infested/infected apples discarded by utility points near exposure groups of *V. inaequalis***

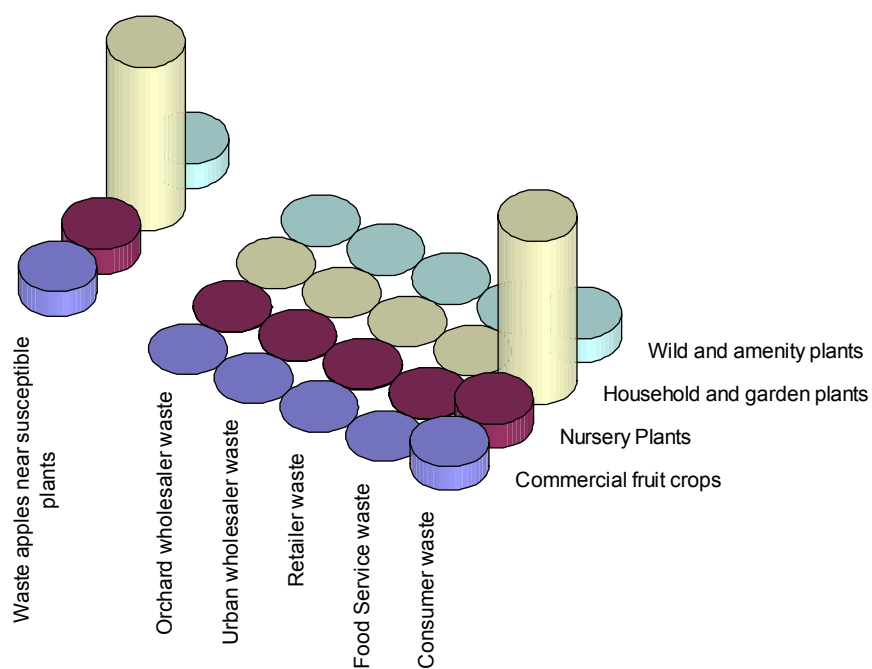


Table 75 is the summary of the probability that exposure of the host plants would result from a discarded a single infested/infected apple from different utility points. Evidence is provided in the text below under different exposure groups.

**Table 75 The probability of exposure of susceptible host plants of *V. inaequalis* by utility points discarding a single infested/infected apple near exposure group**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Exp</b> Orchard wholesaler waste <sup>59</sup>	Extremely low	Negligible	Negligible	Negligible
<b>Exp</b> Urban wholesaler waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Retailer waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Food service waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Consumer waste	Negligible	Negligible	Extremely low	Negligible

#### *Commercial fruit crops*

##### *Commercial fruit crops near utility points*

The proportions of the five utility points near commercial fruit crops susceptible to *V. inaequalis* are shown in Table 74. It was estimated that commercial fruit crops are certain to be located near all orchard wholesalers, very unlikely to be near retailers and consumers, and extremely unlikely to be near urban wholesalers and food services.

The relative amounts of infested/infected apples, discarded from different utility points near commercial plants susceptible to *V. inaequalis* is indicated in Figure 30.

##### *Exposure to host*

As shown in Table 75, it is considered that the probability that exposure of commercial fruit crops would result from discarding a single infested/infected apple, from different utility points would be extremely low for orchard wholesalers and negligible for urban wholesalers, retailers, food services and consumers.

Factors common to all exposure scenarios for various host-utility group combinations are given in the sub-section on the sequence of events for successful exposure of susceptible hosts to *V. inaequalis*. Supporting evidence for factors specific to different host groups are provided in the text below.

Apple (*Malus* spp.) and loquat (*Eriobotrya japonica*) are highly susceptible to *V. inaequalis*. Large extents of apple are planted as monocultures in pome fruit production areas.

<sup>59</sup> As indicated in the method section, for pathogens waste includes discarded infested/infected apples.

**Exp** commercial fruit crops  
from orchard wholesaler waste  
**Extremely low**

The probability that exposure of commercial fruit crops would result from orchard wholesalers discarding a single infested/infected apple: extremely low.

- Majority of orchard wholesalers dispose of their waste into an area within the orchard premises generally away from commercial plants for hygienic reasons.
- Commercial fruit crops are unlikely to be present near landfill sites to which some orchard wholesalers would dispose of their waste.
- All commercial varieties of apple are susceptible to scab, particularly during spring with new growth.

**Exp** commercial fruit crops  
from urban wholesaler waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from urban wholesalers discarding a single infested/infected apple: **Negligible**.

- Commercial fruit crops are unlikely to be located near landfill sites where urban wholesaler waste is dumped.

**Exp** commercial fruit crops  
from retailer waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from retailers discarding a single infested/infected apple: **Negligible**.

- Retail waste in metropolitan and suburban areas would be disposed of in landfill sites where exposure to commercial fruit crops is highly unlikely.

**Exp** commercial fruit crops  
from food service waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from food service establishments discarding a single infested/infected apple: **Negligible**.

- Commercial fruit crops are unlikely to be located near landfill sites in metropolitan and suburban areas where food service industry waste is disposed.

**Exp** commercial fruit crops  
from consumer waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from consumers discarding a single infested/infected apple: **Negligible**.

- The majority of consumers would be located in metropolitan and suburban areas and their waste is commonly disposed of in landfills. Commercial fruit crops would not be present near these sites.
- Some consumer waste in suburban and rural areas may be utilised for composting. Commercial fruit crops are unlikely to be present close to domestic compost heaps.
- Population density near commercial fruit tree production areas is generally low.

### *Nursery plants*

#### *Nursery plants near utility points*

The proportions of the five utility points near nursery plants susceptible to *V. inaequalis* are shown in Table 74. It was estimated that nursery plants are very unlikely to be near orchard



wholesalers, retailers and consumers and extremely unlikely to be near urban wholesalers and food services.

The relative amounts of waste apples discharged or discarded near nursery plants susceptible to *V. inaequalis* is indicated in Figure 30.

#### *Exposure to host*

As shown in Table 75, it is considered that the probability that exposure of nursery plants would result from discarding a single infested/infected apple, from different utility points would be negligible for orchard wholesalers, urban wholesalers, retailers, food services and consumers.

Factors common to all exposure scenarios for various host-utility group combinations are given in the sub-section on the sequence of events for successful exposure of susceptible hosts to *V. inaequalis*. Supporting evidence for factors specific to different host groups are provided in the text below.

*Venturia inaequalis* attacks cultivated apple (*Malus* spp.), loquat (*Eriobotrya japonica*), arrow-wood (*Viburnum* spp.) and *Sarcocephalus esculentus*. These are likely to be found in nurseries.

**Exp** nursery plants from  
orchard wholesaler waste  
**Negligible**

The probability that exposure of susceptible nursery plants would result from orchard wholesalers discarding a single infested/infected apple: **Negligible**.

- Some orchard wholesalers could have their own pome fruit nurseries near the orchards. However, different entrepreneurs usually operate nurseries and apple orchards.
- Nurseries have a high population of plants grown at high densities. These conditions provide favourable micro-climatic conditions for transfer of the pathogen to a susceptible host.
- Nursery plants would have an abundance of susceptible tissue close to the ground level. The pathogen from a discarded infected fruit would have a greater chance to reach a susceptible site.
- Nursery management requires high hygienic standards to produce healthy plants. It would require regular application of pesticides to maintain pest free status.
- Nurseries raising plants other than apple, which is susceptible to scab, are unlikely to be located near orchard wholesalers.
- Orchards adopting IFP programs are unlikely to dispose of their organic waste near nurseries.
- Transfer of conidia and ascospores by wind-driven rain and soil splash is unlikely.

**Exp** nursery plants from urban  
wholesaler waste  
**Negligible**

The probability that exposure of susceptible nursery plants would result from urban wholesalers discarding a single infested/infected apple: **Negligible**.

- Urban wholesale waste is disposed of in landfill sites.
- Retail nurseries with susceptible fruit and other amenity plants are unlikely to be located near wholesale waste dumps.

<p><b>Exp</b> nursery plants from retailer waste</p> <p><b>Negligible</b></p>	<ul style="list-style-type: none"> <li>• There are rare instances of retail nurseries being located near urban waste dumps but high hygienic standards would be maintained to achieve pest and disease freedom.</li> </ul> <p>The probability that exposure of susceptible nursery plants would result from retailers discarding a single infested/infected apple: <b>Negligible.</b></p> <ul style="list-style-type: none"> <li>• Some major retailers located in metropolitan, suburban and rural areas would have susceptible host plants for sale in the same premises. However, waste stored temporarily within the premises would not expose nursery plants to infection.</li> <li>• Organic waste from retailers in metropolitan and suburban areas would be disposed of in landfills, but nurseries plants are unlikely to be present near these sites.</li> <li>• Waste from rural establishments if used for composting may sometimes be near nursery plants, but the transfer of the pest to a host is unlikely.</li> </ul>
<p><b>Exp</b> nursery plants from food service waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible nursery plants would result from food service establishments discarding a single infested/infected apple: <b>Negligible.</b></p> <ul style="list-style-type: none"> <li>• Most food service establishments are located in metropolitan or suburban areas.</li> <li>• Waste from food services industry would be disposed of in landfills, and retail nurseries are unlikely to be located near these sites.</li> </ul>
<p><b>Exp</b> nursery plants from consumer waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible nursery plants would result from consumers discarding a single infested/infected apple: <b>Negligible.</b></p> <ul style="list-style-type: none"> <li>• Most consumers are in metropolitan and suburban areas and their waste is disposed of in landfills. Nursery plants are unlikely be present near landfill sites.</li> <li>• Indiscriminate disposal of infected fruit in retail nurseries is unlikely be significant as a potential source of infection as retail nurseries maintain high hygienic standards.</li> </ul>

### *Household and garden plants*

#### *Household and garden plants near utility points*

The proportion of the five utility points near household and garden plants susceptible to *V. inaequalis* are shown in Table 74. It was estimated that household and garden plants are very unlikely to be near orchard wholesalers, extremely unlikely to be near urban wholesalers, retailers and food services, and unlikely to be near consumers.

The relative amounts of waste apples discharged or discarded near household and garden plants susceptible to *V. inaequalis* is indicated in Figure 30.

*Exposure to host*

As shown in Table 75, it is considered that the probability that exposure of nursery plants would result from discarding a single infested/infected apple, from different utility points would be negligible for orchard wholesalers, urban wholesalers, retailers and food services and extremely low for consumers.

Factors common to all exposure scenarios for various host-utility group combinations are given in the sub-section on the sequence of events for successful exposure of susceptible hosts to *V. inaequalis*. Supporting evidence for factors specific to different host groups are provided in the text below.

*V. inaequalis* attacks cultivated apple (*Malus* spp.), loquat (*Eriobotrya japonica*), arrow-wood (*Viburnum* spp.) and *Sarcocephalus esculentus*. Some of these may be found as household and garden plants. In addition crab apple may be grown as ornamental trees.

<p><b>Exp</b> household and garden plants from orchard wholesaler waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household and garden plants to <i>V. inaequalis</i> would result from orchard wholesalers discarding a single infested/infected apple: <b>Negligible</b>.</p> <ul style="list-style-type: none"> <li>• Most orchard wholesalers are likely to discard their waste in an isolated area within the orchard premises. Some may dispose their waste in landfills.</li> <li>• It would be unlikely that orchard wholesalers have their waste disposal sites near residential areas where susceptible household and garden plants are likely to be present. Household and garden plants are not present near landfills.</li> </ul>
<p><b>Exp</b> household and garden plants from urban wholesaler waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household and garden plants would result from urban wholesalers discarding a single infested/infected apple: <b>Negligible</b>.</p> <ul style="list-style-type: none"> <li>• Urban wholesaler waste is disposed of in landfills.</li> <li>• It is highly unlikely that susceptible household plants would be near landfill sites.</li> </ul>
<p><b>Exp</b> household and garden plants from retailer waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household and garden plants would result from retailers discarding a single infested/infected apple: <b>Negligible</b>.</p> <ul style="list-style-type: none"> <li>• Household and garden plants are for sale at major retail outlets, but retail waste collected within the premises is unlikely to be exposed to susceptible plants, as waste is properly stored in bins.</li> <li>• Retail waste in urban areas is disposed of in landfills, and household and garden plants are unlikely to be nearby.</li> </ul>
<p><b>Exp</b> household and garden plants from food service waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household and garden plants would result from food service establishments discarding a single infested/infected apple: <b>Negligible</b>.</p> <ul style="list-style-type: none"> <li>• Most food service establishments are located in metropolitan and urban centres, and these may be located some distance from household and garden plants.</li> </ul>

**Exp** household and garden  
plants from consumer waste

**Extremely low**

- The waste from these establishments goes into landfills. The probability that exposure of susceptible household and garden plants would result from consumers discarding a single infested/infected apple: **Extremely low**.
- Most consumers in metropolitan and suburban areas dispose of their waste in landfills. Household and garden plants are unlikely to be present near these sites.
- Some consumers in suburban households are likely to utilise waste to make compost. Fruit trees (e.g. apple, loquat and crab apple trees) would be in some home gardens. Transfer of the pathogen from waste to susceptible hosts is unlikely.

#### *Wild and amenity plants*

##### *Wild and amenity plants near utility points*

The proportions of the five utility points near wild and amenity plants susceptible to *V. inaequalis* are shown in Table 74. It was estimated that wild and amenity plants are very unlikely to be near orchard wholesalers and consumers, and extremely unlikely to be near urban wholesalers, retailers and food services.

The relative amounts of waste apples discharged or discarded near wild and amenity plants susceptible to *V. inaequalis* are given in Figure 30.

##### *Exposure to host*

As shown in Table 75, it is considered that the probability that exposure of nursery plants would result from discarding a single infested/infected apple, from different utility points would be negligible for orchard wholesalers, urban wholesalers, retailers, food services and consumers.

Factors common to all exposure scenarios for various host-utility group combinations are given in the sub-section on the sequence of events for successful exposure of susceptible hosts to *V. inaequalis*. Supporting evidence for factors specific to different host groups is provided in the text below.

*Venturia inaequalis* attacks mainly crab apple (*Malus* spp.), but also arrow-wood (*Viburnum* spp.), *Sarcocephalus esculentus* and loquat (*Eriobotrya japonica*). Some of these may be present in the wild as a result of birds and other animals spreading the seeds.

**Exp** wild and amenity plants  
from orchard wholesaler waste

**Negligible**

The probability that exposure of susceptible wild and amenity plants would result from orchard wholesalers discarding a single infested/infected apple: **Negligible**.

- Most orchard wholesalers dispose of their waste into a waste dumpsite within the premises. Wild and amenity plants found in the orchard would be removed but some plants germinating from seeds dispersed by birds and other animals may be present near dumpsites. However, transfer of the pathogen is unlikely.
- Some orchard wholesalers would dispose of their waste into landfills. Apple seeds in the waste may germinate to produce apple seedlings growing in the wild. Similarly, other

	susceptible wild and amenity plants may be found near this site.
<b>Exp</b> wild and amenity plants from urban wholesaler waste <b>Negligible</b>	<p>The probability that exposure of susceptible wild and amenity plants would result from urban wholesalers discarding a single infested/infected apple: <b>Negligible</b>.</p> <ul style="list-style-type: none"> <li>Urban wholesale waste is sent to landfills. These sites are likely to have wild apple seedlings and other susceptible plants established from discarded apple seeds in the waste.</li> <li>Transfer of the pathogen to susceptible hosts is highly unlikely.</li> </ul>
<b>Exp</b> wild and amenity plants from retailer waste <b>Negligible</b>	<p>The probability that exposure of susceptible wild and amenity plants would result from retailers discarding a single infested/infected apple: <b>Negligible</b>.</p> <ul style="list-style-type: none"> <li>Retail waste is likely to be disposed of in landfills.</li> <li>Wild apple seedlings established from seeds in discarded apple cores and wild crab apple trees are unlikely to be nearby.</li> </ul>
<b>Exp</b> wild and amenity plants from food service waste <b>Negligible</b>	<p>The probability that exposure of susceptible wild and amenity plants would result from food service establishments discarding a single infested/infected apple: <b>Negligible</b>.</p> <ul style="list-style-type: none"> <li>Waste from food service establishments is disposed of in landfills. Wild apple seedlings and wild crab apple trees are likely to be present near these sites but transfer of the pathogen is unlikely.</li> </ul>
<b>Exp</b> wild and amenity plants from consumer waste <b>Negligible</b>	<p>The probability that exposure of susceptible wild and amenity plants would result from consumers discarding a single infested/infected apple: <b>Negligible</b>.</p> <ul style="list-style-type: none"> <li>Many consumers, particularly those in metropolitan and suburban areas, are likely to dispose of their waste in landfills. Wild apple seedlings and crab apple trees would be present at these sites.</li> <li>Some residents in suburban areas may utilise the waste to make compost. The transfer of the pathogen from a compost heap to a crab apple or apple tree would be unlikely.</li> <li>The chances of exposure of susceptible wild host plants in parks near recreational facilities and along roadsides to an infected fruit are negligible. In these situations plants are likely to be widely dispersed.</li> </ul>

### ***Conclusion—probability of distribution***

The partial probability of distribution from each of the utility points to each of the exposure groups is summarised in Table 76. The simulation model using @risk calculated this. The quantitative model evaluated the effect of the ‘volume of trade’ during a specified period when calculating the partial probability of distribution.

**Table 76 Partial probabilities of distribution (PPD)<sup>2</sup> for *V. inaequalis***

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
Orchard wholesalers	Extremely low	Negligible	Negligible	Negligible
Urban wholesalers	Negligible	Negligible	Negligible	Negligible
Retailers	Extremely low	Extremely low	Negligible	Negligible
Food service	Negligible	Negligible	Negligible	Negligible
Consumers	Extremely low	Extremely low	Moderate	Extremely low
<b>PPD<sup>60</sup></b>	<b>Extremely low</b>	<b>Extremely low</b>	<b>Moderate</b>	<b>Extremely low</b>

### Probability of establishment or spread

The assessment for the probability of establishment or spread was carried out in the following manner. Firstly, partial probabilities for establishment and for spread were assessed separately based on the relevant available scientific information. Secondly, the combined partial probability of establishment or spread for each of the four exposure groups was assessed. The relevant information for the assessment for the probability of establishment or spread is presented below against the factors listed ISPM 11, Rev. 1.

#### *Partial probability of establishment*

ISPM 11 factor	Relevant information
<b>Availability of suitable hosts, alternate hosts and vectors in the PRA area</b>	<ul style="list-style-type: none"> <li>The apple production area in Western Australia (WA) covers 1,874 hectares over four growing regions. Most of the recent plantings are medium to high-density populations, i.e. closer plantings (Jarvis, 2000).</li> <li>All cultivated <i>Malus</i> spp. are susceptible to scab. Most of the commercial varieties are susceptible to scab but Jonathan, Red Delicious and Golden Delicious show some resistance. Gala is moderately susceptible but Lady William, Granny Smith, Pink Lady™ and Sundowner™ are very susceptible (McKirdy, 2003). Wild and ornamental species of <i>Malus</i> are equally susceptible to scab.</li> <li>Vectors are not required for establishment of this pathogen.</li> </ul>

<sup>60</sup> <sup>2</sup>Partial probability of distribution is actually referring to the probability of entry and was estimated by @risk.

ISPM 11 factor	Relevant information
<b>Suitability of the environment</b>	<p>However, conidia of <i>V. inaequalis</i> were found on the legs of aphids removed from severely infected trees (Dillon-Weston and Petherbridge, 1933). Therefore, aphids and other pests of apple have the potential to involuntarily disseminate conidia.</p> <ul style="list-style-type: none"> <li>• There have been six previous outbreaks of scab in the south-west of WA since the first detection in Manjimup in 1930 (MacHardy, 1996). He showed that during recurrence of scab around Manjimup in 1989, 455 trees were infected at 10 locations between December and March. This shows that environmental conditions are suitable for development of the disease.</li> <li>• The areas in WA that experience spring and summer rains are more susceptible to scab than the lower south-west region, which has a Mediterranean-type climate (MacHardy, 1996).</li> <li>• The mean annual rainfall in the Perth Hills and Manjimup exceeds 1,000 mm per annum. These conditions are ideal for establishment of the disease.</li> <li>• The temperature, wetness and relative humidity have an effect on spore germination and infection (Studt and Weltzien, 1975). The temperature range in these areas is within the range favourable for ascospore and conidial germination. This has been demonstrated in previous scab outbreaks (MacHardy, 1996).</li> <li>• The optimum temperature range for ascogonial development and maturation is 8–12°C and 16–18°C, respectively (James and Sutton, 1982).</li> </ul>
<b>The potential for adaptation of the pest</b>	<ul style="list-style-type: none"> <li>• The occurrence of fungicide tolerant strains (Koller <i>et al.</i>, 1997; Lalancette <i>et al.</i>, 1987) and strains with reduced sensitivity to DMIs (Stains and Jones, 1985; Whelan <i>et al.</i>, 1992) has been demonstrated. Therefore, the scab pathogen can develop fungicide resistance.</li> <li>• The adaptation of this pathogen to overcome host resistance has also been reported. As a consequence, seven physiologic races have been identified (CABI, 2003a). Race 1 of the pathogen has been reported from Australia (Heaton <i>et al.</i>, 1991) and New Zealand (Patterson <i>et al.</i>, 2003). Therefore, the scab pathogen has the potential to adapt to overcome host resistance.</li> </ul>
<b>The reproductive strategy of the pest</b>	<ul style="list-style-type: none"> <li>• The scab fungus can reproduce sexually or asexually. Sexual reproduction occurs via ascospores produced in ascocarps (pseudothecia) in overwintered leaves or fruit on the orchard floor.</li> <li>• Ascospores released from pseudothecia overwintering on leaves and fruit provide the inoculum for new growth at bud break. The lesions developing from ascospores produce conidia (Biggs, 1990).</li> </ul>

ISPM 11 factor	Relevant information
	<ul style="list-style-type: none"> <li>Conidia produced on leaves and fruit are the principal source of inoculum for the build up of the disease in the summer. Several secondary cycles may occur during the growing season. Each cycle takes about 9–17 days to show visible symptoms after conidia penetrate and ramify in the host tissues (Biggs, 1990).</li> </ul>
<b>Minimum population needed for establishment</b>	<ul style="list-style-type: none"> <li>Potentially a single ascospore or conidium can initiate an infection, provided environmental factors are favourable for germination.</li> <li>Inoculum dose has a considerable influence on the amount of scab that develops on mature Granny Smith apples. Five-fold increases in inoculum dose (i.e. 118, 590, 2,950, 14,750, 73,750 and 368,750 viable conidia per cm<sup>3</sup>) resulted in about one, 14, 48, 70, and 98 per cent scabbed fruit, respectively. The higher the inoculum dose the greater is the damage (MacHardy, 1996).</li> </ul>
<b>The method of pest survival</b>	<ul style="list-style-type: none"> <li>The pathogen survives from one season to another by pseudothecia where asci and ascospores continue to mature over the winter months (Biggs, 1990).</li> <li>The fungus can also overwinter as mycelia in twig lesions in maritime climates, but this method of survival is unusual elsewhere (Biggs, 1990).</li> </ul>
<b>Cultural practices and control measures</b>	<ul style="list-style-type: none"> <li>Integrated Pest and Disease Management (IPDM) programs are undertaken in commercial orchards in Australia. Commercial orchards have strategies in place for the management of chemical sprays to prevent development of resistant strains. In Orange and Batlow, NSW, Australia, apple scab is controlled by the application of protectant fungicides at seven to ten day intervals, supplemented by curative sprays when required following infection warnings (Penrose, 1992). These fungicides would be effective in controlling scab in WA.</li> <li>During the 1989–1990 scab outbreaks in WA, sanitation methods (stripping infected leaves from young trees, pruning and removal of infected shoots, mulching with leaf litter, ploughing to bury leaves, using sheep to graze the orchard floor), chemical methods (application of fungicides, spraying the ground with five per cent urea at early leaf fall), and other methods (restriction of fruit movement, orchard inspections) were employed to successfully eradicate scab.</li> </ul>

*Conclusion—partial probability of establishment*

Based on the above evidence, partial probability of establishment for each of the exposure groups is assessed as follows.

Partial probability of establishment for commercial fruit crops: **High**.

Partial probability of establishment for nursery plants: **High**.



Partial probability of establishment for household and garden plants: **Moderate**.

Partial probability of establishment for wild and amenity plants: **Moderate**.

### ***Partial probability of spread***

<b>ISPM 11 factor</b>	<b>Relevant information</b>
<b>Suitability of the natural and managed environment</b>	<ul style="list-style-type: none"> <li>Apple scab is widespread in the eastern States of Australia where the disease is managed. Occurrence of several small outbreaks of scab in WA in the past indicates that the disease can spread in the natural environment when conditions are conducive for the spread of scab.</li> <li>The disease management programs undertaken in orchards to maintain general hygiene may have reduced the spread potential during the previous outbreaks in WA.</li> </ul>
<b>Presence of natural barriers</b>	<ul style="list-style-type: none"> <li>WA is isolated from the closest apple growing area in South Australia by a dry land mass. It is unlikely that the pathogen would disseminate by rain or wind over such long distances.</li> <li>Physical barriers may prevent long-range spread of the pathogen but, if scab were to be introduced to WA, physical barriers are unlikely to be a limiting factor for the spread of scab. The disease has the potential to gradually spread by expanding its foci of infection to all production areas in WA.</li> </ul>
<b>Potential for movement with commodities or conveyances</b>	<ul style="list-style-type: none"> <li>The pathogen can infect most above ground parts but the most obvious sites of infection are leaves and fruit (Biggs, 1990).</li> <li>The most likely mode of introduction of scab into WA would be via infected planting material or contaminated fruit (MacHardy, 1996).</li> <li>Inadvertent transmission on clothing by humans has also been suggested as a possible means of introducing the disease into WA (MacHardy, 1996).</li> </ul>
<b>Intended use of the commodity</b>	<ul style="list-style-type: none"> <li>Apples would be used mainly for human consumption. However, substandard apples would be channelled into juicing or processing.</li> </ul>
<b>Potential vectors of the pest</b>	<ul style="list-style-type: none"> <li>There are no specific vectors but some insects coming into contact with ascospores or conidia of the pathogen have the potential to spread the spores, provided the viability is retained.</li> </ul>
<b>Potential natural enemies</b>	<ul style="list-style-type: none"> <li>Species antagonistic to pseudothecial formation and ascospore production of <i>V. inaequalis</i> have been reported under experimental conditions (Boudreau and Andrews, 1987; Cullen <i>et al.</i>, 1984; Miedtke and Kennel, 1990; Pillion <i>et al.</i>, 1997). They include <i>Aureobasidium pullulans</i>, <i>Chaetomium globosum</i>, <i>Athelia bomacina</i>, <i>Coniothyrium</i> sp. and <i>Phoma</i> sp. Some of these species are likely to exist under natural conditions in orchards or waste dumps.</li> </ul>

*Conclusion—partial probability of spread*

Based on the above evidence, partial probability of spread for each of the exposure groups is assessed as follows.

Partial probability of spread for commercial fruit crops: **High**.

Partial probability of spread for nursery plants: **High**.

Partial probability of spread for household and garden plants: **High**.

Partial probability of spread for wild and amenity plants: **Low**.

**Combined partial probability of establishment or spread**

The combined partial probabilities of establishment or spread were determined by combining probabilities of establishment and probabilities of spread using the matrix of ‘rules’ for combining descriptive likelihoods as presented in the method section. The results are indicated in Table 77.

**Table 77 Combined partial probabilities of establishment or spread of *V. inaequalis***

	<b>Commercial fruit crops</b>	<b>Nursery plants</b>	<b>Household and garden plants</b>	<b>Wild and amenity plants</b>
<b>Establishment</b>	High	High	Moderate	Moderate
<b>Spread</b>	High	High	High	Low
<b>PPES<sup>61</sup></b>	High	High	Moderate	Low

Additional evidence to support the combined partial probability of establishment or spread for specific exposure groups is provided in the text below.

**Commercial fruit crop**  
**High**

Most apple cultivars grown in WA are susceptible to scab. The environmental conditions are favourable for infection, and monoculture and high-density plantings also favour rapid spread of the disease. In areas where Mediterranean-type climate occurs, conditions are not ideal for disease establishment and spread. However, occurrence of several small outbreaks in commercial orchards over some years indicates that scab has the potential to spread in WA.

**Susceptible nursery plants**  
**High**

In nurseries, the micro-climatic effects created by close planting and overhead irrigation (if undertaken) can create environmental conditions suitable for rapid spread of the pathogen. Use of infected planting material has been attributed as one of the means of introduction and spread of scab in WA. To ensure freedom from scab, nurseries would be sprayed with chemicals.

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<sup>61</sup> PPES = partial probability of establishment or spread.

<b>Susceptible household plants</b>	The number of susceptible host plants would be few and low in density. This would limit the availability of susceptible tissues.
<b>Moderate</b>	Some householders would attempt to control the disease either by sanitation methods or use of chemicals, but these measures are likely to be successful only if the disease is detected early and application of chemicals is timed properly. Most organic growers will not use chemical sprays.
<b>Susceptible wild and amenity plants</b>	Several host-specific forms of <i>V. inaequalis</i> infect amenity plants (Menon, 1956). Such plants are unlikely to serve as an alternative host for scab. Most susceptible wild and amenity plants are fewer in number and scattered over a wide area. It is almost certain that wild and amenity plants infected by scab would not be sprayed with fungicides to control the disease.
<b>Low</b>	

### Assessment of consequences

Impact scores allocated for the direct and indirect criteria are given in Table 78. Available supporting evidence is provided in the text below.

Based on the following evidence and the impact scores allocated for the direct and indirect criteria the overall consequence of entry and establishment or spread of *V. inaequalis* is estimated as **Low**.

**Table 78 Impact scores for *V. inaequalis***

<b>Direct impact</b>	<b>Impact scores</b>
Plant life or health	E
Human life or health	A
Any other aspects of the environment	A
<b>Indirect impact</b>	
Control or eradication	E
Domestic trade or industry	D
International trade	D
Environment	B
Communities	C

#### **Direct impact**

##### **Plant life or health – E**

Consequences affecting plant life or health would be minor at the national level, significant at the regional level and highly significant at the district level. The rating assigned to this criterion was therefore ‘E’.

- Health of the plant is affected directly by lowering the fruit quality and indirectly by affecting the vigour of plant growth (Biggs, 1990). Fruit with scabby growth is not acceptable to consumers and is unsaleable, and mature fruit with ‘pin-point’ lesions may develop fruit rot symptoms after storage. Such fruit will be discarded.
- Crop loss figures are not available for Australia, but significant crop losses (70 per cent or more) have been reported elsewhere when environmental conditions are favourable for the pathogen (Biggs, 1990).
- In south-west WA, there have been six outbreaks of scab since the first detection in Manjimup in 1930 (MacHardy, 1996). These outbreaks occurred around the Manjimup and Albany districts from 1930–1991 (MacHardy, 1996). He showed that another unrelated attack occurred in Stoneville 30 km north to north-east of Perth in 1991–1992. At Mt. Baker in 1936–1939, more than 11,000 trees were destroyed or returned to the nursery that supplied the plants. In 1947–1948, about 3,700 young trees were destroyed and about 19,000 trees or stocks were cut back (MacHardy, 1996). During the 1989 recurrence of scab around Manjimup, trees in 10 locations were infected between December and March. These outbreaks would have contributed to actual or potential yield reductions.
- The direct impact of scab on other susceptible household plants or on wild plants is difficult to estimate. Direct impact is likely to be discernible only by commercial growers who are directly affected. Other species such as arrow-wood (*Viburnum* spp.), *Sarcocephalus esculentus* and loquat (*Eriobotrya japonica*) can succumb to the disease (CABI, 2003a; MacHardy, 1996), but during earlier outbreaks in WA damage to these crops was not reported.

**Human life or health –** The rating assigned to this criterion was ‘A’.

**A**

- Apple scab is not known to have any direct impacts on human life or health.

**Any other aspects of environmental effects** There are no known direct impacts of scab on the environment and the rating assigned to it was therefore ‘A’.

**– A**

- During previous outbreaks of scab in WA, there was no evidence that scab infected native plant species thereby endangering biodiversity. Therefore, scab is unlikely to cause a reduction of plant species that are part of the ecosystem.
- There was no direct impact on the non-living environment, such as the physical environment.

**Indirect impact**

**Control or eradication**

**– E**

The indirect impact on new or modified eradication, control, surveillance/monitoring and compensation strategies was

considered minor at the national level, significant at the regional level and highly significant at the district level. The rating assigned to this criterion was therefore 'E'.

- Scab is effectively controlled in the eastern States of Australia by using protective and curative fungicides. These applications are made when required following infection warnings (Penrose, 1992).
- During the 1989–1990 scab outbreak, several strategies were adopted to eradicate the disease including sanitation, chemical control and other methods. These programs were highly successful, but significant costs were incurred in controlling and eradicating scab in WA. However, long-term economic viability of the majority of commercial orchards has not been threatened.
- In the event of an incursion of scab in WA, an eradication program would be initiated under the WA scab plan (Kumar, 2002).
- If scab occurs in WA, additional costs would be incurred for eradicating or controlling scab. The cost is likely to depend on the severity and duration of the outbreak. Eradication programs can be very expensive if an outbreak is not detected early, and involve joint participation from all levels of government and industry.
- Previous scab outbreaks in WA have been contained and eradicated. Therefore, it would be feasible to control the disease with chemical sprays or even to eradicate it using a number of strategies as has been done previously.
- However, additional resources may be required to provide assistance to growers either to control or eradicate the pathogen. If the eradication program were not successful, presence of scab in WA would require minor modifications to horticultural practices.
- Compensation has been paid to growers affected by scab during previous outbreaks.

#### Domestic trade or industry – D

The indirect consequences on domestic trade are unlikely to be discernable at a national level and would be of minor significance at the regional level. A rating of 'D' was assigned to this criterion.

- Scab is primarily a disease affecting the quality of fruit. Australian consumers have a very low tolerance for blemished fruit. Such fruit is likely to be down graded or rejected at different points in the marketing chain.
- Scab occurs in the eastern States in Australia. There is free movement of apple fruit between all States and Territories, except WA.
- Currently, there are trading restrictions on planting materials and a ban on the movement of fruit into WA. Therefore, national marketing arrangements for movement of fruit are

unlikely to change in the short-term.

- However, if scab were to establish in WA and it could not be eradicated, there may be scope to open up the market to WA, subject to meeting quarantine requirements for other pests not in WA.

**International trade – D** The indirect consequences on international trade are unlikely to be discernable at the national level and of minor significance at the regional level. A rating of ‘D’ was assigned to this criterion.

- At present, Australia exports about 10 per cent of the apples produced, valued at AUD21.6 million. WA contributes a significant amount to the total exports.
- Australia exports apples to 10 major destinations. Japan imports only Fuji apples from Tasmania. Scab is present in Japan and the UK, which are two significant markets. None of the other markets, which are tropical countries, have recorded scab (CABI, 2003a).
- Occurrence of scab in the eastern States in Australia has not resulted in restrictions being imposed for the international trade in fruit.
- Other countries are unlikely to introduce restrictions on trade in apples if scab were to be introduced into WA, but apple fruit from WA may then not be able to command premium prices.
- Apple producing countries are able to export their fruit to most markets around the world, regardless of the presence of scab in the export production areas.
- Currently, there are no disruptions in trade owing to failure to comply with changes in international consumer demand.
- Major markets in Europe demand the use of environmentally sustainable practices in fruit production. Excessive use of fungicides may lead to rejection of fruit.

**Environment – B** The indirect consequences on the environment are unlikely to be discernable at district level and would be of minor at the local level. A rating of ‘B’ was assigned to this criterion.

- Currently, management of scab in Australia is based on an IFP program, which includes application of fungicide.
- No unacceptable effects on the environment have been reported during previous attempts to control scab in WA.
- In designated environmentally sensitive areas or protected areas, apples are unlikely to be a major host but there is a low likelihood of occurrence of crab apple trees and wild apple trees. Scab infection on these trees is unlikely to have an environmental impact.
- It is unlikely that scab would affect plant species or impact on ecological processes such as erosion, water table changes, increased fire hazard and nutrient cycling.
- Additional applications of fungicides would be required to

**Communities – C**

control scab, which may have a local environmental impact.

The indirect consequences on communities are unlikely to be discernable at the regional level, would be of minor significance at the district level and significant at the local level. A rating of ‘C’ was assigned to this criterion.

- There would be some social implications if several farms were infected by scab causing significant economic damage.
- The main effect would be discontinuing workers owing to reduced or lack of fruit production.
- It is unlikely that there would be any effect on the tourist industry should scab occur in WA.
- Scab would have little or no effect on water quality, recreational uses, tourism, and animal grazing, hunting or fishing.

**Conclusion—consequences**

Based on the decision rule described in the method section, i.e. where the consequences of a pest with respect to one or more criteria are ‘E’, the overall consequences are considered to be ‘moderate’. Therefore the overall consequences of apple scab are **Moderate**.

**Unrestricted annual risk**

Unrestricted annual risk is the result of combining annual probability of entry, establishment or spread with the outcome of overall consequences. Probabilities and consequences are combined using the ‘rules’ shown in the risk estimation matrix in the method section. The unrestricted annual risk estimation for apple scab is shown in Table 79.

**Table 79 Risk estimation of *V. inaequalis***

Overall probability of entry, establishment or spread <sup>62</sup>	<b>Low</b>
Consequences	<b>Moderate</b>
Unrestricted annual risk	<b>Low</b>

<sup>62</sup> Calculated by @ risk.

## **Codling moth**

### **Biology**

Codling moth, *Cydia pomonella* (Linnaeus), has four life stages: adult, egg, larva, and pupa.

Adult is a small grey-brown moth. Eggs are laid singly on developing fruits and foliage. After hatching, the larva burrows immediately into a fruitlet. Larvae pass through five instars whilst feeding within the fruit, and then vacate it. Larvae then spin cocoons within cracks in the tree trunk or under loose pieces of bark or amongst debris on the ground (HortResearch, 1999b). Cocoons can also be found in fruit containers and other equipment (Hely *et al.*, 1982).

Life cycle development varies seasonally but has an average of 68 days. The number of generations per year varies from 1 to 4 depending on the climate, and sometimes the host plant (CABI, 2003a). In New Zealand, there is one full generation per year in the central and southern areas of New Zealand, and two generations in Hawke's Bay and the northern areas of the North Island (HortResearch, 1999b).

### **Risk scenario**

The risk scenario of concern for codling moth in this IRA is the larva living inside the apple fruit.



## Probability of importation

The initiating step for the importation scenario for apple fruit is the sourcing of apples from orchards in New Zealand, while the end-point is the release of imported apples from the port of entry. The importation scenario is divided into eight steps and the likelihood of the codling moth being present at each step is summarised in Figure 31. The available evidence supporting the likelihood assessments is provided in the text below.

**Figure 31 The importation steps and the likelihood of the codling moth being present at each step**



**Importation step 1  
(Imp1)**

**High**

The likelihood that codling moth is present in the source orchard in New Zealand: **High**

- Codling moth is common throughout New Zealand (HortResearch, 1999b), and apple is its main host plant (CABI, 2002).

**Importation step 2  
(Imp2)**

**Low**

The likelihood that picked apple fruit is infested with codling moth: **Low**

HortResearch (1999b) and CABI (2002) provide the following relevant information:

- Eggs are laid on or close to the developing fruit.
- The caterpillars hatch within about a week and enter the fruit within 24 hours. This may occur anywhere on the surface but is primarily on the ripe side and/or through the calyx.
- The first stage caterpillar constructs a spiral gallery or mine just below the fruit surface; it then moults to second stage and begins radial penetration of the fruit; later stages consume some of the seeds and tunnel extensively in the fruit. Larvae pass through five instars whilst feeding within the fruit, and then vacate it.
- After about four weeks, the mature larva leaves the fruit and spins a cocoon within cracks in the tree trunk or under loose pieces of bark or amongst debris on the ground.
- In New Zealand, codling moth has one generation in the south, one and a partial second generation in Nelson, Canterbury, Otago and southern part of North Island, and two generation in Hawkes Bay and northern part of North Island.
- According to Rothschild and Vickers (1991), commercial orchards using broad-spectrum insecticides correctly can keep codling moth damage to below 2%.
- In Nova Scotia, the degree of infestation under insecticide-free conditions varied from 6 to 10% of the entire crop in an orchard over 12 years, depending on the cultivar (MacLellan, 1977). In an orchard in Lake Ontario, USA, where there is one generation and a partial second, similar to those seen in southern England, damage ranged from 7 to 35% (Glass and Lienk, 1971). In warmer climates, where two or more generations occur, damage to apples has been reported as being as high as 84% in the Crimea (Tanskii and Bulgak, 1981), or 65 to 100% in Australia (Geier, 1964).

*Summary*

Based on the above information that one to two generations of codling moth occur in New Zealand, reasonable estimate would be that the likelihood that picked apple fruit is infested with codling

### Importation step 3 (Imp3)

Negligible

moth in New Zealand would be in the range of low probability (5-30%) and thus Imp2 was assessed as low.

The likelihood that clean fruit is contaminated by codling moth during picking or transport to the packing house: **Negligible**

- Fruit are picked into harvesting bags and then transferred into bins kept on the ground in the orchard prior to transportation to the packing house.
- Young larvae of codling moth would not leave the fruit; mature larvae can leave fruit and seek cocooning sites other than fruit to pupate.
- In addition, even if they come out from one fruit and pupate on another fruit, the total number of infected or infested apple will not increase as a single larva will usually attack only one fruit, and fruits are seldom attacked by more than one larva (CABI, 2002).

#### *Summary*

Based on the above information, the likelihood for Imp3 was assessed as negligible.

### Importation step 4 (Imp4)

High

The likelihood that codling moth survives routine processing procedures in the packing house: **High**

#### *Washing*

- Larvae of codling moth feed internally within the apple and they would not be removed by external high-volume/high pressure washing.

#### *Brushing*

- Larvae of codling moth feed internally within the apple and they would not be removed by brushing.

#### *Waxing*

- There is no evidence to suggest that larvae protected inside apple fruit would not be able to survive the waxing process.

#### *Sorting and Grading*

- Sorting and grading would remove some fruit that are contaminated with larvae since the presence of frass (droppings) outside the fruit would be noticeable.

#### *Packaging*

- Packaging would have little effect on the survival of codling moth. In most cases the packaging of apples is designed to maximise heat discharge from the fruit while minimising loss of moisture.

#### *Cold Storage*

- The cocooned larvae are likely to survive because codling

moth overwinters as cocooned larvae on the host in cracks and under bark.

- Larvae inside apple fruit would be able to survive storage prior to transportation since they can feed inside the fruit.
- Diapausing codling moth larvae are cold hardy and can survive exposure of  $-20^{\circ}\text{C}$  for 3 days (Neven, 1998).

#### *Summary*

Based on the above evidence that codling moth larvae would not be removed by routine processing procedures and can survive cold storage undertaken in the packing house, the likelihood for Imp4 was assessed as high.

#### **Importation step 5 (Imp5)**

**Negligible**

The likelihood that clean fruit is contaminated by codling moth during processing in the packing house: **Negligible**

- As the larvae live inside the fruit, codling moth would not be able to contaminate clean fruit during processing in the packing house.

#### **Importation step 6 (Imp6)**

**High**

The likelihood that codling moth survives palletisation, quality inspection, containerisation and transportation to Australia: **High**

- Diapausing codling moth larvae are cold hardy and can survive exposure of  $-20^{\circ}\text{C}$  for 3 days (Neven, 1998).
- The larvae inside the fruit would be able to survive the palletisation, quality inspection, containerisation and refrigerated transport to Australia.

#### **Importation step 7 (Imp7)**

**Negligible**

The likelihood that clean fruit is contaminated by codling moth during palletisation, quality inspection and transportation:

**Negligible**

- As the larvae live inside the fruit, codling moth would not contaminate clean fruit.

#### **Importation step 8 (Imp8)**

**High**

The likelihood that codling moth survives and remains with fruit after on-arrival minimum border procedures: **High**

- The minimum border procedures as described in the method section would not be effective in detecting larvae inside the fruit.

#### ***Conclusions—probability of importation***

When the above likelihoods were inserted into the simulation model, the probability of importation of codling moth from one year of trade was found to be **Low**.

#### **Probability of distribution**

The initiating step for the distribution scenario is the release of imported apples from the port of entry, while the last step is the pest being distributed (as a result of the processing, sale or

disposal of these apple fruit) in a viable state to an endangered area and subsequently being exposed to a suitable host.

In order to assess the probability of distribution, the distribution scenario is addressed in the three subheadings below. First is a brief description of sequences of events leading to a successful exposure of the pest from infested/infected apple to a susceptible host plant. Second is the assessment of partial probability of distribution of the pest in relation to each of the exposure groups. Third is the conclusion for the probability of distribution.

### ***Sequence of events for successful exposure***

The sequence of events that has to be completed for a successful exposure of a susceptible host to the pest is summarised below.

The insect stage associated with the imported apple is the larvae. There is usually only one larva per apple. The only means for codling moth to leave fruit or packaging and enter the environment of exposure groups is through adult flight. If the larva were to survive cold storage or controlled atmosphere it would have to move out from the fruit to find a site to pupate. There would be mortality during the larva's search for a pupating site. Pupae need time to develop and become mature. If the adult were to emerge from this pupal stage it could occur at unpacking and repacking facilities or retailers (utility points), on discarded fruit in waste, at landfills where the waste is disposed, and during transportation of purchased apples from retailers to households.

The adults are capable of flying for 300m for most females and 1 km for most males. Sexual reproduction is essential. Female codling moths produce a potent sex pheromone to enable long-range communication with males seeking a mate (HortResearch, 1999b). After mating, Alpha-farnesene produced by fruit stimulates egg laying in the female.

A successful exposure of codling moth from infested fruit to its hosts means that mature larvae need to come out from fruit to pupate, pupae need to develop to become adult, and adult female would need to locate a male to mate and subsequently lay her eggs on a susceptible fruiting host.

### ***Partial probability of distribution***

The partial probability of distribution (PPD) was estimated separately for each of the four exposure groups: commercial fruit crops; nursery plants; household and garden plants; and, wild and amenity plants.

The details and the method of calculation for the PPD of the four exposure groups are explained in the method section and the results are presented in a series of tables and figures below. The information from these tables and figures was used to assess the probability of distribution of codling moth to all the exposure groups.

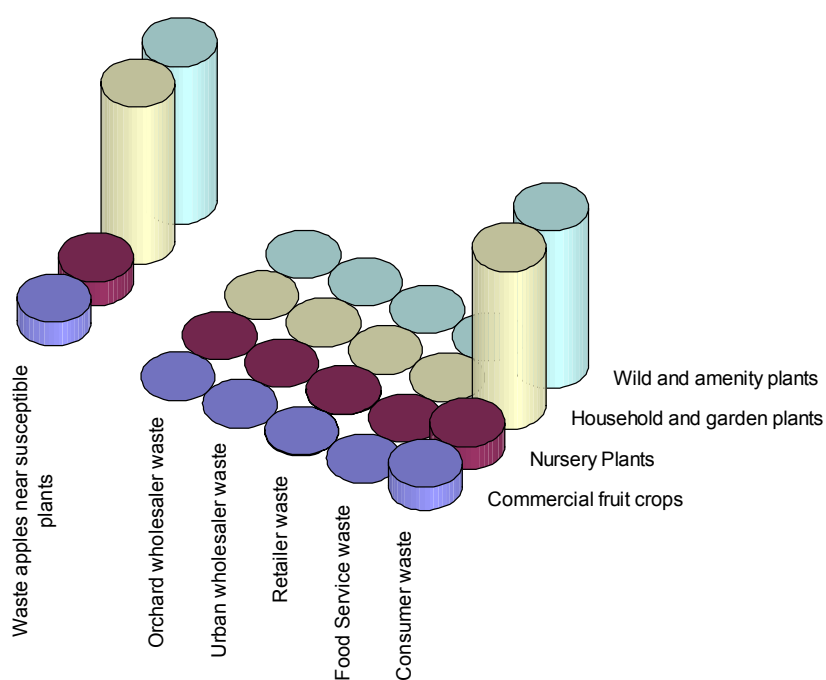
Table 80 indicates the proportions of the five utility points near each of the exposure groups of codling moth. The main hosts of codling moth include pome fruit (apple and pear), stone fruit (apricot, cherry, plum and peach) and walnuts.

**Table 80 The proportions of utility points near host plants susceptible to codling moth in the four exposure groups**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Proximity</b> Orchard wholesalers	Certain	Very low	Very low	Very low
<b>Proximity</b> Urban wholesalers	Extremely low	Extremely low	Extremely low	Extremely low
<b>Proximity</b> Retailers	Very low	Very low	Extremely low	Extremely low
<b>Proximity</b> Food services	Extremely low	Extremely low	Extremely low	Extremely low
<b>Proximity</b> Consumers	Very low	Very low	Low	Low

Figure 32 gives a pictorial representation of the relative amounts of infested/infected apples, an escaped pest or contaminated packaging material discharged or discarded from different utility points near each of the exposure groups of codling moth.

**Figure 32 Pictorial representation of the relative amounts of infested/infected apple waste<sup>63</sup> from utility points to near exposure groups of codling moth**



<sup>63</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or an escaped pest, or contaminated packaging material.

Table 81 is the summary of the probability that exposure of the host plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points. Evidence is provided in the text below under different exposure groups.

**Table 81 The probability of exposure of susceptible host plants of codling moth from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Exp</b> Orchard wholesaler waste <sup>64</sup>	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Urban wholesaler waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Retailer waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Food service waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Consumer waste	Negligible	Negligible	Negligible	Negligible

#### *Commercial fruit crops*

##### *Commercial fruit crops near utility points*

The proportions of the five utility points near commercial fruit crops of codling moth are shown in Table 80. It was estimated that commercial fruit crops are certain to be located near all orchard wholesalers, very unlikely to be near retailers and consumers, and extremely unlikely to be near urban wholesalers and food service as most of these are in metropolitan areas.

The relative amounts of infested/infected apples, or an escaped pest, or contaminated packaging material discharged or discarded from different utility points to near commercial fruit crops susceptible to codling moth are indicated in Figure 32.

##### *Exposure to host*

The main commercial hosts of this pest are pome fruit (apple and pear), stone fruit (apricot, cherry, plum, nectarine and peach) and walnut.

<sup>64</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or escaped pest, or contaminated packaging material.



A successful exposure of codling moth from infested fruit to its hosts means that mature larvae need to come out from fruit to pupate, pupae need to develop to become adult, and adult female would need to locate a male to mate and subsequently lay her eggs on a susceptible fruiting host. The chance for this to happen depends on several factors, including the mortality caused by handling and consumption of the fruit and casualties caused when larvae search for a pupation site, the level of infestation/infection and number of apples in the same utility points, reproductive strategy, life span of the pest as well as availability of susceptible hosts.

As shown in Table 81, it was considered that the probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

<p><b>Exp</b> commercial fruit crops from orchard wholesaler waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: <b>Negligible</b>.</p> <ul style="list-style-type: none"> <li>• Apple trees are readily available in commercial orchards.</li> <li>• Pome fruit and stone fruit are the main commercial crops that codling moth attacks.</li> <li>• Alpha-farnesene produced by fruit stimulates egg laying in female codling moth.</li> </ul>
<p><b>Exp</b> commercial fruit crops from urban wholesaler waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>• Commercial fruit crops are not located in urban areas.</li> <li>• Urban wholesaler waste is disposed into bins and taken to landfills. Commercial fruit crops are usually not located adjoining these sites.</li> </ul>
<p><b>Exp</b> commercial fruit crops from retailer waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>• Most retailers are located in urban areas not close to commercial fruit crops.</li> <li>• Retailer waste may be used for composting in rural areas and some of these sites may be near commercial orchards.</li> </ul>
<p><b>Exp</b> commercial fruit crops from food service waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>• Most food service waste is disposed of in landfill sites, which are generally not near commercial fruit crops.</li> </ul>
<p><b>Exp</b> commercial fruit crops from consumer waste</p>	<p>The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple,</p>

**Negligible**

an escaped pest or contaminated packaging material from consumers: **Negligible**

- Majority of consumers are located in metropolitan and suburban areas. Waste produced by people in metropolitan areas and some in urban areas is generally disposed into landfills. Commercial fruit crops would usually not be present adjoining these sites.
- Households and population densities around commercial orchards are very low.
- Some consumer waste in suburban and rural areas may be utilised for composting. Commercial fruit crops can be present close to compost heaps.

*Nursery plants*

*Nursery plants near utility points*

The proportions of the five utility points near nursery plants of codling moth are shown in Table 80. It was estimated that nursery plants are very unlikely to be near orchard wholesalers, retailers and consumers, and extremely unlikely to be near urban wholesalers and food service.

The relative amounts of waste apples discharged or discarded near nursery plants susceptible to codling moth are indicated in Figure 32.

*Exposure to host*

The main nursery hosts of this pest are pome fruit (apple and pear), stone fruit (apricot, cherry, plum, nectarine and peach), walnut, chestnut, quince, persimmon, crab apple and pomegranate.

A successful exposure of codling moth from infested fruit to its hosts means that mature larvae need to come out from fruit to pupate, pupae need to develop to become adult, and adult female would need to locate a male to mate and subsequently lay her eggs on a susceptible fruiting host. The chance for this to happen depends on several factors, including mortality caused by handling and consumption of the fruit and casualties caused when larvae search for a pupation site, the level of infestation/infection and the number of apples in the same utility points, the reproductive strategy and life span of the pest as well as the availability of susceptible hosts. It is improbable that nursery stock would be fruiting, and as previously mentioned, the female is stimulated by alpha-farnesene produced by fruit to lay eggs.

As shown in Table 81, it was considered that the probability that exposure of nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** nursery plants from  
orchard wholesaler waste  
**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- If a nursery were to be located near orchard wholesaler waste

the chance of a successful exposure would be negligible due to the fact that codling moth require a fruiting host, which is improbable in a nursery, to oviposit.

**Exp** nursery plants from urban  
wholesaler waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

- There are rare instances of nurseries being located near to urban waste dumps, however as previously mentioned nursery stock are unlikely to be fruiting.

**Exp** nursery plants from retailer  
waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Suitable nursery plants are for sale in major retail outlets.
- A number of fresh food markets will have nursery plants near apple fruit. However there are a limited number of nurseries associated with fresh food markets that also maintain or store actively growing suitable host trees.
- However, as previously mentioned, it is improbable that fruiting hosts will be present in nurseries.

**Exp** nursery plants from food  
service waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- As previously mentioned, it is improbable that fruiting hosts will be present in nurseries.

**Exp** nursery plants from  
consumer waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. Nurseries are generally not located near these sites.

### *Household and garden plants*

#### *Household and garden plants near utility points*

The proportions of the five utility points near household and garden plants of codling moth are shown in Table 80. It was estimated that household and garden plants are unlikely to be near consumers, very unlikely to be near orchard wholesalers, and extremely unlikely to be near urban wholesalers, retailers and food services.

The relative amounts of waste apples discharged or discarded near household and garden plants susceptible to codling moth are indicated in Figure 32.

### *Exposure to host*

Household and garden plant hosts of codling moth include pome fruit (apple and pear), stone fruit (apricot, cherry, plum, nectarine and peach), walnut, quince, persimmon, crab apple, pomegranate, chestnut and hawthorn.

A successful exposure of codling moth from infested fruit to its hosts means that mature larvae need to come out from fruit to pupate, pupae need to develop to become adult, and adult female would need to locate a male to mate and subsequently lay her eggs on a susceptible fruiting host. The chance for this to happen depends on several factors, including mortality caused by the handling and consumption of the fruit and casualties caused when larvae search for a pupation site, the level of infestation/infection and number of apples in the same utility points, the reproductive strategy and life span of the pest as well as the availability of susceptible hosts.

As shown in Table 81, it was considered that the probability that exposure of household and garden plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** household and garden  
plants from orchard wholesaler  
waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**.

- Orchard wholesale waste sites are mostly located within the orchard premises and are not located near household and garden plants.

**Exp** household and garden  
plants from urban wholesaler waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**.

- Urban wholesaler waste is disposed into landfill sites, which are generally not near residential properties.

**Exp** household and garden  
plants from retailer waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Retailer waste would be disposed to landfills, which are generally not near residential properties.

**Exp** household and garden  
plants from food service waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Food service waste would be disposed to landfills, which are generally not near residential properties.

**Exp** household and garden  
plants from consumer waste  
**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. However, local authorities are now encouraging composting of food waste in suburban backyards rather than disposing of all waste into landfill.
- Most consumers in metropolitan and suburban areas dispose of their waste to landfills, which are generally not near household and garden plants.
- Utilisation of waste to make compost is becoming a common practice in some suburban and rural households.
- The various hosts of codling moth are commonly grown as garden plants in the Western Australia.
- Household and garden host trees would be exposed to codling moth from household apples such as an infected apple core that is composted in a garden. Although the host tree would have to be fruiting at the time of exposure for a successful exposure.

*Wild and amenity plants*

*Wild and amenity plants near utility points*

The proportions of the five utility points near wild and amenity plants of codling moth are shown in Table 80. It was estimated that wild and amenity plants are unlikely to be near consumers, very unlikely to be near orchard wholesalers, and extremely unlikely to be near urban wholesalers, retailers and food services.

The relative amounts of waste apples discharged or discarded near wild and amenity plants susceptible to codling moth are indicated in Figure 32.

*Exposure to host*

Wild and amenity plant hosts of codling moth include pome fruit (apple and pear), stone fruit (apricot, cherry, plum, nectarine and peach), walnut, quince, persimmon, crab apple, pomegranate, chestnut and hawthorn.

A successful exposure of codling moth from infested fruit to its hosts means that mature larvae need to come out from fruit to pupate, pupae need to develop to become adult, and adult female would need to locate a male to mate and subsequently lay her eggs on a susceptible fruiting host. The chance for this to happen depends on several factors, including mortality caused by the handling and consumption of the fruit and casualties caused when larvae search for a pupation site, the level of infestation/infection and the number of apples in the same utility points, the reproductive strategy and life span of the pest as well as the availability of susceptible hosts.

As shown in Table 81, it was considered that the probability that exposure of wild and amenity plants would result from discharge or discard of either a single infested/infected

apple, an escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** wild and amenity plants  
from orchard wholesaler waste

**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Orchard wholesale waste sites are mostly located within the orchard premises and are not located near wild and amenity plants.
- Susceptible feral plants e.g. volunteer apple seedlings, crab apple etc. may be present near orchard wholesalers waste disposal sites.

**Exp** wild and amenity plants  
from urban wholesaler waste

**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

Urban wholesale waste is disposed at landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. crab apple trees, apple seedlings, stone fruit seedlings.

**Exp** wild and amenity plants  
from retailer waste

**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

Retailer waste would be disposed to landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. crab apple trees, apple seedlings, stone fruit seedlings.

**Exp** wild and amenity plants  
from food service waste

**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

Food service waste would be disposed to landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. crab apple trees, apple seedlings, stone fruit seedlings.

**Exp** wild and amenity plants  
from consumer waste

**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. crab apple trees, apple seedlings, stone fruit seedlings.

- Consumers discard apple cores in the environment or in bins in parks. Bins for waste in parks that may not be removed on a daily basis and these would provide a sheltered environment for the insect to emerge before the fruit desiccates or decays.
- Apple seedlings can establish from discarded apple cores. However, population densities of susceptible wild and amenity host plants in parks, near recreational facilities and along roadsides may be low. Prunus species are sometimes planted as street trees.
- Consumers who consider apple cores to be biodegradable indiscriminately discard them in the environment. Spoilt apples or cores discarded into the wild are likely to be isolated.

### **Conclusion—probability of distribution**

The partial probability of distribution from each of the utility points to each of the exposure groups is summarised in Table 83. These were calculated by the simulation model using @risk. The quantitative model evaluated the effect of the ‘volume of trade’ during a specified period when calculating the partial probability of distribution.

**Table 82 Partial probabilities of distribution (PPD)<sup>65</sup> for codling moth**

UTILITY POINTS	PPD			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Orchard wholesalers</b>	Extremely low	Negligible	Negligible	Negligible
<b>Urban wholesalers</b>	Negligible	Negligible	Negligible	Negligible
<b>Retailers</b>	Extremely low	Extremely low	Extremely low	Extremely low
<b>Food services</b>	Extremely Low	Extremely Low	Extremely low	Extremely low
<b>Consumers</b>	Very low	Very low	Low	Low
<b>Overall PPD</b>	<b>Very low</b>	<b>Very low</b>	<b>Low</b>	<b>Low</b>

### **Probability of establishment or spread**

The assessment for the probability of establishment or spread is carried out in the following manner. Firstly, partial probability for establishment and for spread was assessed separately based on the relevant available scientific information. Secondly, the conclusions for the combined partial probability of establishment or spread for each of the four exposure groups

<sup>65</sup> Partial probability of distribution is actually referring to the probability of entry and was estimated by @risk

are provided at the end of this section. The relevant information for the assessment for the probability of establishment or spread is presented below against the factors listed in ISPM 11, Rev. 1.

***Partial probability of establishment***

ISPM 11 factor	Relevant information
<b>Availability of suitable hosts, alternate hosts and vectors in the PRA area</b>	<ul style="list-style-type: none"> <li>Apple (including crab apples) and pear are the main host plants for codling moth. It can complete its life cycle on these hosts. Other recorded hosts include quince, walnuts, orange, persimmon, pomegranate, hawthorn, damson, chestnut, cherry, nectarines, peaches, apricot and plums (CABI, 2003a).</li> <li>These host plants are grown in Western Australia.</li> </ul>
<b>Suitability of the environment</b>	<ul style="list-style-type: none"> <li>Several codling moth outbreaks have occurred in Western Australia and have been successfully eradicated. This is clear indication that the Western Australia environment is very suitable and establishment would be virtually certain to occur if codling moth is introduced into Western Australia.</li> </ul>
<b>The potential for adaptation of the pest</b>	<ul style="list-style-type: none"> <li>Genetic adaptability of codling moth is not known. However, it is likely to have no problem to adapt to the climatic conditions in Western Australian orchards since several outbreaks have already occurred there.</li> </ul>
<b>The reproductive strategy of the pest</b>	<ul style="list-style-type: none"> <li>Codling moth can only reproduce sexually.</li> <li>The number of generations per year varies from 1 to 4 depending on the climate, and sometimes the host plant (CABI, 2003a). During each generation a small proportion of the larvae enter diapause for up to 2 years (Yothers and Carlson, 1941). The female moth has mature oocytes upon emergence (Deseö, 1970).</li> <li>Flight occurs at and after dusk, mainly on warm, still evenings. A female attracts a mate by releasing a pheromone (Ferro and Akre, 1975). Mating can take up to 80 minutes depending on whether the male has been previously mated.</li> <li>Egg-laying usually takes place on warm evenings (12 to 30°C). Eggs are laid singly on developing fruits and foliage.</li> <li>Adult females usually lay approximately 250-300 eggs, ovipositing for 4 to 7 days, and living for about 4 days after the last oviposition.</li> <li>After hatching, the larva burrows immediately into a fruit. Larvae pass through five instars whilst feeding within the fruit, and then vacate it. Larvae then spin cocoons within cracks in the tree trunk or under loose pieces of bark or amongst debris on the ground.</li> <li>Where the pest has more than one generation a year, pupation of a significant proportion of the population of the early generations starts immediately. For the last generation, larvae overwinter and pupate the following spring.</li> </ul>



ISPM 11 factor	Relevant information
<b>Minimum population needed for establishment</b>	<ul style="list-style-type: none"> <li>A population can be started from eggs laid by a mated female.</li> </ul>
<b>Cultural practices and control measures</b>	<ul style="list-style-type: none"> <li>Integrated Pest Management (IPM) programmes are utilised in the production of Australian apples including apples grown in Western Australia.</li> <li>Recently, Apple &amp; Pear Australia Limited have established four major development strategies including the use of Integrated Fruit Production (IFP) that aims to ensure fruit is grown in an environmentally safe way that minimises pesticide use (APAL, 2003), similar to the IFP employed by Zealand orchardists in the production of their fruit (ENZA, 2003).</li> <li>The practices employed during the cultivation/production of the host crops between New Zealand and Australia are considered to be similar so there would be no influence on codling moth's ability to establish in Australia.</li> <li>Pest control programs are also similar between New Zealand and Australia.</li> </ul>

*Conclusion—partial probability of establishment*

Based on the above evidence, partial probability of establishment for each of the exposure groups is assessed as follows.

Partial probability of establishment for commercial fruit crops: **High**

Partial probability of establishment for nursery plants: **Low**

Partial probability of establishment for household and garden plants: **High**

Partial probability of establishment for wild and amenity plants: **High**

*Partial probability of spread*

ISPM 11 factor	Relevant information
<b>Suitability of natural and/or managed environment</b>	<ul style="list-style-type: none"> <li>There is limited information on the ability of codling moth to spread in natural or managed environments.</li> <li>Codling moth is thought to have originated in the Palaearctic region and has spread along with the cultivation of apples to most temperate regions of the world, including Europe, China, North and South America, South Africa, Australia and New Zealand (Bradley <i>et al.</i>, 1979).</li> <li>Codling moth has also spread in the eastern states of Australia and successfully entered Western Australia several times, indicating the environment in Western Australia would be suitable for its spread.</li> </ul>

ISPM 11 factor	Relevant information
<b>Presence of natural barriers</b>	<ul style="list-style-type: none"> <li>In Western Australia, apple and pears are grown in the Southwest area. Many other hosts of codling moth are also grown there.</li> <li>Studies indicate that most males (80%) can fly for one km from their point of release and some individuals have been recovered up to 4.8 km away, or even as far as 11 km. On the other hand, 90% of marked mated females have been captured within 300 m of their release point and maximum dispersal may be as low as 600 m (HortResearch, 1999b).</li> </ul>
<b>The potential for movement with commodities or conveyances</b>	<ul style="list-style-type: none"> <li>As the larvae of codling moth live inside the fruit, they would be dispersed into new areas with the movement of infested fruit.</li> <li>The historic records for introduction of <i>C. pomonella</i> throughout the world emphasise the dangers inherent in transporting infested plant material from country to country (CABI, 2003a).</li> </ul>
<b>Intended use of the commodity</b>	<ul style="list-style-type: none"> <li>Apples would be used mostly for consumption by both humans and animals and would be widely distributed around Western Australia.</li> <li>It is possible that any fruit that is spoiled or damaged would be sent for processing into juice, snack food bars or heat and eat desserts for example. Apple fruit would not be used for propagation purposes. Most apple production today is from clonally propagated fruiting varieties, which are grafted and budded onto clonal rootstocks selected for their size, disease resistance and adaptability.</li> <li>Named varieties are propagated by vegetative means, as they do not come true from seed. If larvae have contaminated the fruit, they will be transferred with the commodity around Western Australia.</li> </ul>
<b>Potential vectors of the pest in the PRA area</b>	<ul style="list-style-type: none"> <li>Codling moth is capable of independent flight and does not require a vector for its spread.</li> </ul>
<b>Potential natural enemies of the pest in the PRA area.</b>	<ul style="list-style-type: none"> <li>Many natural enemies have been reported to attack codling moth larvae and pupae and some are present in Australia (CABI, 2003a).</li> <li>The minute egg parasite <i>Trichogramma minutum</i> Riley also is present in Western Australia (CABI, 2003a).</li> </ul>

#### *Conclusion—partial probability of spread*

Based on the above evidence, partial probability of spread for each of the exposure groups is assessed as follows.

Partial probability of spread for commercial fruit crops: **High**

Partial probability of spread for nursery plants: **High**

Partial probability of spread for household and garden plants: **High**

Partial probability of spread for wild and amenity plants: **High**

***Combined partial probability of establishment or spread***

The combined partial probability of establishment or spread was determined by combining probabilities of establishment and probabilities of spread using the matrix of ‘rules’ for combining descriptive likelihoods as presented in the method section. The results are indicated in Table 83.

**Table 83 Combined partial probabilities of establishment or spread of codling moth**

	<b>Commercial fruit crops</b>	<b>Susceptible Nursery plants</b>	<b>Susceptible household and garden plants</b>	<b>Susceptible wild and amenity plants</b>
<b>Establishment</b>	High	Low	High	High
<b>Spread</b>	High	High	High	High
<b>PPES<sup>66</sup></b>	High	Low	High	High

Additional evidence to support the combined partial probability of establishment or spread for specific exposure groups is provided in the text below.

**Commercial fruit crops**

**High**

The fact that there have been a few outbreaks of codling moth in Western Australia indicates that codling moth is very likely to establish or spread in Western Australia.

**Susceptible nursery plants**

**Low**

In nursery plants, it is not likely for the host plants to have fruit. The codling moth larvae have to find a fruit within 24 hours after hatching. Therefore, it is unlikely that they will be able to establish among susceptible nursery plants.

**Susceptible household and garden plants**

**High**

Apart from the main hosts of apple and pears, codling moth has also been reported to feed on many other hosts including almond, apricot, Japanese plum, maize, sweet cherry, quince and walnut. There are plenty of opportunities for codling moth to find a susceptible household plant and it is very likely that it will establish or spread on household and garden plants.

**Susceptible wild and amenity plants**

**High**

As codling moth feeds on a range of host plants, some of them will be available in the wild. Therefore, it is also very likely that codling moth will be able to establish or spread in the wild if introduced into Western Australia.

<sup>66</sup> PPES = partial probability of establishment or spread

## Assessment of consequences

Codling moth is only a regional concern. Thus the following assessment of consequences applies only to the regional level (Western Australia) not national level.

Impact scores allocated for the direct and indirect criteria are shown in Table 84. Available supporting evidence is provided in the text below.

**Table 84 Impact scores for codling moth**

Direct impact	Impact scores
Plant life or health	D
Human life or Health	A
Other aspects of the environment	A
Indirect impact	
Control or eradication	E
Domestic trade or industry	B
International trade	D
The environment	B
Communities	A

### Direct impact

#### Plant life or health - D

Consequences affecting plant life or health are of minor significance at the regional level. Thus a rating of 'D' was assigned for this criterion.

- Codling moth is a major pest of apples and pears and is considered an important pest wherever it has established in Australia.
- Crop losses caused by codling moth on pome fruits around the world are difficult to assess, as the methods used are often inadequate and not strictly comparable.
- According to Rothschild and Vickers (1991), commercial orchards using broad-spectrum insecticides correctly can keep codling moth damage to below 2%.
- In Nova Scotia, the degree of infestation under insecticide-free conditions varied from 6 to 10% of the entire crop in an orchard over 12 years, depending on the cultivar (MacLellan, 1977).
- In an orchard in Lake Ontario, USA, where there is one generation and a partial second, similar to those seen in southern England, damage ranged from 7 to 35% (Glass and

	<p>Lienk, 1971).</p> <ul style="list-style-type: none"> <li>• In warmer climates, where two or more generations occur, damage to apples has been reported as being as high as 84% in the Crimea (Tanskii and Bulgak, 1981), or 65 to 100% in Australia (Geier, 1964).</li> </ul>
<b>Human life or health - A</b>	There are no known direct impacts of codling moth on human life or health and the rating assigned to this criterion was therefore 'A'.
<b>Any other aspects of the environment - A</b>	There are no known impact of codling moth on any other aspects of the environment and the rating assigned to this criterion was therefore 'A'.
<b>Indirect impact</b>	
<b>Control or eradication E</b>	<p>The indirect impact on new or modified eradication, control, surveillance/monitoring and compensation strategies is of significance at the regional level. A rating of 'E' was assigned to this criterion.</p> <ul style="list-style-type: none"> <li>• If codling moth enters Western Australia again, the eradication program will be very expensive. It has already cost the WA Government and fruit growing industry several million dollars to eradicate three outbreaks since 1993, including a two-year eradication campaign to control an incursion at Dwellingup.</li> <li>• Insecticide usage within the Western Australian pome fruit industry would increase should codling moth become established and continue until such time as alternative control measures, such as pheromone disruption techniques become established. Currently, insecticide is largely limited to the control of Mediterranean fruit fly in pome fruit industry in this state.</li> <li>• The economic consequences, as a result of eradication, control and management restructuring, would be significant to Western Australia.</li> </ul>
<b>Domestic trade or industry - B</b>	<p>The indirect consequences on domestic trade are unlikely to be discernable at the regional level and of minor significance at the local level. A rating of 'B' was assigned to this criterion.</p> <ul style="list-style-type: none"> <li>• It is considered that the presence of codling moth in commercial production areas of Western Australia will not result in interstate trade restrictions as it is already established in the eastern States.</li> <li>• However, restrictions in the movement of fruit and other host material would need to be put in place to contain the pest if there is an outbreak in WA.</li> </ul>
<b>International trade - D</b>	The indirect consequences on international trade are of minor significance at the regional level. A rating of 'D' was assigned to

this criterion.

- The presence of codling moth in commercial production areas in Western Australia would have an effect on Western Australia's access to overseas markets (such as Japan) where this pest is absent.

#### Environment - B

The indirect consequences on the environment would be unlikely to be discernible at the district level and a rating of '**B**' was assigned to this criterion.

- Chemical control or biological control would have some impact on the environment: increased insecticide use can cause undesired effects on the environment, introduction of new biocontrol agents can affect existing biological control programmes or impact on biodiversity.

#### Communities - A

The presence of codling moth would have limited social effects, if any, and a rating of '**A**' was assigned to this criterion.

### Conclusion—consequences

Based on the decision rule described in the method section, i.e. where the consequences of a pest with respect to one or more criteria are '**E**', the overall consequences are considered to be 'moderate'. Therefore the overall consequences of codling moth are **moderate**.

### Unrestricted annual risk

Unrestricted annual risk is the results of combining annual probability of entry, establishment or spread with the outcome of overall consequences. Probabilities and consequences are combined using the 'rules' shown in the risk estimation matrix in the method section. The unrestricted annual risk estimation for codling moth is shown in Table 85.

**Table 85 Risk estimation for codling moth**

Overall probability of entry, establishment or spread <sup>67</sup>	<b>Low</b>
Consequences	<b>Moderate</b>
Unrestricted risk	<b>Low</b>

As indicated in Table 85, the unrestricted annual risk for codling moth is low, which is above the appropriate level of protection (ALOP) of very low. Therefore, risk management would be required for this pest.

<sup>67</sup> Calculated by @risk.

## **European red mite**

### **Biology**

European red mite (ERM), *Panonychus ulmi* Koch, has five life stages: adult, egg, larva, protonymph, and deutonymph.

The adult females are the largest and their bright red colour makes them just visible to the naked eye. The female body is oval and strongly convex and has short pale legs. The adult male is smaller, yellowish-green to bright red and with a narrower pear-shaped body, tapering to the rear with legs longer relative to the body.

Female European red mites produce two types of eggs, namely summer and winter eggs. Summer eggs are laid on the leaves until autumn. The eggs have a characteristic dorsal spine, are 0.15 mm in diameter, and are slightly smaller and more orange than the winter eggs (Collyer, 1998). Resilient winter eggs enable the mite to 'overwinter' and are produced from late summer to late autumn. The majority of winter eggs are laid on the bark and wood of its host tree. However, winter eggs can be laid on leaves and on late season fruit (HortResearch, 1999b) if population pressures are high enough. Summer eggs are usually produced from adults hatched from winter eggs and hatch within 12 days depending on weather conditions. Lifecycle development from eggs to adult usually takes 28 days depending on weather conditions and successive generations can occur over a season.

European red mite has an extensive host range with pome fruit, stone fruit, grapevine and citrus included in the 45 genera within 17 families listed as host species. European red mite is adapted to deciduous trees.

### **Risk scenario**

The risk scenario of concern for European red mite is that nymphs and adult mites can be on fruit and winter eggs can be laid on the apple fruit when population pressures are high.

## Probability of importation

The initiating step for the importation scenario for apple fruit is the sourcing of apples from orchards in New Zealand, while the end-point is the release of imported apples from the port of entry. The importation scenario is divided into eight steps and the likelihood of the European red mite being present at each step is summarised in Figure 33. The available evidence supporting the likelihood assessments is provided in the text below.

**Figure 33 The importation steps and the likelihood of the European red mite being present at each step**





**Importation step 1  
(Imp1)**

**High**

The likelihood that European red mite is present in the source orchards in New Zealand: **High**

- ERM is found throughout New Zealand (McLaren *et al.*, 1999).
- ERM is common in orchards throughout New Zealand and has long been an important pest of pipfruit (HortResearch, 1999b).

**Importation step 2  
(Imp2)**

**Low**

The likelihood that picked apple fruit is infested with European red mite: **Low**

- European red mite mainly feeds on leaves of apple (HortResearch, 1999b). However, some mites can be found on fruit if the population is high.

HortResearch (1999b) provide the following information about the egg laying of the European red mite as follows:

- Females lay summer eggs through November, and further generation cycles are completed in about 30 - 35 days. In late summer, shortening day length and falling temperatures trigger the onset of winter egg laying, which is also influenced by the condition of the host leaves. It may begin as early as the end of January if leaf condition deteriorates, but more usually, winter egg laying commences in February and reaches a peak though late February and March.
- The winter eggs are dormant (in diapause) and are laid mainly on the bark or wood of the host tree, and some are deposited on the fruit - in both the calyx and stalk ends of the fruit.

*Summary*

Based on above evidence that some mites can be on fruit and winter eggs can be laid on fruit, the likelihood for Imp2 was assessed as low.

**Importation step 3  
(Imp3)**

**Very low**

The likelihood that clean fruit is contaminated by European red mite during harvesting and transport of apples to the packing house: **Very low**

- Fruit are picked into harvesting bags and then transferred into bins kept on the ground in the orchard prior to transportation to the packing house.
- Adults and nymphs are mainly on leaves and they will be able to contaminate clean fruit if the infested/infected leaves are picked and placed into the bags together with the picked fruit.
- However, the number of leaves picked is very low and amounts to 200 leaves per bin (Armour, 2003).

**Importation step 4  
(Imp4)**

**Low**

The likelihood that European red mite survives routine processing procedures in the packing house: **Low**

Washing

- The adults and nymphs would be eliminated by high-

volume/high pressure washing, as they are not attached to the fruit.

- Winter eggs could survive the washing.

#### *Brushing*

- Brushing can reduce the presence of the adults and nymphs but the winter eggs in the calyx-end could survive.

#### *Waxing*

- The diapausing winter eggs could survive low temperature waxing.

#### *Sorting and grading*

- Some winter eggs on fruit may not be eliminated during sorting and grading.

#### *Packaging*

- Packaging would have little affect on the survival of the European red mite. In most cases the packaging of apples is designed to maximise heat discharge from the fruit while minimising loss of moisture.

#### *Cold Storage*

- European red mite overwinters as winter eggs and this suggests that temporary cold storage would not be effective to kill diapausing winter eggs.

#### *Summary*

Packing house procedures would be effective to remove nymphs and adults of the mites, but not effective to remove winter eggs. The likelihood for Imp4 was assessed as low.

#### **Importation step 5 (Imp5) Negligible**

The likelihood that clean fruit is contaminated by European red mite during processing in the packing house: **Negligible**

- The remaining winter eggs on fruit are not be able to contaminate clean fruit.
- At the low temperatures employed in cold storage, even if the mites were still present, they would not move about to contaminate clean fruit.

#### **Importation step 6 (Imp6) High**

The likelihood that European red mite survives palletisation, quality inspection, containerisation and transportation to Australia: **High**

- Any remaining mites, especially the winter eggs at the stem or calyx-end of fruit would be able to survive palletisation, quality inspection, containerisation and refrigerated transport to Australia.

<b>Importation step 7 (Imp7)</b> <b>Negligible</b>	<p>The likelihood that clean fruit is contaminated by European red mite during palletisation, quality inspection and transportation: <b>Negligible</b></p> <ul style="list-style-type: none"><li>• Even if adults and nymphs are still present on fruit, they would not move about to contaminate clean fruit at the low temperatures employed in cold storage during transportation.</li></ul>
<b>Importation step 8 (Imp8)</b> <b>High</b>	<p>The likelihood that ERM survives and remains with fruit after on-arrival minimum border procedures: <b>High</b></p> <ul style="list-style-type: none"><li>• The minimum border procedures as described in the method section would not effective in detecting winter eggs.</li></ul>

### ***Conclusions—probability of importation***

When the above likelihoods were inserted into the simulation model, the probability of importation of European red mite from one year of trade was found to be **Very low**.

### **Probability of distribution**

The initiating step for the distribution scenario is the release of imported apples from the port of entry, while the last step is the pest being distributed (as a result of the processing, sale or disposal of these apple fruit) in a viable state to an endangered area and subsequently being exposed to a suitable host.

In order to assess the probability of distribution, the distribution scenario is addressed in the three subheadings below. First is a brief description of sequences of events leading to a successful exposure of the pest from infested/infected apple to a susceptible host plant. Second is the assessment of partial probability of distribution of the pest in relation to each of the exposure groups. Third is the conclusion for the probability of distribution.

#### ***Sequence of events for successful exposure***

The sequence of events that has to be completed for a successful exposure of a susceptible host to the pest is summarised below.

The mite stage associated with the imported apple is the winter eggs. If these diapause winter eggs survive cold storage, nymphs can hatch from the eggs after the apples have been taken out of cold storage. Development does not begin until temperatures average at least 7°C (HortResearch, 1999b). After hatching, the first instar nymphs would be to remain on the fruit and not enter the environment from the utility points such as wholesalers or retailers as there would be great difficulty for them to leave the fruit to find an alternative host. However, when spoilt apple fruit or cores are disposed of as waste, the eggs either die with the waste or eggs hatch and nymphs attempt to leave before the apples desiccate or decay. European red mite does not have wings, and is therefore limited in its ability to enter into the environment. Nymphs hatching from winter eggs are only able to crawl for a short distance. When population densities are high, nymphs can disperse by crawling to a high point and ballooning on wind currents by means of a silken thread; however, this is almost certain to be not the case for mites hatched from imported infested/infected fruit. In addition, there is little wind in the indoor environment or close to ground situation to assist their dispersal.

A successful exposure of ERM from winter eggs on imported fruit to the host means that they need to hatch, and nymphs to find a susceptible host plant to feed.

### ***Partial probability of distribution***

The partial probability of distribution (PPD) was estimated separately for each of the four exposure groups: commercial fruit crops; nursery plants; household and garden plants; and, wild and amenity plants.

The details and the method of calculation for the PPD of the four exposure groups are explained in the method section and the results are presented in a series of tables and figures below. The information from these tables and figures was used to assess the probability of distribution of ERM to all the exposure groups.

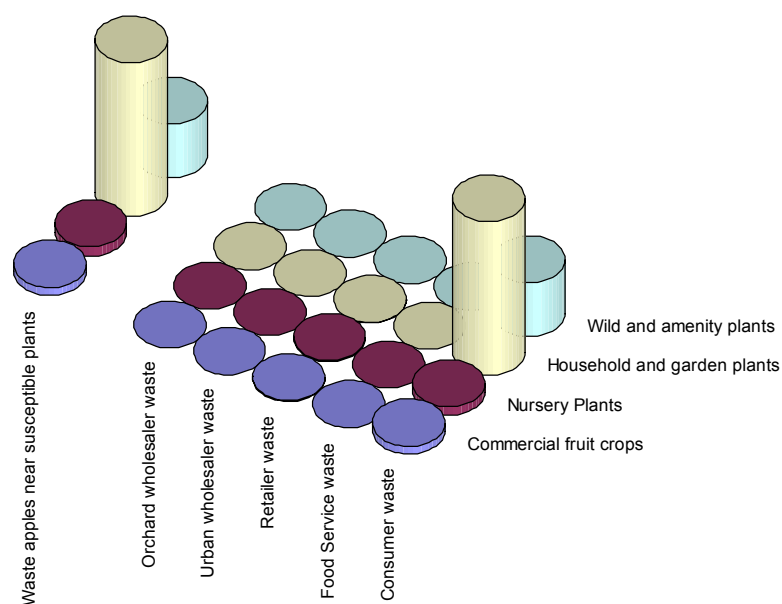
Table 86 indicates the proportions of the five utility points near each of the exposure groups of ERM. ERM has an extensive host range and is known to feed on plants in 45 genera within 17 families. It most often inhabits orchard trees of the family Rosaceae: apple, plum, pear, peach, and cherry are common hosts. It also occurs on almond, walnut, currant, gooseberry, raspberry, grapevine, citrus, elm, oak, rowan, and ornamental shrubs and trees of the genera *Prunus*, *Sorbus* and *Ribes* (Collyer, 1998). They mainly feed on the leaves of the host plants but can also feed on the fruit. Given the wide range of hosts that includes both deciduous and evergreen plants, a susceptible host plant would be available all year around.

**Table 86 The proportions of utility points near host plants susceptible to European red mite in the four exposure groups**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Proximity</b> Orchard wholesalers	Certain	Very Low	Very Low	Very Low
<b>Proximity</b> Urban wholesalers	Extremely Low	Extremely Low	Extremely Low	Extremely Low
<b>Proximity</b> Retailers	Very Low	Low	Very Low	Extremely Low
<b>Proximity</b> Food services	Extremely Low	Extremely Low	Extremely Low	Extremely Low
<b>Proximity</b> Consumers	Very Low	Very Low	Moderate	Low

Figure 34 gives a pictorial representation of the relative amounts of infested/infected apples, an escaped pest, contaminated packaging material discharges or discarded from different utility points to near exposure groups of European red mite.

**Figure 34 Pictorial representation of the relative amounts of infested/infected apple waste<sup>68</sup> from utility points to near exposure groups of European red mite**



<sup>68</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or an escaped pest, or contaminated packaging material.

Table 87 is the summary of the probability that exposure of the host plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points. Evidence is provided in the text below under different exposure groups.

**Table 87 The probability of exposure of susceptible host plants of European red mite from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Exp</b> Orchard wholesaler waste <sup>69</sup>	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Urban wholesaler waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Retailer waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Food service waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Consumer waste	Negligible	Negligible	Negligible	Negligible

### *Commercial fruit crops*

#### *Commercial fruit crops near utility points*

The proportions of the five utility points near commercial fruit crops of ERM are shown in Table 86. It was estimated that commercial fruit crops are certain to be located near all orchard wholesalers, very unlikely to be near retailers and consumers, and extremely unlikely to be near urban wholesalers and food services as most of these are in metropolitan areas.

The relative amounts of infested/infected apples, or an escaped pest, or contaminated packaging material discharged or discarded from different utility points to near commercial fruit crops susceptible to European red mite are indicated in Figure 34.

#### *Exposure to hosts*

The most common commercial fruit crops of ERM include orchard trees of the family Rosaceae such as apple, plum, pear, peach, and cherry.

A successful exposure of ERM to susceptible host plant requires hatched nymph to find a susceptible host to feed. The chance for this to happen depends on several factors, including mortality caused by the handling and consumption of fruit, mortality of mites after hatching

<sup>69</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or escaped pest, or contaminated packaging material.

from winter eggs, the level of infestation/infection and number of apples in the same utility points, as well as availability of susceptible hosts and life span of pest.

As shown in Table 87, it was considered that the probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** commercial fruit crops  
from orchard wholesaler waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Apple, plum, pear, peach, and cherry trees are readily available in commercial orchards.

**Exp** commercial fruit crops  
from urban wholesaler waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

- Commercial fruit crops are not located in urban areas.
- Urban wholesaler waste is disposed into bins and taken to landfills. Commercial fruit crops are unlikely to be located adjoining these sites.

**Exp** commercial fruit crops  
from retailer waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Most retailers are located in urban areas not close to commercial fruit crops.
- Retailer waste may be used for composting in rural areas and some of these sites may be near commercial orchards.

**Exp** commercial fruit crops  
from food service waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Most food service outlets are located in metropolitan and suburban areas not close to commercial fruit crops. Waste produced by food service outlets in metropolitan and suburban areas is generally disposed into landfills remote from commercial fruit crops.

**Exp** commercial fruit crops  
from consumer waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Majority of consumers are located in metropolitan and suburban areas. Waste produced by people in metropolitan areas and some in urban areas is generally disposed into landfills. Commercial fruit crops would usually not be present

adjoining these sites.

- Households and population densities around commercial orchards are very low.
- Some consumer waste in suburban and rural areas may be utilised for composting. Commercial fruit crops can be present close to compost heaps.

### *Nursery plants*

#### *Nursery plants near utility points*

The proportions of the five utility points near nursery plants of ERM are shown in Table 86. It was estimated that nursery plants are very unlikely to be near orchard wholesalers, retailers and consumers, and extremely unlikely to be near urban wholesalers and food services.

The relative amounts of waste apples discharged or discarded near nursery plants susceptible to European red mite are indicated in Figure 34.

#### *Exposure to hosts*

The nursery plant hosts of ERM include those listed under commercial fruit crops as well as almond, walnut, currant, gooseberry, elm, oak, rowan and numerous ornamental trees and shrubs.

A successful exposure of ERM to susceptible host plant requires hatched nymph to find a susceptible host to feed. The chance for this to happen depends on several factors, including mortality caused by the handling and consumption of fruit, mortality of mites after hatching from winter eggs, the level of infestation/infection and number of apples in the same utility points, as well as availability of susceptible hosts and life span of pest.

As shown in Table 87, the probability that exposure of nursery plants that would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

<p><b>Exp</b> nursery plants from orchard wholesaler waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>• There are rare instances of nurseries being located near to orchard wholesaler waste.</li> </ul>
<p><b>Exp</b> nursery plants from urban wholesaler waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>• There are rare instances of nurseries being located near to urban waste dumps.</li> </ul>
<p><b>Exp</b> nursery plants from retailer waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: <b>Negligible</b></p>



- Nursery plants are for sale in major retail outlets.
- Many hosts of ERM are common plant in nurseries in the temperate regions of Australia, particularly during the dormant period over winter and to a limited extent during the spring and summer months.
- Retail garden nurseries have a high density of a range of plant materials in a small area. They often maintain a high hygienic standard, usually fogging with insecticide, to prevent insect and mite attacks.
- A number of fresh food markets will have nursery plants near apple fruit. However there are a limited number of nurseries associated with fresh food markets that also maintain or store actively growing apple trees.
- Most of the waste from retail outlets and urban retailers is collected on a regular basis and disposed of in landfill.

**Exp** nursery plants from food  
service waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Most food service industries are located in urban areas. There are instances of nurseries being located near food services.
- However, food service industry waste is disposed into bins and taken to landfills. Nursery plants are unlikely to be near these sites.

**Exp** nursery plants from  
consumer waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Most consumers are in metropolitan and suburban areas and their waste is generally disposed into landfills.
- Nurseries are generally not located near these sites.

### *Household and garden plants*

#### *Household and garden plants near utility points*

The proportions of the five utility points near household and garden plants of ERM are shown in Table 86. It was estimated that household and garden plants are unlikely to be near consumers, very unlikely to be near orchard wholesalers, and extremely unlikely to be near urban wholesalers, retailers and food services.

The relative amounts of waste apples discharged or discarded near household and garden plants susceptible to European red mite are indicated in Figure 34.

### *Exposure to hosts*

The household and garden host plants of ERM included many of the species listed in the data sheet such as alders, ashes, birches, oaks, poplars, camellias, gardenias, as well as several ornamental *Prunus* species.

A successful exposure of ERM to susceptible host plant requires hatched nymph to find a susceptible host to feed. The chance for this to happen depends on several factors, including mortality caused by the handling and consumption of fruit, mortality of mites after hatching from winter eggs, the level of infestation/infection and number of apples in the same utility points, as well as availability of susceptible hosts and life span of pest.

As shown in Table 87, the probability that exposure of household and garden plants that would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

<p><b>Exp</b> household and garden plants from orchard wholesaler waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Orchard wholesale waste sites are mostly located within the orchard premises and are not located near household and garden plants.</li> </ul>
<p><b>Exp</b> household and garden plants from urban wholesaler waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Urban wholesaler waste is disposed into landfill sites, which are generally not near residential properties.</li> </ul>
<p><b>Exp</b> household and garden plants from retailer waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Retailer waste would be disposed to landfills, which are generally not near residential properties.</li> </ul>
<p><b>Exp</b> household and garden plants from food service waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Food service industries are unlikely to have host plants susceptible to ERM within their premises.</li> <li>Waste from food services is disposed into landfills sites.</li> </ul>
<p><b>Exp</b> household and garden plants from consumer waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: <b>Negligible</b></p>

- Most consumers are in metropolitan and suburban areas and their waste is usually disposed into landfills that are generally not near household and garden plants.
- However, utilisation of waste to make compost is becoming a common practice in some suburban and rural households rather than disposing of all waste into landfill.
- Hosts of ERM are commonly grown as a garden plant in the temperate regions of Australia.

### *Wild and amenity plants*

#### *Wild and amenity plants near utility points*

The proportions of the five utility points near wild and amenity plants of ERM are shown in Table 86. It was estimated that wild and amenity plants are unlikely to be near consumers, very unlikely to be near orchard wholesalers, and extremely unlikely to be near urban wholesalers, retailers and food services.

The relative amounts of waste apples discharged or discarded near wild and amenity plants susceptible to European red mite are indicated in Figure 34.

#### *Exposure to hosts*

The wild and amenity host plants of ERM include many of the species as listed in the data sheet such as alders, ashes, birches, oaks, poplars, camellias, gardenias, as well as several ornamental *Prunus* species.

The successful exposure of ERM to susceptible host plant requires hatched nymph to find a susceptible host to feed. The chance for this to happen depends on several factors, including mortality caused by the handling and consumption of fruit, mortality of mites after hatching from winter eggs, the level of infestation/infection and number of apples in the same utility points, as well as availability of susceptible hosts and life span of pest.

As shown in Table 87, it was considered that the probability that exposure of wild and amenity plants would result from discharge or discard of either a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** wild and amenity plants  
from orchard wholesaler waste

**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Orchard wholesale waste sites are mostly located within the orchard premises and are not located near wild and amenity plants.
- Susceptible feral plants e.g. volunteer apple seedlings, crab apple etc. may be present near orchard wholesalers waste disposal sites.

**Exp** wild and amenity plants  
from urban wholesaler waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

- Urban wholesale waste is disposed at landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. crab apple trees, apple seedlings.

**Exp** wild and amenity plants  
from retailer waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Retailer waste would be disposed to landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. crab apple trees, apple seedlings.

**Exp** wild and amenity plants  
from food service waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Food service waste is disposed into bins and taken to landfills. Seedlings originating from seeds dispersed by birds could be present.

**Exp** wild and amenity plants  
from consumer waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. crab apple trees, apple seedlings.
- Consumers discard apple cores in the environment or in bins in parks. Bins for waste in parks that may not be removed on a daily basis would provide a sheltered environment for the insect to emerge before the fruit desiccates or decays.
- Seedlings of apple and other host plants can establish from discarded fruit containing seeds. However, population densities of susceptible wild and amenity plants in parks, near recreational facilities and along roadsides may be low.
- Consumers who consider apple cores to be biodegradable indiscriminately discard them in the environment. Spoilt apples or cores discarded into the wild are likely to be isolated.

**Conclusion—probability of distribution**

The partial probability of distribution from each of the utility points to each of the exposure groups is summarised in Table 88. These were based on the data and assessment provided above and calculated by the simulation model using the @risk. The quantitative model evaluated the effect of the ‘volume of trade’ during a specified period when calculating the partial probability of distribution.

**Table 88 Partial probabilities of distribution (PPD)<sup>70</sup> for European red mite**

UTILITY POINTS	PPD			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Orchard wholesalers</b>	Extremely low	Negligible	Negligible	Negligible
<b>Urban wholesalers</b>	Negligible	Negligible	Negligible	Negligible
<b>Retailers</b>	Extremely low	Very low	Extremely low	Extremely low
<b>Food services</b>	Negligible	Negligible	Negligible	Negligible
<b>Consumers</b>	Very low	Very low	Low	Very low
<b>Overall PPD</b>	<b>Very low</b>	<b>Very low</b>	<b>Low</b>	<b>Very low</b>

**Probability of establishment or spread**

The assessment for the probability of establishment or spread is carried out in the following manner. Firstly, partial probability for establishment and for spread was assessed separately based on the relevant available scientific information. Secondly, the conclusions for the combined partial probability of establishment or spread for each of the four exposure groups are provided at the end of this section. The relevant information for the assessment for the probability of establishment or spread is presented below against the factors listed ISPM 11, Rev. 1.

**Partial probability of establishment**

ISPM 11 factor	Relevant information
<b>Availability of suitable hosts, alternate hosts and vectors in the PRA area</b>	<ul style="list-style-type: none"> <li>ERM attacks apple, plum, pear, peach, cherry, almond, walnut, currant, gooseberry, raspberry and is polyphagous on a wide range of dicotyledonous plants some of which are used for shelterbelt plantings (HortResearch, 1999b).</li> <li>Commercial crops such as plum, pear, peach, cherry, almond, walnut, currant, raspberry are grown in all States and</li> </ul>

<sup>70</sup> Partial probability of distribution is actually referring to the probability of entry and was estimated by @risk.

ISPM 11 factor	Relevant information
<b>Suitability of the environment</b>	<p>Territories in Australia, except in the northern tropical regions, and are also found in suburban backyards in temperate Australia.</p> <ul style="list-style-type: none"> <li>The European red mite is found throughout Asia, Africa, eastern Australia, Europe, North and South America and New Zealand. In New Zealand ERM is most prevalent in the drier areas (Collyer, 1998).</li> <li>Poole et al. (2001) indicate that the Western Australian climate is marginal for establishment of ERM after analysing climate modelling scenarios using Climex® and data from locations where ERM occurs in Australia and world-wide.</li> <li>Several of the commercial crops listed above are not grown in protected environments such as in glasshouses.</li> </ul>
<b>The potential for adaptation of the pest</b>	<ul style="list-style-type: none"> <li>ERM has shown the propensity to develop resistance. Most populations are now resistant to the older groups of acaricides such as the organochlorines (CABI, 2003a).</li> <li>Resistance to the newer acaricides such as mitochondrial respiration inhibitors and chitin-synthase inhibitors are now starting to appear (CABI, 2003a).</li> </ul>
<b>The reproductive strategy of the pest</b>	<ul style="list-style-type: none"> <li>ERM is usually sexually reproductive. However, it is not necessary for females to find a mate as unfertilised females will produce only male offspring that then mate and then go on to start a colony.</li> <li>ERM has from five to seven generations during the summer, each generation extending over approximately one month, depending upon temperatures (Collyer, 1998).</li> </ul>
<b>Minimum population needed for establishment</b>	<ul style="list-style-type: none"> <li>A colony can be founded from eggs laid by a single unmated female mite. These eggs then produce only males.</li> </ul>
<b>Cultural practices and control measures</b>	<ul style="list-style-type: none"> <li>Integrated Pest Management (IPM) programs are utilised in the production of apples in Australia including Western Australia. Many aspects of the IPM are similar to the IFP program used by New Zealand orchardists</li> <li>A wide range of insect and mite predators attacks ERM. Some natural enemies of ERM present in New Zealand such as earwigs, ladybirds of the genus <i>Stethorus</i> and generalist predators are also present in Western Australia.</li> </ul>

#### *Conclusion—partial probability of establishment*

Based on the above evidence, partial probability of establishment for each of the exposure groups are as follows:

Partial probability of establishment for commercial fruit crops: **Moderate**.

Partial probability of establishment for nursery plants: **Moderate**.

Partial probability of establishment for household and garden plants: **Moderate**.

Partial probability of establishment for wild and amenity plants: **Moderate**.

### ***Partial probability of spread***

<b>ISPM 11 factor</b>	<b>Relevant information</b>
<b>Suitability of natural and/or managed environment</b>	<ul style="list-style-type: none"> <li>ERM is present in the eastern states of Australia and there are similar environments in Western Australia that would be suitable for its spread.</li> </ul>
<b>Presence of natural barriers</b>	<ul style="list-style-type: none"> <li>The commercial fruit crops of ERM are grown in southwestern part of Western Australia and there are natural barriers present between some districts. It would be difficult for the mites to disperse from one district to another if unaided.</li> <li>Given the polyphagous nature of ERM there are many other host plants available between the commercial fruit orchards in different areas of Western Australia and this would help the spread of ERM.</li> </ul>
<b>Potential for movement with commodities or conveyances</b>	<ul style="list-style-type: none"> <li>Movement of commodities would help the dispersal of ERM because winter eggs and mites can be on fruit.</li> </ul>
<b>Intended use of the commodity</b>	<ul style="list-style-type: none"> <li>Apples would be used mostly for consumption by humans and would be widely distributed around the State.</li> </ul>
<b>Potential vectors of the pest</b>	<ul style="list-style-type: none"> <li>ERM does not require a vector for its spread since it is capable of ballooning.</li> </ul>
<b>Potential natural enemies</b>	<ul style="list-style-type: none"> <li>Natural enemies such as spiders and predatory mites in the PRA area, especially generalist predators, may be able to attack ERM but there is no evidence that they would be effective.</li> </ul>

### ***Conclusion—partial probability of spread***

Based on the above evidence, partial probability of spread for each of the exposure groups is as follows:

Partial probability of spread for commercial fruit crops: **High**

Partial probability of spread for nursery plants: **High**

Partial probability of spread for household and garden plants: **High**

Partial probability of spread for wild and amenity plants: **High**

### ***Combined partial probability of establishment or spread***

The combined partial probability of establishment or spread was determined by combining probabilities of establishment and probabilities of spread using the matrix of 'rules' for

combining descriptive likelihoods as presented in the method section. The results are indicated in Table 89.

**Table 89 Combined partial probabilities of establishment or spread of European red mite**

	<b>Commercial fruit crops</b>	<b>Nursery plants</b>	<b>Household and garden plants</b>	<b>Wild and amenity plants</b>
<b>Establishment</b>	Moderate	Moderate	Moderate	Moderate
<b>Spread</b>	High	High	High	High
<b>PPES<sup>71</sup></b>	Moderate	Moderate	Moderate	Moderate

Additional evidence to support the combined partial probability of establishment or spread for specific exposure groups is provided in the text below.

<b>Commercial fruit crops</b>	<ul style="list-style-type: none"> <li>Commercial fruit crops of ERM are grown in many parts of Western Australia.</li> </ul>
<b>Moderate</b>	<ul style="list-style-type: none"> <li>ERM has shown its ability to establish or spread readily in Asia, Africa, Europe, North and South America, eastern Australia and New Zealand.</li> </ul>
<b>Susceptible nursery plants</b>	<ul style="list-style-type: none"> <li>ERM attacks many plants that are sold as nursery plants in Western Australia and is polyphagous on many dicotyledonous shrubs and trees (HortResearch, 1999b).</li> </ul>
<b>Moderate</b>	
<b>Susceptible household and garden plants</b>	<ul style="list-style-type: none"> <li>The establishment of ERM in susceptible household and garden plants will be largely dependent on (1) the availability of a wide range of host plants; (2) the extent of Western Australian households growing backyard apple trees and other host plants; and, (3) the willingness of suburban gardeners to adequately control pests and diseases particularly on their fruit trees.</li> <li>Climatic limits and the extent of apple trees and other host plants in suburban backyards can have an effect on the establishment or spread of ERM.</li> </ul>
<b>Moderate</b>	
<b>Susceptible wild and amenity plants</b>	<ul style="list-style-type: none"> <li>Since ERM is a temperate insect, climatic factors would affect its establishment or spread in Western Australia.</li> <li>ERM is capable of ballooning and thus would be able to spread from one wild host to another with the aid of wind.</li> </ul>
<b>Moderate</b>	

## Assessment of consequences

European red mite is a regional concern only. Thus the following assessment of consequences applies only to the regional level (Western Australia) not national level.

<sup>71</sup> PPES = partial probability of establishment or spread.



Impact scores allocated for the direct and indirect criteria are shown in Table 90. Available supporting evidence is provided in the text below.

**Table 90 Impact scores for European red mite**

<b>Direct impact</b>	<b>Impact scores</b>
Plant life or health	D
Human life or health	A
Any other aspects of environment	A
<b>Indirect impact</b>	
Control or eradication	D
Domestic trade or industry	C
International trade	D
Environment	B
Communities	A

***Direct impact***

<b>Plant life or health – D</b>	<p>Consequences affecting plant life or health are of minor significance at regional level. A rating of ‘D’ was assigned to this criterion.</p> <ul style="list-style-type: none"> <li>European red mite is considered as an important pest of many fruit trees.</li> <li>European red mite feeding results in loss of green leaf pigment (chlorophyll) from the leaves caused by draining the contents from the inner leaf cells, which then collapse and die. Leaf bronzing and defoliation results from high density and persistent mite populations. ERM also causes damage by infecting the fruit with (overwintering) eggs at harvest time (HortResearch, 1999b)</li> <li>If draining of chlorophyll from the leaves occurs early in the season, it may have a detrimental effect on fruit bud formation and thus affect the crop in the succeeding year (Collyer, 1998).</li> <li>ERM has a very high reproductive rate and is capable of producing 5–7 overlapping generations in a growing season resulting in rapid population build up.</li> </ul>
<b>Human life or health – A</b>	<p>There are no known direct impacts of ERM on human life or health and the rating assigned to this criterion was therefore ‘A’.</p>
<b>Any other aspects of environmental effects – A</b>	<p>There is no known direct impact of ERM on any other aspects of the environment and a rating of ‘A’ was assigned to this criterion.</p>

**Indirect impact**

<b>Control or eradication – D</b>	<p>The indirect impact on new or modified eradication, control, surveillance/monitoring and compensation strategies is of minor significance at regional level. A rating of ‘D’ was assigned to this criterion.</p> <p>Indirect consequences of the eradication or control as a result of the introduction of ERM.</p> <ul style="list-style-type: none"> <li>• An increase in the use of insecticides for its control.</li> <li>• Disruption to current IPM programs because of the need to re-introduce or substitute predacious mites resistant to currently used insecticides.</li> <li>• Subsequent increase in cost of production to producers.</li> <li>• Increased costs for crop monitoring and consultant’s advice to the producer.</li> </ul>
<b>Domestic trade or industry – C</b>	<p>The indirect consequences on domestic trade are unlikely to be discernable at the regional level and of minor significance at the district level. A rating of ‘C’ was assigned to this criterion.</p> <p>The presence of ERM on commercial apple crops could result in:</p> <ul style="list-style-type: none"> <li>• trade restrictions in the sale or movement of fruit within Western Australia.</li> </ul>
<b>International trade – D</b>	<p>The indirect consequences on international trade are of minor significance at the regional level. A rating of ‘D’ was assigned to this criterion.</p> <ul style="list-style-type: none"> <li>• Western Australia’s ERM pest free status on international markets would be compromised.</li> </ul>
<b>Environment – B</b>	<p>The indirect consequences on the environment would not be discernible at the regional level and of minor significance at the local level and a rating of ‘B’ was assigned to this criterion.</p> <ul style="list-style-type: none"> <li>• Increased insecticide use could cause undesired effects on the environment.</li> <li>• The introduction of new pesticide resistant mite biocontrol agents could affect existing biological control programs.</li> <li>• ERM has many hosts that are found in the environment.</li> </ul>
<b>Communities – A</b>	<ul style="list-style-type: none"> <li>• The presence of ERM would have limited social effects, if any, and a rating of ‘A’ was assigned to this criterion.</li> </ul>

**Conclusion—consequences**

Based on the decision rule described in the method section, i.e. where the consequences of a pest with respect to one or more criteria are ‘D’, the overall consequences are considered to be ‘low’. Therefore the overall consequences of ERM are **low**.

## Unrestricted annual risk

Unrestricted annual risk is the results of combining annual probability of entry, establishment or spread with the outcome of overall consequences. Probabilities and consequences are combined using the ‘rules’ shown in the risk estimation matrix in the method section. The unrestricted annual risk estimation for ERM is shown in Table 91.

**Table 91 Risk estimation for European red mite**

Overall probability of entry, establishment or spread <sup>72</sup>	<b>Very low</b>
Consequences	<b>Low</b>
Unrestricted annual risk	<b>Negligible</b>

As indicated in Table 91, the unrestricted annual risk for European red mite is negligible, which is below the appropriate level of protection (ALOP) of very low. Therefore, risk management would not be required for this pest.

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<sup>72</sup> Calculated by @ risk.

## **Mealybugs**

This assessment relates to two species of mealybugs:

Citrophilus mealybug, *Pseudococcus calceolariae* (Maskell); and,

Mealybug, *Planococcus mali* Ezzat and McConnell.

## **Biology**

Apart from taxonomy, information on *Planococcus mali* is very limited. It was intercepted in Honolulu on *Olearia chathamica* from New Zealand in 1937, and intercepted on apple from Tasmania at Buffalo, New York and Boston, Massachusetts in 1946. Subsequently it was named and described by (Ezzat and McConnell, 1956). The mealybug is probably fairly common in Tasmania on various plants, but has been found only once on the mainland (Williams, 1985). Cox (1987) also recorded the species from apple in New Zealand and stated it was fairly common and widespread being found mainly on introduced plants. There is no recent information in relation to the occurrence of this species in apple orchards in New Zealand (HortResearch, 1999b), however, Cox (1987) and Cox (1989) reported it as sometimes causing damage to blackcurrants in New Zealand.

In New Zealand, citrophilus mealybug *P. calceolariae* is much more important than *Planococcus mali* on apple and **the following assessment mainly applies to citrophilus mealybug but should also cover *Planococcus mali*.**

Females of citrophilus mealybug develop through egg and three immature instars and undergo a final moult to become adult. The female is a slow moving, oval shaped insect approximately 3-4 mm in length. Males develop through egg, first and second feeding instars, and short-lived third (about 2 days) and longer-lived fourth (about 4 days) non-feeding instars before moulting into tiny, winged adults with a pair of stout, wax, terminal filaments.

Parthenogenesis has not been reported in citrophilus mealybug, and experience suggests that sexual reproduction is essential (CABI, 2002). Mature females produce a sex pheromone, which attracts crawling males from short distances or flying males from distances in excess of one metre.

Like other scale insects, mealybugs debilitate plant hosts by sucking sap during feeding and contaminating the plant with honeydew on which sooty mould can grow. Although mealybugs live mainly on the bark of apple trees (HortResearch, 1999b), they also can be found on fruit and tend to live around or in the calyx of fruit.

Other information relevant in the biology of mealybugs is available in the datasheet in Appendix 3 in Part B.

## **Risk scenario**

The risk scenario of concern for the mealybugs in this IRA is that some nymphs and adults feed on and/or contaminate the apple fruit.

## Probability of importation

The initiating step for the importation scenario for apple fruit is the sourcing of apples from orchards in New Zealand, while the end-point is the release of imported apples from the port of entry. The importation scenario is divided into eight steps and the likelihood of the mealybugs being present at each step is summarised in Figure 35. The available evidence supporting the likelihood assessments is provided in the text below.

**Figure 35 The importation steps and the likelihood of mealybugs being present at each step**



<b>Importation step 1 (Imp1)</b>  <b>High</b>	<p>The likelihood that mealybugs are present in the source orchards in New Zealand: <b>High</b>.</p> <ul style="list-style-type: none"> <li>• Citrophilus mealybug is common throughout the major fruit growing regions of the North Island and in Nelson on the South Island, but has not been recorded any further south (HortResearch, 1999b).</li> </ul>
<b>Importation step 2 (Imp2)</b>  <b>Low</b>	<p>The likelihood that picked apple fruit is infested with mealybugs: <b>Low</b>.</p> <ul style="list-style-type: none"> <li>• There is no specific information about the rate of citrophilus mealybug attack on apple fruit.</li> <li>• However, mealybugs live mainly on the bark of apple and pear trees and small colonies of all stages may develop in the calyx of pipfruit and amongst the fruit clusters (HortResearch, 1999b).</li> <li>• Three species of mealybugs are commonly found in apple orchards and they are longtailed mealybug, <i>Pseudococcus longispinus</i> and obscure mealybug, <i>P. viburni</i> as well as citrophilus mealybug (HortResearch, 1999b). Several other species can also be found on apple (see categorisation table). Therefore, for mealybug infestation on apple, only a proportion can be attributed to citrophilus mealybug.</li> </ul>

#### Summary

Based on this evidence, if the likelihood that picked fruit are infested by all species of mealybugs can reasonably be considered as moderate, the likelihood for citrophilus mealybug or *P. mali* would be low because only less than one third of the infestations could be attributed to the particular species of concern. The likelihood for Imp2 was assessed as low.

<b>Importation step 3 (Imp3)</b>  <b>Very low</b>	<p>The likelihood that clean fruit is contaminated by mealybugs during harvesting and transport of apples to the packing house: <b>Very low</b>.</p> <ul style="list-style-type: none"> <li>• Fruit are picked into harvesting bags and then transferred into bins kept on the ground in the orchard prior to transportation to the packing house.</li> <li>• Mealybugs are mobile at all life stages.</li> <li>• First instar nymphs are highly mobile while adults can move slowly. They would be able to infest the clean fruit from other infested fruit or leaves if present during harvesting.</li> <li>• Again, only a small proportion of such contamination can be attributed to citrophilus mealybug or <i>P. mali</i>.</li> </ul>
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#### Summary

Based on this evidence that, if present, mealybugs can contaminate clean fruit but only a small portion can be attributed to citrophilus

**Importation step 4  
(Imp4)****Low**

mealybug or *P. mali*, the likelihood for Imp3 was assessed as very low.

The likelihood that mealybugs survive routine processing procedures in the packing house is **Low**.

*Washing*

- The washing process including high volume washing has been shown to significantly reduce the number of mealybugs on the fruit, however, those located beneath the calyx of apples with a closed calyx cavity would remain with the fruit (Whiting *et al.*, 1998).

*Brushing*

- Mealybugs located beneath the calyx of apples with a closed calyx cavity would remain with the fruit during brushing (Whiting *et al.*, 1998).

*Waxing*

- There is no evidence to indicate that mealybugs hidden in the calyx of apples with a closed calyx cavity would not survive low temperature waxing.

*Sorting and grading*

- Mealybugs hidden in the calyx of apples with a closed calyx cavity coupled with their small size would escape the attention of sorters and graders.

*Packaging*

- Packaging would have little effect on the survival of mealybugs. In most cases the packaging of apples is designed to maximise heat discharge from the fruit while minimising loss of moisture.

*Cold Storage*

- Citrophilus mealybug overwinter under the bark of deciduous pipfruit trees, and on a range of other host plants in the sward or surrounding shelter-belts or shrubs (HortResearch, 1999b) suggesting that temporary cold storage will not be effective in killing the mealybugs.
- Another species of mealybug, *Pseudococcus affinis* is able to survive up to 42 days at 0°C (Hoy and Whiting, 1997).

*Summary*

Although washing has been shown effective in reducing the number of mealybugs with fruit, the fact that citrophilus mealybug has been detected both at pre-clearance in New Zealand and at on-arrival inspection in the US on New Zealand apples exported to the USA (MAFNZ, 2003b; USDA-APHIS, 2003) indicates that some mealybugs would be able to survive the packing house process. The likelihood for Imp4 was assessed as very low.

**Importation step 5  
(Imp5)**

**Extremely low**

The likelihood that clean fruit is contaminated by mealybugs during processing in the packing house: **Extremely low**.

- As mentioned, mealybugs are mobile at all life stages and it is likely that they would infest clean fruit by moving from infested fruit. However, the dislodged mealybugs after dumping in or washing by water would be unlikely to reinfest clean fruit.
- There is opportunity for mealybugs dislodged in the conveyer belt to reinfest clean fruit. Overall, the likelihood that mealybugs as a whole will contaminate clean fruit during processing in the packing house would be very low but again only a small portion can be attributed to citrophilus mealybug or *P. mali*.
- At low temperatures employed in cold storage mealybugs cease to move and would not move about to contaminate clean fruit.

*Summary*

Based on this evidence that mealybugs would not move around at cold storage, the likelihood for Imp5 was assessed as extremely low.

**Importation step 6  
(Imp6)**

**High**

The likelihood that mealybugs survive palletisation, quality inspection, containerisation and transportation and remains undetected: **High**

- The remaining mealybugs at the stem or calyx-end of fruit would be likely to survive palletisation, quality inspection, containerisation and refrigerated transport to Australia.

*Summary*

The fact that citrophilus mealybug has been detected both at pre-clearance in New Zealand and at on-arrival inspection in the US on New Zealand apples exported to the USA (MAFNZ, 2003b; USDA-APHIS, 2003) indicates mealybugs can survive this process. The likelihood for Imp6 was assessed as high.

**Importation step 7  
(Imp7)**

**Negligible**

The likelihood that clean fruit is contaminated by mealybugs during palletisation, quality inspection and transportation:

**Negligible.**

- Mealybugs surviving to this stage are most likely to be located beneath the calyx of apples with a closed calyx and would not be able to move about to contaminate clean fruit during palletisation, quality inspection and transportation.
- At low temperatures employed in cold storage during transportation, mealybugs cease to move and would not move about to attach to clean fruit.



*Summary*

Based on this evidence, the likelihood for Imp7 was assessed as negligible.

**Importation step 8  
(Imp8)**

The likelihood that mealybugs survive and remain with fruit after on-arrival minimum border procedures: **High**.

**High**

- The minimum border procedures as described in the method section would not be effective in detecting the mealybugs.

***Conclusions—probability of importation***

When the above likelihoods were inserted into the simulation model, the probability of importation of mealybugs from one year of trade was found to be **Very low**.

**Probability of distribution**

The initiating step for the distribution scenario is the release of imported apples from the port of entry, while the last step is the pest being distributed (as a result of the processing, sale or disposal of these apple fruit) in a viable state to an endangered area and subsequently being exposed to a suitable host.

In order to assess the probability of distribution, the distribution scenario is addressed in the three subheadings below. First is a brief description of sequences of events leading to a successful exposure of the pest from infested/infected apple to a susceptible host plant. Second is the assessment of partial probability of distribution of the pest in relation to each of the exposure groups. Third is the conclusion for the probability of distribution.

***Sequence of events for successful exposure***

The sequence of events that has to be completed for a successful exposure of a susceptible host to the pest is summarised below.

The insect stages associated with the apple fruit are either nymphs or adults which hide within the calyx, around the stalk or under fruit sepals. The only means for mealybugs to leave fruit or packaging and enter the environment of exposure groups is through movement of nymphs or adults. If nymphs or adults survive storage, they will still be associated with the fruit when the imported apples are taken out from storage.

Mealybugs do not have wings, and are therefore limited in their ability to disperse. Mealybugs would remain on the fruit and not enter the environment from the utility points such as wholesalers or retailers. However, when the spoilt fruit or cores are disposed as waste, the adults and nymphs either die or slowly move into the environment via wind dispersal, crawling, or movement of infested material. For the citrophilus mealybug, parthenogenesis has not been reported in this species, and experience suggests that sexual reproduction is essential. Eggs are laid within a waxy ovisac formed by the female body. If there are eggs associated with the fruit, crawlers can hatch from the eggs and neonate crawlers spend the first few days of their lives sheltering under the disintegrating ovisac before dispersing to feed. Crawlers usually do not move far from their feeding site for the first moult (CABI, 2002). In addition, there is no wind in the indoor environment or close to ground situation to assist their dispersal.

A successful exposure of mealybugs from infested fruit to its hosts means that nymphs and adults would need to find to a susceptible host plant by crawling or wind dispersal, and adult females would need to locate a male to mate with and lay its eggs.

### ***Partial probability of distribution***

The partial probability of distribution (PPD) was estimated separately for each of the four exposure groups: commercial fruit crops; nursery plants; household and garden plants; and, wild and amenity plants.

The details and the method of calculation for the PPD of the four exposure groups are explained in the method section and the results are presented in a series of tables and figures below. The information from these tables and figures was used to assess the probability of distribution of mealybugs to all the exposure groups.

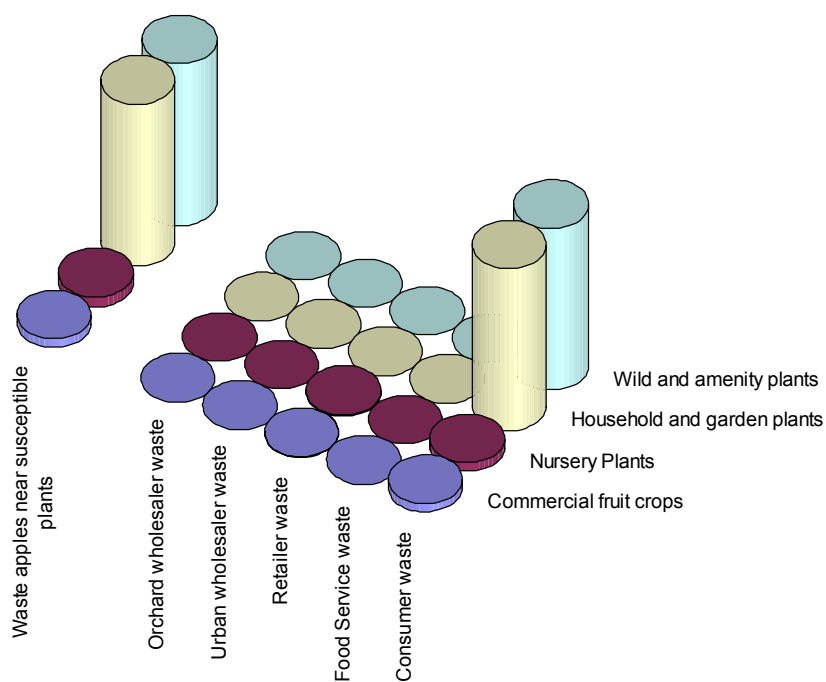
Table 92 indicates the proportions of the five utility points near each of the exposure groups of mealybugs. Citrophilus mealybug is highly polyphagous and has been recorded from hosts in 40 plant families (CABI, 2002), and the exposure groups are related to many host plants. Hosts include apple, pear, citrus, grape, stonefruit, potato, hibiscus and roses.

**Table 92 The proportions of utility points near host plants susceptible to mealybugs in the four exposure groups**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Proximity</b> Orchard wholesalers	Certain	Very Low	Very Low	Very Low
<b>Proximity</b> Urban wholesalers	Extremely Low	Extremely Low	Extremely Low	Extremely Low
<b>Proximity</b> Retailers	Very Low	Low	Very Low	Very Low
<b>Proximity</b> Food services	Extremely Low	Extremely Low	Extremely Low	Extremely Low
<b>Proximity</b> Consumers	Very Low	Very Low	Moderate	Moderate

Figure 36 gives a pictorial representation of the relative amounts of infested/infected apples, an escaped pest or contaminated packaging material discharged or discarded from different utility points near each of the exposure groups of mealybugs.

**Figure 36 Pictorial representation of the relative amounts of infested/infected apple waste<sup>73</sup> from utility points to near exposure groups of mealybugs**



<sup>73</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or an escaped pest, or contaminated packaging material.

Table 93 is the summary of the probability that exposure of the host plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points. Evidence is provided in the text below under different exposure groups.

**Table 93 The probability of exposure of susceptible host plants of mealybugs from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Exp</b> Orchard <sup>74</sup> wholesaler waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Urban wholesaler waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Retailer waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Food service waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Consumer waste	Negligible	Negligible	Negligible	Negligible

#### *Commercial fruit crops*

##### *Commercial fruit crops near utility points*

The proportions of the five utility points near commercial fruit crops of mealybugs are shown in Table 92. It was estimated that commercial fruit crops are certain to be located near orchard wholesalers, very unlikely to be near retailers and consumers, and extremely unlikely to be near urban wholesalers and food services as most of these are in metropolitan areas.

The relative amounts of infested/infected apples, or an escaped pest, or contaminated packaging material discharged or discarded from different utility points to near commercial fruit crops susceptible to mealybugs are indicated in Figure 36.

##### *Exposure to host*

The commercial fruit crops of citrophilus mealybug include apple, pear, grape, stonefruit and many others.

A successful exposure of mealybugs from infested fruit to its hosts means that nymphs and adults would need to find to a susceptible host plant by crawling or wind dispersal, and adult females would need to locate a male to mate with and lay its eggs. The chance for this to

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<sup>74</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or an escaped pest, or contaminated packaging material.

happen depends on several factors, including the mortality of nymphs and adults, level of infestation/infection and number of apples in the same utility points, availability and susceptibility of hosts and life span of the pest.

As shown in Table 93, it was considered that the probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** commercial fruit crops  
from orchard wholesaler waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Host plants such as apple and pear trees and grape vines are readily available in commercial orchards.
- Orchard wholesalers are certain to be always located near commercial fruit crops.
- However, the volume of imported apple that would be distributed to orchard wholesalers is extremely low.
- Neonate crawlers spend the first few days of their lives sheltering under the disintegrating ovisac before dispersing to feed. They usually do not move far from their feeding site for the first moult.
- Adult females are slow moving. Males are capable of crawling short distances or flying from distances in excess of one metre when attracted to female sex pheromones.

**Exp** commercial fruit crops  
from urban wholesaler waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

- Commercial fruit crops are not located in urban areas.
- Urban wholesaler waste is disposed into bins and taken to landfills. Commercial fruit crops are unlikely to be near these sites.

**Exp** commercial fruit crops  
from retailer waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Most retailers are located in urban areas and are not close to commercial fruit crops.
- Retailer waste may be used for composting in rural areas and some of these sites may be near commercial orchards.

**Exp** commercial fruit crops  
from food service waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Most food service industries are located in urban areas and are not close to commercial fruit crops.
- Food service industry waste is disposed into bins and taken to landfills. Commercial fruit crops are unlikely to be near these sites.

**Exp** commercial fruit crops  
from consumer waste

**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- The majority of consumers are located in metropolitan and suburban areas. Waste produced by people in metropolitan areas and some in urban areas is generally disposed into landfills. Commercial fruit crops would usually not be near these sites.
- Households and population densities around commercial orchards are very low.
- Some consumer waste in suburban and rural areas may be utilised for composting. Commercial fruit crops can be present close to compost heaps.

### *Nursery plants*

#### *Nursery plants near utility points*

The proportions of the five utility points near nursery plants of mealybugs are shown in Table 92. It was estimated that nursery plants are unlikely to be near retailers, very unlikely to be near orchard wholesalers and consumers, and extremely unlikely to be near urban wholesalers and food services.

The relative amounts of waste apples discharged or discarded near nursery plants susceptible to mealybugs are indicated in Figure 36.

#### *Exposure to host*

The nursery plants of citrophilus mealybugs include apple, pear, citrus, grape, stonefruit, hibiscus and many others.

A successful exposure of mealybugs from infested fruit to its hosts means that nymphs and adults would need to find to a susceptible host plant by crawling or wind dispersal, and adult females would need to locate a male to mate with and lay its eggs. The chance for this to happen depends on several factors, including the mortality of nymphs and adults, level of infestation/infection and number of apples in the same utility points, availability and susceptibility of hosts and life span of the pest.

As shown in Table 93, it was considered that the probability that exposure of nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** nursery plants from  
orchard wholesaler waste

The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected

<b>Negligible</b>	<p>apple, an escaped pest or contaminated packaging material from orchard wholesalers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>• Host plants such as apple, pear, citrus, grape, stonefruit, hibiscus, roses, and many other listed hosts of mealybugs are common in nurseries.</li> <li>• Retail garden nurseries have a high density of a range of plant materials in a small area. They often maintain a high hygienic standard, usually fogging with insecticide, to prevent insect attacks.</li> <li>• There are rare instances of nurseries being located near to orchard wholesaler waste.</li> </ul>
<b>Exp</b> nursery plants from urban wholesaler waste <b>Negligible</b>	<p>The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>• There are rare instances of nurseries being located near to urban waste dumps.</li> </ul>
<b>Exp</b> nursery plants from retailer waste <b>Negligible</b>	<p>The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>• Apple, pear, grape, potato and many other nursery plants are for sale in major retail outlets.</li> <li>• Host plants such as apple, pear and grape are a common plant in nurseries in the temperate regions of Australia, particularly during the dormant period over winter and to a limited extent during the spring and summer months. Other host plants such as hibiscus, potato, oleander, roses are common nursery plants.</li> <li>• Retail garden nurseries have a high density of a range of plant materials in a small area. They often maintain a high hygienic standard, usually fogging with insecticide, to prevent insect attacks.</li> <li>• A number of fresh food markets will have nursery plants near apple fruit. However, there are a limited number of nurseries associated with fresh food markets that also maintain or store actively growing apple trees.</li> </ul>
<b>Exp</b> nursery plants from food service waste <b>Negligible</b>	<p>The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from food services: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>• Most food service industries are located in urban areas. There are instances of nurseries being located near food services.</li> <li>• However, food service industry waste is disposed into bins and taken to landfills. Nurseries would not be near landfill sites in which food services waste is disposed.</li> </ul>

**Exp** nursery plants from  
consumer waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. Nurseries are generally not located near these sites.

#### *Household and garden plants*

##### *Household and garden plants near utility points*

The proportions of the five utility points near household and garden plants of mealybugs are shown in Table 92. It was estimated that household and garden plants are moderately likely to be near consumers, very unlikely to be near orchard wholesalers and retailers, and extremely unlikely to be near urban wholesalers and food services.

The relative amounts of waste apples discharged or discarded near household and garden plants susceptible to mealybugs are indicated in Figure 36.

##### *Exposure to host*

The household and garden plants of citrophilus mealybugs include apple, pear, grape, stonefruit, hibiscus and many others.

A successful exposure of mealybugs from infested fruit to its hosts means that nymphs and adults would need to find to a susceptible host plant by crawling or wind dispersal, and adult females would need to locate a male to mate with and lay its eggs. The chance for this to happen depends on several factors, including the mortality of nymphs and adults, level of infestation/infection and number of apples in the same utility points, availability and susceptibility of hosts and life span of the pest.

As shown in Table 93, it was considered that the probability that exposure of household and garden plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** household and garden  
plants from orchard wholesaler  
waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Orchard wholesaler waste sites are mostly located within the orchard premises and are not located near household and garden plants.

**Exp** household and garden  
plants from urban wholesaler waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

- Urban wholesaler waste is disposed into landfill sites that are generally not near residential properties.



<b>Exp</b> household and garden plants from retailer waste <b>Negligible</b>	<p>The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>• Retailer waste would be disposed to landfills that are generally not near residential properties.</li> </ul>
<b>Exp</b> household and garden plants from food service waste <b>Negligible</b>	<p>The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from food services: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>• Food service industries are unlikely to have host plants susceptible to mealybugs within their premises.</li> <li>• Waste from food services is disposed into landfills sites.</li> </ul>
<b>Exp</b> household and garden plants from consumer waste <b>Negligible</b>	<p>The probability that exposure of susceptible household plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>• Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. However, local authorities are now encouraging composting of food waste in suburban backyards rather than disposing of all waste into landfill.</li> <li>• Most consumers in metropolitan and suburban areas dispose of their waste to landfills, which are generally not near household and garden plants.</li> <li>• Apple, pears and grapes and many other host plants are commonly grown as garden plants in the temperate regions of Australia.</li> <li>• Household apple trees would be exposed to mealybugs from household apples, for example, an infected apple core that is composted in a garden.</li> </ul>

### *Wild and amenity plants*

#### *Wild and amenity plants near utility points*

The proportions of the five utility points near wild and amenity plants of mealybugs are shown in Table 92. It was estimated that wild and amenity plants are unlikely to be near consumers, very unlikely to be near orchard wholesalers and retailers, and extremely unlikely to be near urban wholesalers and food services.

The relative amounts of waste apples discharged or discarded near wild and amenity plants susceptible to mealybugs are indicated in Figure 36.

#### *Exposure to host*

The wild and amenity plants of citrophilus mealybug include apple, pear, grape, stonefruit and many others.

A successful exposure of mealybugs from infested fruit to its hosts means that nymphs and adults would need to find to a susceptible host plant by crawling or wind dispersal, and adult females would need to locate a male to mate with and lay its eggs. The chance for this to happen depends on several factors, including the mortality of nymphs and adults, level of infestation/infection and number of apples in the same utility points, availability and susceptibility of hosts and life span of the pest.

As shown in Table 93, it was considered that the probability that exposure of wild and amenity plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** wild and amenity plants  
from orchard wholesaler waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Orchard wholesaler waste sites are mostly located within the orchard premises and are not located near wild and amenity plants.
- Susceptible feral plants (e.g. volunteer apple seedlings, crab apple, pear, stonefruit, etc.) may be present near orchard wholesaler's waste disposal sites.

**Exp** wild and amenity plants  
from urban wholesaler waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

- Urban wholesale waste is disposed at landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds (e.g. crab apple trees, apple, pear or stonefruit seedlings).

**Exp** wild and amenity plants  
from retailer waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Retailer waste would be disposed to landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds (e.g. crab apple trees, apple, pear or stonefruit seedlings).

**Exp** wild and amenity plants  
from food service waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Food service waste is disposed into bins and taken to landfills. Seedlings originating from seeds dispersed by birds would be present.

**Exp** wild and amenity plants  
from consumer waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds (e.g. crab apple trees, apple, pear or stonefruit seedlings).
- Consumers discard apple cores in the environment or into bins in parks. Bins for waste in parks may not be removed on a daily basis and these would provide a sheltered environment for the insect to emerge before the fruit desiccates or decays.
- Apple seedlings can establish from discarded apple cores. However, population densities of susceptible wild and amenity apple plants in parks, near recreational facilities and along roadsides may be low.
- Consumers who consider apple cores to be biodegradable indiscriminately discard them in the environment. Spoilt apples or cores discarded into the wild are likely to be isolated.

#### **Conclusion—probability of distribution**

The partial probability of distribution from each of the utility points to each of the exposure groups is summarised in Table 94. These were based on the data and assessment provided above and calculated by the simulation model using the @risk. The quantitative model evaluated the effect of the ‘volume of trade’ during a specified period when calculating the partial probability of distribution.

**Table 94 Partial probabilities of distribution (PPD)<sup>75</sup> for mealybugs**

UTILITY POINTS	PPD			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Orchard wholesalers</b>	Extremely low	Negligible	Negligible	Negligible
<b>Urban wholesalers</b>	Negligible	Negligible	Negligible	Negligible
<b>Retailers</b>	Extremely low	Very low	Extremely low	Extremely low
<b>Food services</b>	Negligible	Negligible	Negligible	Negligible
<b>Consumers</b>	Very low	Very low	Low	Low

<sup>75</sup> Partial probability of distribution is actually referring to the probability of entry and was estimated by @risk.

UTILITY POINTS	PPD			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
Overall PPD	Very low	Very low	Low	Low

### Probability of establishment or spread

The assessment for the probability of establishment or spread is carried out in the following manner. Firstly, partial probability for establishment and for spread was assessed separately based on the relevant available scientific information. Secondly, the conclusions for the combined partial probability of establishment or spread for each of the four exposure groups are provided at the end of this section. The relevant information for the assessment for the probability of establishment or spread is presented below against the factors listed ISPM 11, Rev. 1.

#### *Partial probability of establishment*

ISPM 11 factor	Relevant information
<b>Availability of suitable hosts, alternate hosts and vectors in the PRA area</b>	<ul style="list-style-type: none"> <li>Citrophilus mealybug is highly polyphagous and has been recorded from hosts in 40 plant families (CABI, 2002), including many commercial and nursery plants such as apple, pear, grape, stonefruit, potato, hibiscus and roses.</li> <li>Commercial crops such as apple are grown in all States and Territories in Australia, except in the northern tropical regions, and are also found in suburban backyards in temperate Australia.</li> </ul>
<b>Suitability of the environment</b>	<ul style="list-style-type: none"> <li>Citrophilus mealybug is already reported from New South Wales, Queensland, Tasmania and Victoria, but is absent from Western Australia.</li> <li>Host plants such as apples or pears are not grown in protected environments such as in glasshouses.</li> </ul>
<b>The potential for adaptation of the pest</b>	<ul style="list-style-type: none"> <li>The rate of development of citrophilus mealybug on any host is primarily dependent on temperature (CABI, 2002).</li> <li>For the past four decades, the citrophilus mealybug has been kept under reasonable control by broad-spectrum contact or systemic insecticides. However, resistance to some organophosphates has been reported for other mealybug species such as <i>P. viburni</i> in New Zealand (Charles, 1993). Because of this, organophosphates are gradually being replaced by 'softer' pesticides such as insect growth regulators. However, the insect growth regulators effective against mealybugs are persistent chemicals and there is a risk of mealybugs developing resistance to them (CABI, 2002).</li> </ul>
<b>The reproductive strategy of the pest</b>	<ul style="list-style-type: none"> <li>Parthenogenesis has not been reported for the citrophilus mealybug, and experience suggests that sexual reproduction is essential.</li> </ul>

ISPM 11 factor	Relevant information
<b>Minimum population needed for establishment</b>	<ul style="list-style-type: none"> <li>• Successful mating between a male and a female must occur for viable eggs to be produced.</li> <li>• Mature females of the citrophilus mealybug produce a sex pheromone which attracts crawling males from short distances or flying males from distances in excess of one metre (CABI, 2002).</li> <li>• The pheromone attracts large numbers of males in the field, and has been used to detect three seasonal male flight peaks in Italy (Rotundo <i>et al.</i>, 1979).</li> <li>• Adult females of the citrophilus mealybug may mate almost immediately after moulting, but then spend up to several weeks maturing their eggs (CABI, 2002).</li> <li>• Mature females of the citrophilus mealybug may lay in excess of 700 eggs within a waxy ovisac (CABI, 2002). They commonly move to a protected site to oviposit over a period of up to two weeks. They cease feeding before oviposition, when they are little more than a convenient bag for their eggs. They die at the end of egg laying (CABI, 2002).</li> <li>• Citrophilus mealybug is reported to have three to four generations per year, depending on the country (CABI, 2002).</li> <li>• Mated females of the citrophilus mealybug may lay in excess of 700 eggs within a waxy ovisac (CABI, 2002), and spend up to several weeks maturing their eggs. They commonly move to a protected site to oviposit over a period of up to two weeks (CABI, 2002). A population can be started from these eggs.</li> </ul>
<b>Cultural practices and control measures</b>	<ul style="list-style-type: none"> <li>• For the past four decades, the citrophilus mealybug has been kept under reasonable control by broad-spectrum contact or systemic insecticides. Due to reports of resistance to some organophosphates by other mealybug species, 'softer' pesticides such as insect growth regulators are gradually replacing them. However, the insect growth regulators effective against mealybugs are persistent chemicals and there is a risk of mealybugs developing resistance to them (CABI, 2002).</li> <li>• Sufficient success has been achieved using natural enemies to ensure biological control of mealybugs, especially with the development of Integrated Pest Management (IPM) programs (CABI, 2002).</li> <li>• Natural enemies of citrophilus mealybug such as the coccinellid <i>Cryptolaemus montrouzieri</i> and parasitoids <i>Tetraneura pretiosus</i> and <i>Coccophagus gurneyi</i> are present in Australia. However, only <i>Cryptolaemus montrouzieri</i> is known to be present in Western Australia.</li> </ul>

*Conclusion—partial probability of establishment*

Based on the above evidence, partial probability of establishment for each of the exposure groups are as follow:

Partial probability of establishment for commercial fruit crops: **High**.

Partial probability of establishment for nursery plants: **High**.

Partial probability of establishment for household and garden plants: **High**.

Partial probability of establishment for wild and amenity plants: **High**.

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***Partial probability of spread***

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ISPM 11 factor	Relevant information
<b>Suitability of natural and/or managed environment</b>	<ul style="list-style-type: none"><li>• Citrophilus mealybug is already reported from Queensland, New South Wales, Victoria, Tasmania and South Australia but is absent from Western Australia. There are similar environments in Western Australia that would be suitable for its spread.</li></ul>
<b>Presence of natural barriers</b>	<ul style="list-style-type: none"><li>• The commercial fruit crops of mealybugs are grown in southwestern part of Western Australia and there are natural barriers present between some districts. It would be difficult for the mealybugs to disperse from one district to another if unaided.</li><li>• Female mealybugs do not have wings, and are therefore limited in their ability to disperse. However, there are other host plants available between the commercial apple orchards in different districts of Western Australia and this would help their spread. They can spread by crawling or wind dispersal.</li><li>• Adult males are winged and are capable of short flights.</li><li>• Male dispersal by crawling or flight is strongly affected by the location of females and their production of sex pheromones.</li></ul>
<b>Potential for movement with commodities or conveyances</b>	<ul style="list-style-type: none"><li>• Wind dispersal and the transportation of infested host plants have probably achieved long distance movement of the citrophilus mealybug.</li><li>• The most probable means of dispersal would be either as nymphs hidden within the calyx, around the stalk or under fruit sepals. They are often hidden from view (CABI, 2002).</li><li>• Existing interstate quarantine control on the movement of nursery stock would reduce the scope for the spread.</li></ul>
<b>Intended use of the commodity</b>	<ul style="list-style-type: none"><li>• Apples would be used mostly for consumption by humans and would be widely distributed around the State.</li><li>• If nymphs or adults have contaminated the fruit, they will be distributed with the commodity around the country.</li></ul>
<b>Potential vectors of the pest</b>	<ul style="list-style-type: none"><li>• Mealybugs do not require a vector for their spread since they are capable of dispersing on wind currents.</li></ul>

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ISPM 11 factor	Relevant information
<b>Potential natural enemies</b>	<ul style="list-style-type: none"> <li>Natural enemies of the citrophilus mealybug have originated from Australia and are used to control this pest in other countries.</li> <li>There may be other natural enemies in the PRA area that attack <i>P. calceolariae</i> but there is no evidence that they would be effective.</li> </ul>

*Conclusion—partial probability of spread*

Based on the above evidence, partial probability of spread for each of the exposure groups is as follow:

Partial probability of spread for commercial fruit crops: **Moderate**.

Partial probability of spread for nursery plants: **Moderate**.

Partial probability of spread for household and garden plants: **Moderate**.

Partial probability of spread for wild and amenity plants: **Moderate**.

**Combined partial probability of establishment or spread**

The combined partial probability of establishment or spread was determined by combining probabilities of establishment and probabilities of spread using the matrix of ‘rules’ for combining descriptive likelihoods as presented in the method section. The results are indicated in Table 95.

**Table 95 Combined partial probabilities of establishment or spread of mealybugs**

	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Establishment</b>	High	High	High	High
<b>Spread</b>	Moderate	Moderate	Moderate	Moderate
<b>PPES<sup>76</sup></b>	Moderate	Moderate	Moderate	Moderate

Additional evidence to support the combined partial probability of establishment or spread for specific exposure groups is provided in the text below.

<b>Commercial fruit crops</b>	<ul style="list-style-type: none"> <li>Commercial fruit crops of the mealybugs are grown in many parts of Western Australia.</li> </ul>
<b>Moderate</b>	<ul style="list-style-type: none"> <li>Citrophilus mealybug has shown its ability to establish or spread readily in Asia, Europe, Africa, North and South America and Oceanian regions.</li> </ul>

<sup>76</sup> PPES = partial probability of establishment or spread.

<p><b>Susceptible nursery plants</b> <b>Moderate</b></p>	<ul style="list-style-type: none"> <li>• Mealybugs do not have wings, and are therefore limited in their ability to disperse. They can spread by crawling or wind dispersal.</li> <li>• However, the transportation of infested host plants has probably achieved long distance movement of the citrophilus mealybug.</li> </ul>
<p><b>Susceptible household and garden plants</b> <b>Moderate</b></p>	<ul style="list-style-type: none"> <li>• The establishment of mealybugs in susceptible household and garden plants would be largely dependent on (1) the availability of host plants; (2) the extent of Australian households growing host plants; and, (3) the willingness of suburban gardeners to adequately control pests and diseases on their apple trees.</li> <li>• Citrophilus mealybug could spread in areas of Western Australia via the transportation of infested household and garden plants.</li> </ul>
<p><b>Susceptible wild and amenity plants</b> <b>Moderate</b></p>	<ul style="list-style-type: none"> <li>• Climatic factors would affect the establishment or spread of mealybugs as their rate of development on any host is primarily dependent on temperature.</li> <li>• Female mealybugs do not have wings, and are therefore limited in their ability to disperse. This means that mealybugs will require some assistance to spread from one wild plant to another. However, the citrophilus mealybug is highly polyphagous and has been recorded from hosts in 40 plant families. This would help its establishment or spread.</li> </ul>

## Assessment of consequences

Citrophilus mealybug and *P. mali* are a regional concern only. Thus the following assessment of consequences applies only to the regional level (Western Australia) not national level.

Impact scores allocated for the direct and indirect criteria are shown in Table 96. Available supporting evidence is provided in the text below.



**Table 96 Impact scores for mealybugs**

<b>Direct impact</b>	<b>Impact scores</b>
Plant life or health	D
Human life or health	A
Any other aspects of environment	A
<b>Indirect impact</b>	
Control or eradication	D
Domestic trade or industry	C
International trade	D
Environment	B
Communities	A

**Direct impact**

- Plant life or health – D** Consequences affecting plant life or health are of minor significance at the regional level. A rating of ‘D’ was assigned to this criterion.
- Mealybugs can cause direct harm to a wide range of host plants and have also been reported as a vector of diseases. For example, *P. calceolariae* has been shown to be a vector of the closterovirus associated with grapevine leafroll disease (CABI, 2002).
  - Citrophilus mealybug is highly polyphagous and has been recorded from hosts in 40 plant families.
  - Fruit quality can be reduced by the presence of secondary sooty mould.
- Human life or health – A** There are no known direct impacts of mealybugs on human life or health and the rating assigned to this criterion was therefore ‘A’.
- Any other aspects of environmental effects – A** There is no known direct impact of mealybugs on any other aspects of the environment and a rating of ‘A’ was assigned to this criterion.

**Indirect impact**

- Control or eradication – D** The indirect impact on new or modified eradication, control, surveillance/monitoring and compensation strategies is unlikely to be discernible at the national level and of minor significance at the regional level. A rating of ‘D’ was assigned to this criterion.
- Programs to minimise the impact of these pests on host plants

are likely to be costly and include pesticide applications and crop monitoring.

- Existing control programs can be effective for some hosts (e.g. broad spectrum pesticide applications) but not all hosts (e.g. where specific integrated pest management programs are used).
- An increase in the use of insecticides for its control because of difficulties estimating the optimum time for insecticide application.
- Disruption to IPM programs because of the need to re-introduce or increase the use of organophosphate insecticides.
- Subsequent increase in cost of production to producers.
- Increased costs for crop monitoring and consultant's advice to the producer.

**Domestic trade or industry – C**

The indirect consequences on domestic trade are unlikely to be discernible at the regional level and of minor significance at the district level. A rating of 'C' was assigned to this criterion.

- Restriction of movement of plant material susceptible to mealybugs would be put into place if there is an outbreak of the mealybugs.

**International trade – D**

The indirect consequences on international trade are of minor significance at the regional level. A rating of 'D' was assigned to this criterion.

- If the mealybugs became established in Western Australia, our trading partners could reject consignments of apples and other commodities infested with these mealybugs.

**Environment – B**

The indirect consequences on the environment would not be discernible at the regional level and of minor significance at the local level and a rating of 'B' was assigned to this criterion.

- Mealybugs introduced into a new environment will compete for resources with the native species.
- Increased insecticide use could cause undesired effects on the environment.
- The introduction of new biocontrol agents could affect existing biological control programs.
- Citrophilus mealybug is highly polyphagous and has been recorded from hosts in 40 plant families (CABI, 2002). Many of these plants are grown in orchards or crops under intensive cultivation, or backyards within urban areas. There would be little effect on designated environmentally sensitive or protected areas because few of these host plants grow or are allowed to continue to grow in such areas.

**Communities – A**

The presence of mealybugs would have limited social effects, if any, and a rating of 'A' was assigned to this criterion.

**Conclusion—consequences**

Based on the decision rule described in the method section, i.e. where the consequences of a pest with respect to one or more criteria are ‘**D**’, the overall consequences are considered to be ‘low’. Therefore the overall consequences of mealybugs are **low**.

**Unrestricted annual risk**

Unrestricted annual risk is the result of combining annual probability of entry, establishment or spread with the outcome of overall consequences. Probabilities and consequences are combined using the ‘rules’ shown in the risk estimation matrix in the method section. The unrestricted annual risk estimation for mealybugs is shown in Table 97.

**Table 97 Risk estimation for mealybugs**

Overall probability of entry, establishment or spread <sup>77</sup>	<b>Low</b>
Consequences	<b>Low</b>
Unrestricted annual risk	<b>Very low</b>

As indicated in Table 97, the unrestricted annual risk for mealybugs is very low, which meets the appropriate level of protection (ALOP) of very low. Therefore, risk management would not be required for these pests.

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<sup>77</sup> Calculated by @ risk.

## **Oriental fruit moth**

### **Biology**

The Oriental fruit moth (OFM), *Grapholita molesta* Busck, is a moth with four life stages: adults, eggs, larvae (or caterpillars) and pupae. Adult moths have a wingspan of about 10-16 mm and are dark-grey to brown with a series of darker lines on the forewings. Egg deposition usually begins 2-5 days after the females emerge and continues for 7-10 days. Some 50-200 eggs are laid on the underside of leaves near the growing tips.

The full-grown larva is approximately 12 mm in length and is pink to almost red. The head, top of prothorax and anal plate are brown; a black anal-fork is present above the anal opening. The pupa is reddish brown and is protected by a cocoon made of silken threads and particles of the substrate on which it is resting (CABI, 2002). Cocoons can be found on the host within fissures, under bark, on the ground beneath the leaf litter, under mummified fruit and within the soil. The overwintering generation of larvae of OFM prefer to pupate in litter on the ground.

### **Risk scenario**

The risk scenario of concern for OFM in this IRA is the presence of larvae that have bored into apple fruit.

## Probability of importation

The initiating step for the importation scenario for apple fruit is the sourcing of apples from orchards in New Zealand, while the end-point is the release of imported apples from the port of entry. The importation scenario is divided into eight steps and the likelihood of the OSS being present at each step is summarised in Figure 37. The available evidence supporting the likelihood assessments is provided in the text below.

**Figure 37 The importation steps and the likelihood of the Oriental fruit moth being present at each step**



**Importation step 1  
(Imp1)**

**Low**

The likelihood that oriental fruit moth is present in the source orchards in New Zealand: **Low**

- Oriental fruit moth has a restricted distribution in New Zealand (Baker, 1982). It was first discovered in Auckland in 1976 (Cox and Dale, 1977) and had reached Hawke's Bay by 1982 (Baker, 1982), but is still confined to the North Island (Murrell and Lo, 1998). OFM has been slow to spread in Hawke's Bay (Murrell and Lo, 1998).
- OFM has been found on 5 of 19 Hawke's Bay orchards monitored in 1997/98 (Murrell and Lo, 1998).
- The main plant hosts are species of the genera *Prunus* and *Pyrus*, damage to other crops such as apples and quinces is usually of minor importance in economic terms and occurs where these fruits are grown adjacent to peaches (Rothschild and Vickers, 1991).
- Oriental fruit moth is considered a major pest of stone fruit, such as peach and nectarine, and it is not a major pest of apple fruit (HortResearch, 1999b).

*Summary*

Based on above evidence that oriental fruit moth is confined to the North Island of New Zealand and causes minor damage to apples and quinces and is considered a major pest of stone fruit, such as peach and nectarine, the likelihood for Imp 1 was assessed as low.

**Importation step 2  
(Imp2)**

**Very low**

The likelihood that picked apple fruit is infested with OFM: **Very low**

- OFM lays its eggs on the under surface of leaves on apples and quince (Peterson and Haeussler, 1930). After hatching neonate larvae look for an appropriate entry site on host plants such as near the tip of a shoot, often through a petiole, or directly where two fruits touch each other or are in contact with a twig or leaf.
- Neonate larvae are usually unable to directly penetrate hard young fruits. Later instars are able to enter the fruit after feeding in the pedicel (Rothschild and Vickers, 1991).
- OFM caterpillars feed by boring into the centre of shoots and young stems of fruit trees, particularly stonefruit. This causes the shoot to change colour and die back; sap may exude from the damage holes. This damage is rare in apple trees, where the caterpillars feed more commonly on ripe fruit (HortResearch, 1999b).
- Infestations of hosts such as apple, pear and quince are primarily confined to the fruits (Rothschild and Vickers, 1991).
- OFM damage to apples is virtually confined to very ripe or over ripe fruit (HortResearch, 1999b).

- Up to 50% of the spring and early summer generations form their cocoons on trees however later generations locate cocooning sites on the ground (Russell, 1986).
- On trees, cocoons of earlier generations are constructed in depressions on the fruit surface, in leaf axils or under bark (Helson, 1939). The overwintering generations are found under bark near the base of the tree.

### Summary

Based on the information that OFM caterpillars primarily feed by boring into the centre of shoots and young stems of fruit trees and infestations of apple, pear and quince are primarily confined to very ripe or over ripe fruit, the likelihood for Imp2 was assessed as very low.

### Importation step 3 (Imp3)

Negligible

The likelihood that clean fruit is contaminated by OFM during harvesting and transport of apples to the packing house: **Negligible**

- Fruit are picked into harvesting bags and then transferred into bins kept on the ground in the orchard prior to transportation to the packing house.
- Where the fruit are attacked directly, an individual larva will usually complete its feeding period within the same fruit (Rothschild and Vickers, 1991). Thus the total number of infested/infected apples will not increase. Final instar larvae leave the shoots, stems or fruits to find an appropriate cocooning site.

### Importation step 4 (Imp4)

High

The likelihood that OFM survives routine processing procedures in the packing house: **High**

The following packing house operations may influence the viability of OFM.

### Washing

- Later instar larvae that have not yet exited the apple fruit when harvested will not be affected by high-volume/high pressure washing processes.

### Brushing

- The brushing process would not affect larvae inside fruit.

### Waxing

- The waxing process would not affect larvae inside fruit.

### Sorting and grading

- Sorting and grading would remove some fruit that show damage. However, given the volume of fruit passing through the grading areas some would avoid detection.
- OFM larvae occasionally enter fruit through the inside of the stem and therefore leave no wound area except for a small

mark at the stem-end of the picked fruit (Polk *et al.*, 2003).

- Gum and frass protrude from the wound area as the larvae bore into the fruit. As the gum ages a sooty mould may form on it turning the wound area black (Polk *et al.*, 2003).
- Infested fruit exhibiting gummy exudates or superficial feeding areas would be rejected during sorting and grading.

#### *Packaging*

- Packaging would have little effect on the survival of Oriental fruit moth. In most cases the packaging of apples is designed to maximise heat discharge from the fruit while minimising loss of moisture.

#### *Cold Storage*

- The diapausing overwintering generation remains as a prepupa for 130-300 days (Rothschild and Vickers, 1991) suggesting that temporary cold storage would not be effective to kill the larvae.

#### *Summary*

Based on the above evidence that the larvae of OFM inside the fruit would not be removed by routine packing house procedures, the likelihood for Imp4 was assessed as high.

**Importation step 5  
(Imp5)  
Negligible**

The likelihood that clean fruit is contaminated by OFM during processing in the packing house: **Negligible**.

- OFM larvae remaining inside the fruit will not move about to reinfest other apple fruit.

**Importation step 6  
(Imp6)  
High**

The likelihood OFM survives palletisation, quality inspection, containerisation and transportation to Australia: **High**

- OFM larvae surviving inside apple fruit would survive the palletisation, quality inspection, containerisation and refrigerated transport to Australia.
- OFM has been detected on New Zealand apples exported to the USA (USDA-APHIS, 2003) indicating that they can survive this process.

**Importation step 7  
(Imp7)  
Negligible**

The likelihood that clean fruit is contaminated by OFM during palletisation, quality inspection and transportation: **Negligible**

- Larvae still inside apple fruit would not move about to reinfest clean fruit.

**Importation step 8  
(Imp8)  
High**

The likelihood that OFM survives and remains with fruit after on-arrival minimum border procedures: **High**

The minimum on-arrival border procedures as described in the method section would not be effective in detecting larvae inside the fruit.



**Conclusions—probability of importation**

When the above likelihoods were inserted into the simulation model, the probability of importation of oriental fruit moth from one year of trade was found to be **very low**.

**Probability of distribution**

The initiating step for the distribution scenario is the release of imported apples from the port of entry, while the last step is the pest being distributed (as a result of the processing, sale or disposal of these apple fruit) in a viable state to an endangered area and subsequently being transferred to a suitable host.

In order to assess the probability of distribution, the distribution scenario is addressed in three subheadings below. First is a brief description of sequences of events leading to a successful exposure of the pest from infested/infected apple to a susceptible host plant. Second is the assessment of partial probability of distribution of the pest in relation to each of the exposure groups. Third is the conclusion for the probability of distribution.

**Sequence of events for successful exposure**

The sequence of events that has to be completed for a successful exposure of a susceptible host to the pest is summarised below.

The insect stage associated with apples is the larvae inside the fruit. When the fruit is taken out of storage, the larvae exits the fruit to find a suitable site to pupate. Mortality rate is increased during handling and consumption of fruit as well as during the larva's search for a suitable pupation site. The pupae (surrounded by a silk cocoon) take approximately 15 days to emerge depending on temperature.

Emergence can occur at unpacking and repacking facilities or retailers (utility points), on discarded fruit in waste, at landfills where the waste is disposed, or in compost bins, and during transportation of purchased apples from retailers to households.

Dispersal of adults is by flight. Most adults do not disperse over distances greater than 200 m although distances exceeding 1 km have been recorded. Sexual reproduction is essential in OFM and the female produces a pheromone to attract males. The adult life span ranges from 11-40 days. Egg deposition usually begins 2-5 days after the females emerge and continues for 7-10 days.

A successful exposure of OFM from infested fruit to its hosts means that mature larvae need to emerge from fruit to pupate, pupae need to successfully develop to become adults, and the adult females would need to locate a male to mate with and then find a susceptible fruiting host on which to lay their eggs.

**Partial probability of distribution**

The partial probability of distribution (PPD) was estimated separately for each of the four exposure groups: commercial fruit crops, nursery plants, household and garden plants, and wild and amenity plants.

The details and the method of calculation for the PPD of the four exposure groups are explained in the Methods section. Results are presented in a series of tables and figures

below. The information from these tables and figures was used to assess the probability of distribution of OFM to all the exposure groups.

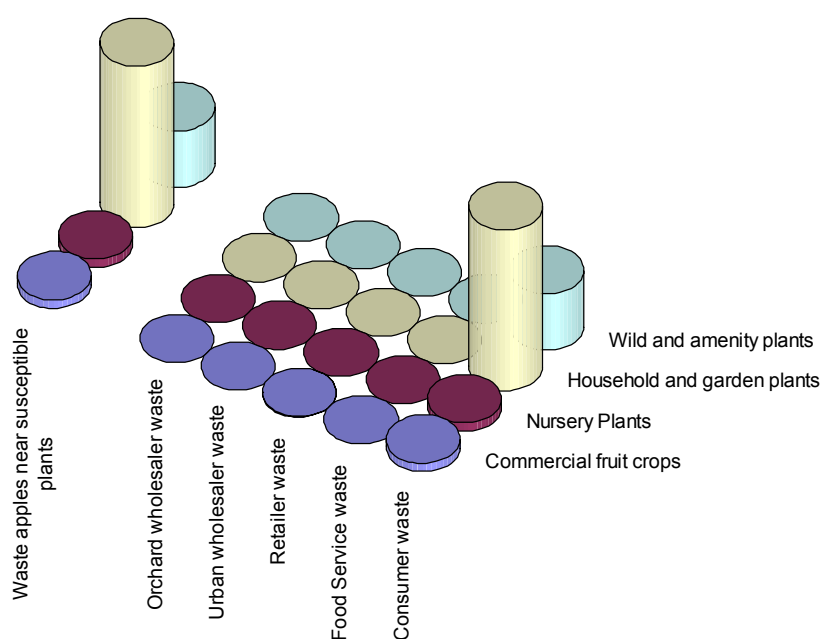
Table 98 indicates the proportions of the five utility points near each of the exposure groups of OFM. The main hosts of OFM include *Prunus* (e.g. plums, peaches, nectarines) and *Pyrus* (pears) species, grape vine, apple, cotoneaster, hawthorn and quince.

**Table 98 The proportions of utility points near host plants susceptible to oriental fruit moth in the four exposure groups**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Proximity</b> Orchard wholesalers	Certain	Very low	Very low	Very low
<b>Proximity</b> Urban wholesalers	Extremely low	Extremely low	Extremely low	Extremely low
<b>Proximity</b> Retailers	Very low	Very low	Very low	Extremely low
<b>Proximity</b> Food services	Extremely low	Extremely low	Extremely low	Extremely low
<b>Proximity</b> Consumers	Very low	Very low	Moderate	Low

Figure 38 gives a pictorial representation of the relative amounts of infested/infected apples, an escaped pest or contaminated packaging material discharged or discarded from different utility points near each of the exposure groups of Oriental fruit moth.

**Figure 38 Pictorial representation of the relative amounts of infested/infected apple waste<sup>78</sup> from utility points to near exposure groups of oriental fruit moth**



<sup>78</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or an escaped pest, or contaminated packaging material.

Table 99 is the summary of the probability that exposure of the host plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points. Evidence is provided in the text below under different exposure groups.

**Table 99 The probability of exposure of susceptible host plants of oriental fruit moth from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Exp</b> Orchard <sup>79</sup> wholesaler waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Urban wholesaler waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Retailer waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Food service waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Consumer waste	Negligible	Negligible	Negligible	Negligible

#### *Commercial fruit crops*

##### *Commercial fruit crops near utility points*

The proportions of the five utility points near commercial fruit crops of OFM are shown in Table 98. It was estimated that commercial fruit crops are certain to be located near all orchard wholesalers, very unlikely to be near retailers and consumers, and extremely unlikely to be near urban wholesalers and food service as most of these are in metropolitan areas.

The relative amounts of infested/infected apples, or an escaped pest, or contaminated packaging material discharged or discarded from different utility points to near commercial fruit crops susceptible to Oriental fruit moth are indicated in Figure 38.

##### *Exposure to host*

The commercial fruit crops of OFM include *Prunus* (e.g. plums, peaches, nectarines), pears, apples and grapevines.

A successful exposure of OFM from infested fruit to its hosts means that mature larvae need to emerge from fruit to pupate, the pupae need to successfully develop to become adults, and the adult females would need to locate a male to mate with and then find a susceptible fruiting

<sup>79</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or escaped pest, or contaminated packaging material.

host on which to lay their eggs. The chance for this to happen depends on several factors, including, the level of infestation/infection and number of apples in the same utility points, mortality rate of larvae, reproductive strategy and life span of the pest, and availability and susceptibility of host.

As shown in Table 99, it was considered that the probability that exposure of commercial fruit crops would result from discharge or the discarding of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** commercial fruit crops  
from orchard wholesaler waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**.

- Consumption of the apple fruit and the search by the larvae for a suitable pupation site would increase mortality.
- Although host trees are readily available in commercial orchards, emerged females would need to find a male, mate and lay eggs within the first 7-10 days of the female's life.
- Most adults do not disperse over distances greater than 200m.

**Exp** commercial fruit crops  
from urban wholesaler waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

- Commercial fruit crops are not located in urban areas.
- Urban wholesaler waste is disposed into bins and taken to landfills. Commercial fruit crops are unlikely to be located adjoining these sites.

**Exp** commercial fruit crops  
from retailer waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Most retailers are located in urban areas not close to commercial fruit crops.
- Retailer waste may be used for composting in rural areas and some of these sites may be near commercial orchards.

**Exp** commercial fruit crops  
from food service waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Most food service venues are not located close to commercial fruit crops.

**Exp** commercial fruit crops  
from consumer waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Majority of consumers are located in metropolitan and

suburban areas. Waste produced by people in metropolitan areas and some in urban areas is generally disposed into landfill. Commercial fruit crops would usually not be present adjoining these sites.

- Households and population densities around commercial orchards are very low.
- Some consumer waste in suburban and rural areas may be utilised for composting. Commercial fruit crops are unlikely to be present close to domestic or commercial compost heaps.

### *Nursery plants*

#### *Nursery plants near utility points*

The proportions of the five utility points near nursery plants hosts of OFM are shown in Table 98. It was estimated that nursery plants are very unlikely to be near orchard wholesalers, retailers and consumers, and extremely unlikely to be near urban wholesalers and food service.

The relative amounts of waste apples discharged or discarded near nursery plants susceptible to Oriental fruit moth are indicated in Figure 38.

#### *Exposure to host*

The nursery plants of OFM include prunus (e.g. plums, peaches, nectarines), pears, apples and grapevines.

A successful exposure of OFM from infested fruit to its hosts means that mature larvae need to emerge from fruit to pupate, the pupae need to successfully develop to become adults, and the adult females would need to locate a male to mate with and then find a susceptible fruiting host on which to lay their eggs. The chance for this to happen depends on several factors, including, the level of infestation/infection and number of apples in the same utility points, mortality rate of larvae, reproductive strategy and life span of the pest, and availability and susceptibility of host.

As shown in Table 99, it was considered that the probability that exposure of nursery plants would result from discharge or the discarding of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** nursery plants from  
orchard wholesaler waste  
**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Most of the listed host plants of OFM are available in nurseries in the temperate regions of Australia, particularly during the dormant period over winter and to a limited extent during the spring and summer months.
- Retail garden nurseries have a high density of a range of plant materials in a small area and often maintain a high hygienic standard usually fogging with insecticide to prevent possible insect attacks.

<b>Exp</b> nursery plants from urban wholesaler waste <b>Negligible</b>	<p>The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>There are rare instances of nurseries being located near to urban waste dumps.</li> </ul>
<b>Exp</b> nursery plants from retailer waste <b>Negligible</b>	<p>The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Many of the listed plants are for sale in major retail outlets.</li> <li>The listed host plants are common in nurseries in the temperate regions of Australia, particularly during the dormant period over winter and to a limited extent during the spring and summer months.</li> <li>Retail garden nurseries have a high density of a range of plant materials in a small area. They often maintain a high hygienic standard, usually fogging with insecticide, to prevent insect attacks.</li> <li>A number of fresh food markets will have nursery plants near apple fruit. However there are a limited number of nurseries associated with fresh food markets that also maintain or store actively growing apple trees.</li> </ul>
<b>Exp</b> nursery plants from food service waste <b>Negligible</b>	<p>The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Most food service venues are not located close to nurseries.</li> </ul>
<b>Exp</b> nursery plants from consumer waste <b>Negligible</b>	<p>The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. Nurseries are generally not located near these sites.</li> </ul>

### *Household and garden plants*

#### *Household and garden plants near utility points*

The proportions of the five utility points near household and garden plants of OFM are shown in Table 98. It was estimated that household and garden plants are moderately likely to be near consumers, very unlikely to be near retailers and orchard wholesalers, and extremely unlikely to be near urban wholesalers, and food services.

The relative amounts of waste apples discharged or discarded near household and garden plants susceptible to Oriental fruit moth are indicated in Figure 38.

### *Exposure to host*

The household and garden plants of OFM include prunus (e.g. plums, peaches, nectarines), pears, apples and grapevines.

A successful exposure of OFM from infested fruit to its hosts means that mature larvae need to emerge from fruit to pupate, the pupae need to successfully develop to become adults, and the adult females would need to locate a male to mate with and then find a susceptible fruiting host on which to lay their eggs. The chance for this to happen depends on several factors, including, the level of infestation/infection and number of apples in the same utility points, mortality rate of larvae, reproductive strategy and life span of the pest, and availability and susceptibility of host.

As shown in Table 99, it was considered that the probability that exposure of household and garden plants would result from discharge or the discarding of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

<p><b>Exp</b> household and garden plants from orchard wholesaler waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: <b>Negligible</b>.</p> <ul style="list-style-type: none"> <li>Orchard wholesale waste sites are mostly located within the orchard premises and are not located near household and garden plants.</li> </ul>
<p><b>Exp</b> household and garden plants from urban wholesaler waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: <b>Negligible</b>.</p> <ul style="list-style-type: none"> <li>Urban wholesaler waste is disposed into landfill sites that are generally not near residential properties.</li> </ul>
<p><b>Exp</b> household and garden plants from retailer waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Retailer waste would be disposed of to landfill sites that are generally not near residential properties.</li> </ul>
<p><b>Exp</b> household and garden plants from food service waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Food service waste would be disposed of in landfill sites that are generally not near household and garden plants.</li> </ul>
<p><b>Exp</b> household and garden plants from consumer waste</p> <p><b>Negligible</b></p>	<p>The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Most consumers are in metropolitan and suburban areas and</li> </ul>



their waste is disposed into landfills. However, local authorities are now encouraging composting of food waste in suburban backyards rather than disposing of all waste into landfill.

- However, utilisation of waste to make compost is becoming a common practice in some suburban and rural households.
- Most consumers in metropolitan and suburban areas dispose of their waste to landfill sites that are generally not near household and garden plants.
- Many host plants are commonly grown as a garden plants in the temperate regions of Australia.
- Household host trees would be exposed to OFM from household apples such as an infested/infected apple core that is composted in a garden.

### *Wild and amenity plants*

#### *Wild and amenity plants near utility points*

The proportions of the five utility points near wild and amenity plants of OFM are shown in Table 98. It was estimated that wild and amenity plants are unlikely to be near consumers, very unlikely to be near orchard wholesalers, and extremely unlikely to be near urban wholesalers, retailers and food services.

The relative amounts of waste apples discharged or discarded near wild and amenity plants susceptible to Oriental fruit moth are indicated in Figure 38.

#### *Exposure to host*

The probability that exposure of wild and amenity plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points are summarised in Table 99 and evidence is provided in the text below.

The wild and amenity plants of OFM include prunus and apples.

A successful exposure of OFM from infested fruit to its hosts means that mature larvae need to emerge from fruit to pupate, the pupae need to successfully develop to become adults, and the adult females would need to locate a male to mate with and then find a susceptible fruiting host on which to lay their eggs. The chance for this to happen depends on several factors, including, the level of infestation/infection and number of apples in the same utility points, mortality rate of larvae, reproductive strategy and life span of the pest, and availability and susceptibility of host.

As shown in Table 99, it was considered that the probability that exposure of wild and amenity plants would result from discharge or the discarding of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** wild and amenity plants  
from orchard wholesaler waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Orchard wholesale waste sites are mostly located within the orchard premises and are not normally located near wild and amenity plants.
- Susceptible feral plants e.g. volunteer host plant seedlings, crab apple etc. may be present near orchard wholesalers waste disposal sites.

**Exp** wild and amenity plants  
from urban wholesaler waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

- Urban wholesale waste is disposed at landfills. Susceptible hosts may grow in the wild near these sites as a result of host plant volunteers, dispersal of seeds by animals e.g. crab apple trees, apple seedlings.

**Exp** wild and amenity plants  
from retailer waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers:

**Negligible**

- Retailer waste would be disposed to landfills. Susceptible hosts may grow in the wild near these sites as a result of host plant volunteers, dispersal of seeds by animals e.g. crab apple trees, apple seedlings.

**Exp** wild and amenity plants  
from food service waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Food service waste is disposed into bins and taken to landfills. Seedlings originating from seeds dispersed by birds could be present.

**Exp** wild and amenity plants  
from consumer waste  
**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. Susceptible hosts may grow in the wild near these sites as a result of host plant volunteers, dispersal of seeds by animals e.g. crab apple trees, apple seedlings.
- Consumers discard apple cores in the environment or in bins in parks. Bins for waste in parks that may not be removed on a daily basis, would provide a sheltered environment for the insect to emerge before the fruit desiccates or decays.
- Apple seedlings can establish from discarded apple cores. However, population densities of susceptible wild and amenity apple plants in parks, near recreational facilities and along

roadsides may be low.

- Consumers who consider apple cores to be biodegradable indiscriminately discard them in the environment. Spoilt apples or cores discarded into the wild are likely to be isolated.

### **Conclusion—probability of distribution**

The partial probability of distribution from each of the utility points to each of the exposure groups is summarised in Table 100. These were calculated by the simulation model using @risk. The quantitative model evaluated the effect of the ‘volume of trade’ during a specified period when calculating the partial probability of distribution.

**Table 100 Partial probabilities of distribution (PPD)<sup>80</sup> for oriental fruit moth**

UTILITY POINTS	PPD			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Orchard wholesalers</b>	Negligible	Negligible	Negligible	Negligible
<b>Urban wholesalers</b>	Negligible	Negligible	Negligible	Negligible
<b>Retailers</b>	Extremely low	Extremely low	Extremely low	Negligible
<b>Food services</b>	Negligible	Negligible	Negligible	Negligible
<b>Consumers</b>	Extremely low	Extremely low	Very low	Very low
<b>Overall PPD</b>	<b>Extremely low</b>	<b>Extremely low</b>	<b>Very low</b>	<b>Very low</b>

### **Probability of establishment or spread**

The assessment for the probability of establishment or spread is carried out in the following manner. Firstly, partial probability for establishment and for spread was assessed separately based on the relevant available scientific information. Secondly, the conclusions for the combined partial probability of establishment or spread for each of the four exposure groups are provided at the end of this section. The relevant information for the assessment for the probability of establishment or spread is presented below against the factors listed in ISPM 11, Rev. 1.

<sup>80</sup> Partial probability of distribution is actually referring to the probability of entry and was estimated by @risk

***Partial probability of establishment***

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ISPM 11 factor	Relevant Information
<b>Availability of suitable hosts, alternate hosts and vectors in the PRA area</b>	<p>There is opportunity for OFM to find a suitable host for it to survive and propagate in Western Australia for the following reasons.</p> <ul style="list-style-type: none"> <li>• The principal economic hosts are fruit trees of the genera, <i>Prunus</i>, <i>Malus</i>, <i>Pyrus</i> and <i>Cydonia</i>.</li> <li>• Other ornamental hosts include <i>Cotoneaster</i>, <i>Crataegus</i>, <i>Photinia</i> and <i>Rosa</i> (Russell, 1986).</li> <li>• Late ripening peach cultivars are particularly vulnerable to this pest.</li> <li>• A range of these hosts is widespread in Western Australia.</li> </ul>
<b>Suitability of the environment</b>	<ul style="list-style-type: none"> <li>• OFM is already reported from New South Wales, Queensland, South Australia, Tasmania and Victoria.</li> <li>• The previously eradicated incursion of OFM indicates that Western Australia has an environment suitable for establishment.</li> </ul>

### The reproductive strategy of the pest

The oriental fruit moth has an effective reproductive strategy that would assist its survival in Western Australia at a rate compatible to that observed in New Zealand and eastern Australia for the following reasons.

- Oriental fruit moth only reproduces sexually.
- Mating activity occurs in the upper canopy of peach trees (Rothschild and Vickers, 1991).
- Adults become sexually active 24-28 hours after emergence, and mating can occur on the same day as emergence (Smith and Summers, 1948; Dustan, 1964).
- Sexual activities are mediated by female pheromones and the calling period extends from about 3 hours before to 1 hour after sunset.
- Males are sexually responsive over a longer period than females (Rothschild and Vickers, 1991).
- Males usually only mate once in a 24 hour period, but may mate with different females on successive nights (Rothschild and Vickers, 1991).
- Females usually only mate once but multiple matings increase later in the season (Rothschild *et al.*, 1984).
- A single mating is sufficient for a female to lay her full complement of viable eggs (Smith and Summers, 1948).
- Egg deposition usually begins 2-5 days after the females emerge and continues for 7-10 days or longer (USDA, 1958).
- Eggs are laid singly and each female lays 50-200 eggs on the underside of leaves near growing tips in peach orchards or on the upper surface of leaves in quince and apple orchards (USDA, 1958).
- Life cycle development is temperature dependent and ranges from 11-40 days (Rothschild *et al.*, 1984).
- OFM is not reliant on fruit to establish, as larvae emerging in spring will attack new vegetative shoots.
- OFM passes the winter as a full-grown larva in a cocoon.
- The mated female lays its eggs singly on twigs or on the undersides of leaves near growing terminals (CABI, 2002). A population can be started from these eggs.

### Minimum population needed for establishment

### Cultural practices and control measures

Practices employed during the cultivation/production of the host crops between New Zealand and Australia that would influence OFM's ability to establish in Australia include.

- Integrated Pest Management (IPM) programmes are utilised in the production of apples in Australia and New Zealand.
- On commercial New Zealand orchards OFM is controlled by sprays applied against leafrollers, principally light brown apple moth (Murrell and Lo, 1998).

*Conclusion—partial probability of establishment*

Based on the above evidence, partial probability of establishment for each of the exposure groups is assessed as follows.

Partial probability of establishment for commercial fruit crops: **High**

Partial probability of establishment for nursery plants: **High**

Partial probability of establishment for household and garden plants: **High**

Partial probability of establishment for wild and amenity plants: **High**

***Partial probability of spread***

ISPM 11 factor	Relevant Information
<b>Suitability of natural and/or managed environment</b>	<p>There is limited information on the ability of OFM to spread in natural or managed environments. Considering that the species has spread throughout the eastern Australian states and all over New Zealand since its accidental introduction, it may also spread in similar environments in Western Australia.</p> <p>OFM has a range of characteristics that assists in its short range dispersal</p> <ul style="list-style-type: none"> <li>• The oriental fruit moth does not require a vector for its dispersal.</li> <li>• The adult male and female are winged and are capable of independent flight.</li> <li>• Male dispersal is strongly affected by the location of females.</li> </ul>
<b>Presence of natural barriers</b>	<ul style="list-style-type: none"> <li>• The Western Australian commercial apple orchards are located in the far south west of the State separated from the eastern States by a large tract of arid land and long distance therefore it would be difficult for OFM to disperse to Western Australia unaided.</li> </ul>
<b>Potential for movement with commodities or conveyances</b>	<ul style="list-style-type: none"> <li>• OFM can disperse both independently and in association with host material.</li> <li>• Spread independent of host material, is by adult flight and in association with farm equipment and packaging.</li> <li>• OFM can also disperse with host material and as such, long distance dispersal is facilitated by the commercial distribution of the host fruit and nursery stock.</li> <li>• If larvae or pupae have contaminated the fruit, they will be transferred with the commodity around the country.</li> <li>• Existing interstate quarantine control on the movement of nursery stock would reduce the scope for spread.</li> </ul>
<b>Intended use of the commodity</b>	<ul style="list-style-type: none"> <li>• Apples would be used mostly for consumption by humans and would be widely distributed around the States.</li> <li>• If larvae or pupae have contaminated the fruit, they will be distributed with the commodity around the country.</li> </ul>

ISPM 11 factor	Relevant Information
<b>Potential vectors of the pest</b>	<ul style="list-style-type: none"> <li>OFM does not require a vector for its spread since it is capable of independent flight.</li> </ul>
<b>Potential natural enemies</b>	<ul style="list-style-type: none"> <li>Other natural enemies in the PRA area, especially generalist predators, may be able to attack but there is no evidence that they would be effective.</li> </ul>

*Conclusion—partial probability of spread*

Based on the above evidence, partial probability of spread for each of the exposure groups is assessed as follows.

Partial probability of spread for commercial fruit crops: **High**.

Partial probability of spread for nursery plants: **High**.

Partial probability of spread for household and garden plants: **High**.

Partial probability of spread for wild and amenity plants: **High**.

***Combined partial probability of establishment or spread***

The combined partial probability of establishment or spread was determined by combining probabilities of establishment and probabilities of spread using the matrix of ‘rules’ for combining descriptive likelihoods as presented in the method section. The results are indicated in Table 101.

**Table 101 Partial probabilities of establishment or spread of Oriental fruit moth**

	Commercial fruit crops	Susceptible Nursery plants	Susceptible household and garden plants	Susceptible wild and amenity plants
<b>Establishment</b>	High	High	High	High
<b>Spread</b>	High	High	High	High
<b>PPES<sup>81</sup></b>	High	High	High	High

<sup>81</sup> PPES = partial probability of establishment or spread.

<b>Commercial fruit crops</b> <b>High</b>	There was an outbreak of OFM in Western Australia in 1952 (Department of Agriculture, Western Australia., 1952).
<b>Nursery plants</b> <b>High</b>	In nursery plants, it is not likely for the host plants to have fruit, however, OFM is able to feed on shoots and leaves as well as fruit.
<b>Household and garden plants</b> <b>High</b>	Susceptible household and garden plants are widely available in Western Australia.
<b>Wild and amenity plants</b> <b>High</b>	OFM is capable of flying distances up to 200 m although some individuals may cover distances exceeding 1 km. A number of widespread native hosts such as cotoneaster, hawthorns and photinias are available for OFM to establish on and spread.

### Assessment of consequences

Oriental fruit moth is only a regional concern. Thus the following assessment of consequences applies only to the regional level (Western Australia) not national level.

Impact scores allocated for the direct and indirect criteria are shown in Table 102. Available supporting evidence is provided in the text below.

**Table 102 Impact scores for Oriental fruit moth**

<b>Direct impact</b>	<b>Impact scores</b>
Plant life or health	D
Human life or Health	A
Any other aspects of environment	A
<b>Indirect impact</b>	
Control or eradication	D
Domestic trade or industry	C
International trade	D
Environment	B
Communities	A



**Direct impact**

**Plant life or health – D**

Consequences affecting plant life or health are of minor significance at the regional level. Thus a rating of ‘D’ was assigned for this criterion.

- OFM is a pest of economic importance to commercial orchards of peaches, nectarines and apricots and also attacks and causes economic damage to other commercial fruits.
- OFM causes young trees to suffer distortion of growing shoots and stems in severe attacks.
- OFM also causes a reduction in the quality of attacked fruit and subsequent reduction in market value (Hogmire and Beavers, 1998).

**Human life or health – A**

There are no known direct impacts of oriental fruit moths on human life or health and the rating assigned to this criterion was therefore ‘A’.

**Environmental effects – A**

- There are no known impact of oriental fruit moth on any other aspects of the environment and the rating assigned to this criterion was therefore ‘A’.

**Indirect impact**

**Control or eradication – D**

The indirect consequences on new or modified eradication, control, surveillance / monitoring and compensation strategies are of minor significance at the regional level. A rating of ‘D’ was assigned to this criterion.

- Increase in the use of insecticides for control of oriental fruit moth due to difficulties in estimating the optimum time for insecticide application.
- Subsequent increase in cost of production to producers in Western Australia and thus orchard profitability.
- Increased costs for crop monitoring and consultant’s advice to the Western Australian producer.

**Domestic trade – C**

The indirect consequences on domestic trade would be unlikely to be discernable at the regional level and of minor significance at the district level. A rating of ‘C’ was assigned to this criterion. The presence of OFM on commercial Western Australian fruit crops would result in quarantine measures to prevent movement of commodities from infected districts to others.

**International trade – D**

The indirect consequences on international trade are unlikely to be discernable at the national level and of minor significance at regional level. A rating of ‘D’ was assigned to this criterion.

- The presence of OFM in commercial production areas of Western Australia would have some effect at the district level due to any limitations or measures required to access overseas

markets where this pest is absent.

**Environment –****B**

The indirect consequences on environment are discernible at the regional level and of minor significance at the local level and a rating of ‘**B**’ was assigned to this criterion.

- Additional pesticide applications or other control activities will be required to control OFM on susceptible fruit crops adding to the chemical load already present in the environment.
- The hosts of oriental fruit moth are several species of commercial fruit crops of the family Rosaceae which means the moth may not cause significant reduction, displacement or elimination of keystone plant species, plant species that are major components of Western Australian ecosystems or endangered native plant species.
- The introduction of OFM into a new environment (Western Australia) may lead to competition for resources with native species.

**Communities –****A**

The presence of the oriental fruit moth would have limited social effects, if any, and a rating of ‘**A**’ was assigned to this criterion.

**Conclusion—consequences**

Based on the decision rule described in the method section, i.e. where the consequences of a pest with respect to one or more criteria are ‘**D**’, the overall consequences are considered to be ‘low’. Therefore the overall consequences of OFM are **low**.

**Unrestricted annual risk**

Unrestricted annual risk is the results of combining annual probability of entry, establishment or spread with the outcome of overall consequences. Probabilities and consequences are combined using the ‘rules’ shown in the risk estimation matrix in the method section. The unrestricted annual risk estimation for codling moth is shown in Table 103.

**Table 103 Risk estimation for oriental fruit moth**

Overall probability of entry, establishment or spread <sup>82</sup>	<b>Very low</b>
Consequences	<b>Low</b>
Unrestricted annual risk	<b>Negligible</b>

As indicated in Table 103, the unrestricted annual risk for oriental fruit moth is negligible, which is below the appropriate level of protection (ALOP) of very low. Therefore, risk management would not be required for this pest.

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<sup>82</sup> Calculated by @ risk.

## **Oystershell Scale**

### **Biology**

Oystershell scale (OSS), *Diaspidiotus ostreaeformis* (Curtis), is a diaspidid hard scale. The female life stages include adult, egg and nymph while the male has adult, egg, nymph, pre-pupa and pupa stages. There is no pupal stage in the female life cycle (McLaren and Walker, 1998). OSS originates from Europe and now occurs in USA, Canada, New Zealand and Australia (Victoria, Tasmania and South Australia) (Brookes and Hudson, 1969).

The nymphs and adult female settle and feed on branches and fruit of the host plant. The mature male, is typical of diaspid scales, being seldom seen and approximately 1mm in length (Giliomee, 1990). The mature adult female is grey coloured, conically shaped and approximately 1.3 mm in diameter; the male has wings and lives from 1-3 days. The male is attracted to the female by pheromones and dies after mating. Oystershell scale reproduces sexually with one annual generation and overwintering occurs as diapausing second instar nymphs.

Like other scale insects, oystershell scale debilitates plant hosts by sucking sap during feeding. Although heavy infestations of oystershell scale are on the bark and stems of apple trees (HortResearch, 1999b), they can also be found on fruit near the calyx or stem-end.

### **Risk scenario**

The risk scenario of concern for OSS in this IRA is nymphs and adults feeding and/or contaminating the apple fruit.

## Probability of importation

The initiating step for the importation scenario for apple fruit is the sourcing of apples from orchards in New Zealand, while the end-point is the release of imported apples from the port of entry. The importation scenario is divided into eight steps and the likelihood of the OSS being present at each step is summarised in Figure 39. The available evidence supporting the likelihood assessments is provided in the text below.

**Figure 39 The importation steps and the likelihood of the oystershell scale being present at each step**



### Importation step 1 (Imp1)

**Very Low**

The likelihood that OSS is present in source orchards in New Zealand: **Very low**

- Oystershell scale *Diaspidiotus ostreaeformis* (Curtis) is the major scale pest of pipfruit in the southern regions of New Zealand (HortResearch, 1999b).
- Oystershell scale is a pest only in Canterbury and Otago pipfruit orchards (HortResearch, 1999b).
- Most New Zealand export apple orchards are located in areas north of Canterbury.
- Oystershell scale is either absent or very rare on apples and pears north of Canterbury (HortResearch, 1999b).
- Fruit cultivars with rough bark are often the first infested as the bark crevices provide refuge for the scale insect from predators and pesticides (Ker and Walker, 1990).

#### Summary

Based on the above information that oystershell scale is only a pest in Canterbury and Otago orchards, the likelihood for Imp1 was assessed as very low.

### Importation step 2 (Imp2)

**Very low**

The likelihood that picked apple fruit is infested with OSS: **Very low**

- Oystershell scale infests mostly the bark on stems and branches of the trees; sometimes it can be found on the fruits, where it causes red spot (CABI, 2002).
- On apple, the infection is usually concentrated around the calyx or stem-end, but may occur anywhere on the fruit surface (HortResearch, 1998).

### Importation step 3 (Imp 3)

**Extremely low**

The likelihood that clean fruit is contaminated by OSS during harvesting and transport of apples to the packing house: **Extremely low**

- Fruit are picked into harvesting bags and then transferred into bins kept on the ground in the orchard prior to transportation to the packing house.
- Oystershell scale produces one generation a year and during harvesting time, all stages of the oystershell scale are present.
- Crawlers are the only mobile stage that could contaminate clean fruit by moving from infested fruit. However, the majority of the infestation is on the bark of stems or branches and these are not likely to be harvested and placed in the harvesting bag.
- Crawlers move about for 48-72 hours then affix in position (Ker and Walker, 1990).
- For other live stages once they settle they are unable to move,

therefore even if they are dislodged from the fruit, they will be unable to get back onto the fruit.

#### *Summary*

Based on the above information that only crawlers are mobile and they mainly infest bark of stems of branches, the likelihood for Imp3 was assessed as extremely low.

#### **Importation step 4 (Imp4) Moderate**

The likelihood that OSS survives routine processing procedures in the packing house: **Moderate**

#### *Washing*

- The washing process including high volume/high pressure washing would be able to reduce the number of oystershell scale on the fruit, as they are only found on the apple surface near the calyx or stem-end and not inside the calyx.

#### *Brushing*

- Some remaining scales would be brushed off.

#### *Waxing*

- Oystershell scale would be able to survive low temperature waxing because they attach to the fruit under a protective grey waxy covering.

#### *Sorting and grading*

- Sorting and grading would remove fruit that is contaminated with scale. However, given the volume of fruit passing through the grading areas, it is expected that some infested fruit would be able to avoid detection and removal.

#### *Packaging*

- Packaging would have little effect on the survival of oystershell scale. In most cases the packaging of apples is designed to maximise heat discharge from the fruit while minimising loss of moisture.

#### *Cold Storage*

- Oystershell scale overwinters as second instar nymphs. This suggests that temporary cold storage would not be effective in killing second instar nymphs.

#### *Summary*

Based on the above information that washing and brushing would reduce the number of OSS, the likelihood for Imp4 was assessed as Moderate.

#### **Importation step 5 (Imp5) Negligible**

The likelihood that clean fruit is contaminated by OSS during processing in the packing house: **Negligible**

- Crawlers are the only mobile stage that could contaminate

	clean fruit by moving from infested fruit. However, they will be washed off and killed at the first stage of the packing house procedure.
<b>Importation step 6 (Imp6)</b> <b>High</b>	<p>The likelihood that OSS survives palletisation, quality inspection, containerisation and transportation to Australia: <b>High</b></p> <ul style="list-style-type: none"> <li>Oystershell scale overwinters as second instar nymphs suggesting that temporary cold storage would not be effective killing the scale.</li> </ul>
<b>Importation step 7 (Imp7)</b> <b>Negligible</b>	<p>The likelihood that clean fruit is contaminated by OSS during palletisation, quality inspection and transportation: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Crawlers are the only stage that is mobile and has the ability to contaminate clean fruit. However, they are very fragile and will not be active or can be killed during cool storage during transportation.</li> <li>In addition, by this stage, most crawlers if not all, would not be associated with the fruit, and any remaining individuals may have already settled.</li> </ul>
<b>Importation step 8 (Imp8)</b> <b>High</b>	<p>The likelihood that OSS survives and remains with fruit after on-arrival minimum border procedures: <b>High</b></p> <ul style="list-style-type: none"> <li>The minimum border procedures as described in the method section would not be effective in detecting oystershell scale.</li> </ul>

### ***Conclusions—probability of importation***

When the above likelihoods were inserted into the simulation model, the probability of importation of oystershell scale from one year of trade was found to be **extremely low**.

### **Probability of distribution**

The initiating step for the distribution scenario is the release of imported apples from the port of entry, while the last step is the pest being distributed (as a result of the processing, sale or disposal of these apple fruit) in a viable state to an endangered area and subsequently being transferred to a suitable host.

In order to assess the probability of distribution, the distribution scenario is addressed in three subheadings below. First is a brief description of sequences of events leading to a successful exposure of the pest from infested/infected apple to a susceptible host plant. Second is the assessment of partial probability of distribution of the pest in relation to each of the exposure groups. Third is the conclusion for the probability of distribution.

#### ***Sequence of events for successful exposure***

The sequence of events that has to be completed for a successful exposure of a susceptible host to the pest is summarised below.

The insect stage associated with the apple is the nymphs or adults. OSS females and nymphs live under scales and cannot disperse by themselves. Male oystershell scales are winged but

they are fragile and only live from 1-3 days. If nymphs or adults survive cold storage or controlled atmosphere storage, they need to mature, mate, and lay eggs on fruit, which would develop and hatch. Egg laying and hatching could occur at unpacking and repacking facilities or retailers (utility points), on discarded fruit in waste, at landfills where the waste is disposed, and during transportation of purchased apples from retailers to households. The only means for OSS to leave fruit or packaging and enter the environment of exposure groups is through crawling or wind assisted dispersal of first instar nymphs or flight of adult males.

A successful exposure of OSS from infested/infected fruit or waste to the host means that the hatched first instar nymphs would need to move onto a susceptible host plant by crawling or with assistance from wind.

### ***Partial probability of distribution***

The partial probability of distribution (PPD) was estimated separately for each of the four exposure groups: commercial fruit crops; nursery plants; household and garden plants; and, wild and amenity plants.

The details and the method of calculation for the PPD of the four exposure groups are explained in the method section and the results are presented in a series of tables and figures below. The information from these tables and figures was used to assess the probability of distribution of OSS to all the exposure groups.

Table 104 indicates the proportions of the five utility points near each of the exposure groups of oystershell scale. OSS has a wide range of host plants, mainly deciduous trees. Host plants have been reported from 41 genera in 18 families including apples, pears, and stone fruits, particularly plum (European and Japanese) but also cherry, peach, prune, almond and nectarine, quince, currants, blueberry, and walnuts. Willows, birches, elms, alders, poplars, maples, lindens, hornbeam, rowans, and other common ornamental trees serve as reservoir hosts for this pest outside orchards.

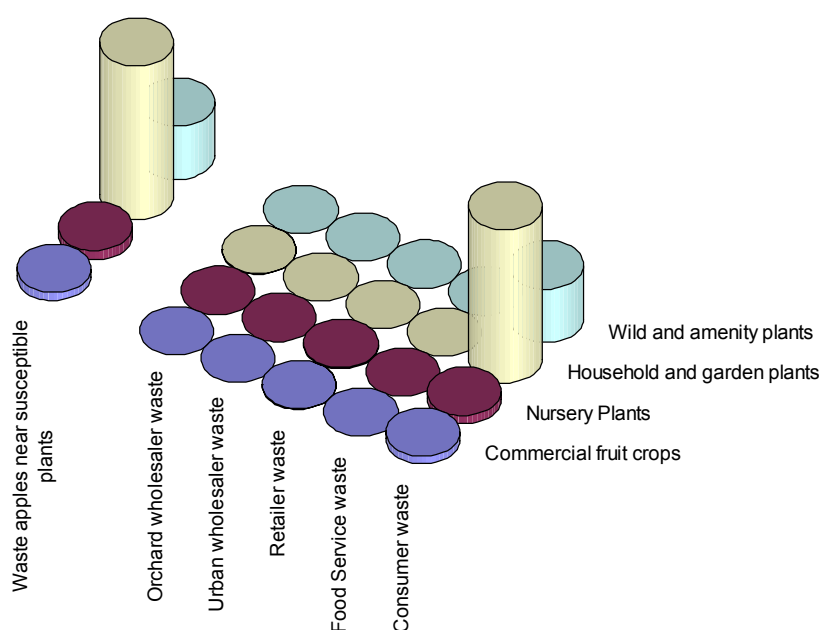
**Table 104 The proportions of utility points near host plants susceptible to oystershell scale in the four exposure groups**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Proximity</b> Orchard wholesalers	Certain	Very Low	Very Low	Very Low
<b>Proximity</b> Urban wholesalers	Extremely Low	Extremely Low	Extremely Low	Extremely Low
<b>Proximity</b> Retailers	Very Low	Low	Very Low	Extremely Low
<b>Proximity</b> Food services	Extremely Low	Extremely Low	Extremely Low	Extremely Low
<b>Proximity</b> Consumers	Very Low	Very Low	Moderate	Low



Figure 40 gives a pictorial representation of the relative amounts of infested/infected apples, an escaped pest or contaminated packaging material discharged or discarded from different utility points near each of the exposure groups of oystershell scale.

**Figure 40 Pictorial representation of the relative amounts of infested/infected apple waste<sup>83</sup> from utility points to near exposure groups of oystershell scale**



<sup>83</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or an escaped pest, or contaminated packaging material.

Table 105 is the summary of the probability that exposure of the host plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points. Evidence is provided in the text below under different exposure groups.

**Table 105 The probability of exposure of susceptible host plants of oystershell scale from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Exp</b> Orchard wholesaler waste <sup>84</sup>	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Urban wholesaler waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Retailer waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Food service waste	Negligible	Negligible	Negligible	Negligible
<b>Exp</b> Consumer waste	Negligible	Negligible	Negligible	Negligible

#### *Commercial fruit crops*

##### *Commercial fruit crops near utility points*

The proportions of the five utility points near susceptible commercial fruit crops of OSS are shown in Table 104. It was estimated that commercial fruit crops are certain to be located near all orchard wholesalers, very unlikely to be near retailers and consumers, and extremely unlikely to be near urban wholesalers and food service as most of these are in metropolitan areas.

The relative amounts of infested/infected apples, or an escaped pest, or contaminated packaging material discharged or discarded from different utility points to near commercial fruit crops susceptible to oystershell scale are indicated in Figure 40.

##### *Exposure to host*

The commercial fruit crops of OSS include apples, pears, stone fruits, particularly plum (European and Japanese), cherry, peach, almond, nectarine, quince, currants, blueberry, and walnuts.

<sup>84</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or escaped pest, or contaminated packaging material.

A successful exposure of OSS to susceptible host means that females need to lay eggs on fruit, eggs hatch, and first instar nymphs would need to move onto a susceptible host plant by crawling, or blown by wind currents or off the clothes of workers in the utility points. The chance for this to happen depends on several factors, including mortality caused by the handling and consumption of the fruit, the level of infestation/infection and the number of apples in the same utility points, the reproductive strategy and life span of the pest as well as availability of susceptible hosts.

As shown in Table 105, it is considered that the probability that exposure of commercial fruit crops would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** commercial fruit crops  
from orchard wholesaler waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Apple, pear, plum (European and Japanese), cherry, peach, almond, nectarine, quince, currants, blueberry, and walnuts are readily available in commercial orchards.

**Exp** commercial fruit crops  
from urban wholesaler waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

- Commercial fruit crops are not located in urban areas.
- Urban wholesaler waste is disposed into bins and taken to landfills. Commercial fruit crops are unlikely to be located adjoining these sites.

**Exp** commercial fruit crops  
from retailer waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Most retailers are located in urban areas not closed to commercial fruit crops.
- Retailer waste may be used for composting in rural areas and some of these sites may be near commercial orchards.

**Exp** commercial fruit crops  
from food service waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Most food service outlets are located in metropolitan and suburban areas not close to commercial fruit crops. Waste produced by food service outlets in metropolitan and suburban areas is generally disposed into landfills remote from commercial fruit crops

**Exp** commercial fruit crops  
from consumer waste  
**Negligible**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**.

- Majority of consumers are located in metropolitan and suburban areas. Waste produced by people in metropolitan areas and some in urban areas is generally disposed into landfills. Commercial fruit crops would usually not be present adjoining these sites.
- Households and population densities around commercial orchards are very low.
- Some consumer waste in suburban and rural areas may be utilised for composting. Commercial fruit crops can be present close to compost heaps.

### *Nursery plants*

#### *Nursery plants near utility points*

The proportions of the five utility points near susceptible nursery plants of OSS are shown in Table 104. It was estimated that nursery plants are unlikely to be near retailers, very unlikely to be near orchard wholesalers and consumers, and extremely unlikely to be near urban wholesalers and food services.

The relative amounts of waste apples discharged or discarded near nursery plants susceptible to oystershell scale are indicated in Figure 40.

#### *Exposure to host*

The nursery plants of OSS include many ornamental deciduous and evergreen trees and shrubs listed in the datasheet.

A successful exposure of OSS to susceptible host means that that females need to lay eggs on fruit, eggs hatch, and the first instar nymphs would need to move onto a susceptible host plant by crawling, or blown by wind currents or off the clothes of workers in the utility points. The chance for this to happen depends on several factors, including mortality caused by the handling and consumption of the fruit, the level of infestation/infection and the number of apples in the same utility points, the reproductive strategy and life span of the pest as well as availability of susceptible hosts.

As shown in Table 105, it is considered that the probability that exposure of nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** nursery plants from  
orchard wholesaler waste  
**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Nurseries would not be located near wholesaler waste disposal sites.

**Exp** nursery plants from urban  
wholesaler waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

- There are rare instances of nurseries being located near to urban waste dumps.

**Exp** nursery plants from retailer  
waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- A number of fresh food markets will have nursery plants close to them.
- Most of the waste from retail outlets and urban retailers is collected on a regular basis.
- Some retailers also have nursery plants for sale in the same store as the apple fruit.
- Apple nursery plants are for sale in major retail outlets.
- Apple is a common plant in nurseries in the temperate regions of Australia, particularly during the dormant period over winter and to a limited extent during the spring and summer months.
- Retail garden nurseries have a high density of a range of plant materials in a small area. They often maintain a high hygienic standard, usually fogging with insecticide, to prevent insect attacks.
- A number of fresh food markets will have nursery plants near apple fruit. However there are a limited number of nurseries associated with fresh food markets that also maintain or store actively growing apple trees.

**Exp** nursery plants from food  
service waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Most food service industries are located in urban areas. There are instances of nurseries being located near food services.
- However, food service industry waste is disposed into bins and taken to landfills. Nursery plants are unlikely to be near these sites.

**Exp** nursery plants from  
consumer waste

**Negligible**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. Nurseries are generally not located near these sites.

### *Household and garden plants*

#### *Household and garden plants near utility points*

The proportions of the five utility points near susceptible household and garden plants of OSS are shown in Table 104. It was estimated that household and garden plants are moderately likely to be near consumers, very unlikely to be near orchard wholesalers and retailers, and extremely unlikely to be near urban wholesalers and food services.

The relative amounts of waste apples discharged or discarded near household and garden plants susceptible to oystershell scale are indicated in Figure 40.

#### *Exposure to host*

The household and garden plants of OSS include apple, plum, and cherry as well as many ornamental trees and shrubs.

A successful exposure of OSS to susceptible host means that that females need to lay eggs on fruit, eggs hatch, and the first instar nymphs would need to move onto a susceptible host plant by crawling, or blown by wind currents or off the clothes of workers in the utility points. The chance for this to happen depends on several factors, including mortality caused by the handling and consumption of the fruit, the level of infestation/infection and the number of apples in the same utility points, the reproductive strategy and life span of the pest as well as availability of susceptible hosts.

As shown in Table 105, it is considered that the probability that exposure of nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** household and garden  
plants from orchard wholesaler  
waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**.

- Orchard wholesale waste sites are mostly located within the orchard premises and are not located near household and garden plants.

**Exp** household and garden  
plants from urban wholesaler waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**.

- Urban wholesaler waste is disposed into landfill sites, which are generally not near residential properties.

**Exp** household and garden  
plants from retailer waste

**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Retailer waste would be disposed to landfills, which are generally not near residential properties.

**Exp** household and garden  
plants from food service waste  
**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Food service industries are unlikely to have host plants susceptible to OSS within their premises.
- Waste from food services is disposed into landfills sites.

**Exp** household and garden  
plants from consumer waste  
**Negligible**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Most consumers are in metropolitan and suburban areas and their waste is disposed into landfills. However, local authorities are now encouraging composting of food waste in suburban backyards rather than disposing of all waste into landfill.
- However, utilisation of waste to make compost is becoming a common practice in some suburban and rural households.
- Discarded apple cores infested with OSS could be discarded in backyard compost.
- Host plants of OSS are commonly grown as a garden plants in the southern regions of Australia.

*Wild and amenity plants*

*Wild and amenity plants near utility points*

The proportions of the five utility points near susceptible wild and amenity plants of OSS are shown in Table 104. It was estimated that wild and amenity plants are unlikely to be near consumers, very unlikely to be near orchard wholesalers, and extremely unlikely to be near urban wholesalers, retailers and food services.

The relative amounts of waste apples discharged or discarded near wild and amenity plants susceptible to oystershell scale are indicated in Figure 40.

Transfer to host

The wild and amenity plants of OSS include apple, plum, and cherry and many other plants.

A successful exposure of OSS to susceptible host means that females need to lay eggs on fruit, eggs hatch, and the first instar nymphs would need to move onto a susceptible host plant by crawling, or blown by wind currents or off the clothes of workers in the utility points. The chance for this to happen depends on several factors, including mortality caused by the handling and consumption of the fruit, the level of infestation/infection and the number of apples in the same utility points, the reproductive strategy and life span of the pest as well as availability of susceptible hosts.

As shown in Table 105, it is considered that the probability that exposure of nursery plants would result from discharge or discard of either a single infested/infected apple, an escaped

pest or contaminated packaging material from different utility points would all be negligible. Other supporting evidence is provided in the text below.

**Exp** wild and amenity plants  
from orchard wholesaler waste

**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from orchard wholesalers: **Negligible**

- Orchard wholesale waste sites are mostly located within the orchard premises and are not located near wild and amenity plants.
- Susceptible feral plants e.g. volunteer apple seedlings, crab apple etc. may be present near orchard wholesalers waste disposal sites.

**Exp** wild and amenity plants  
from urban wholesaler waste

**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from urban wholesalers: **Negligible**

- Urban wholesale waste is disposed at landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. crab apple trees, apple seedlings.

**Exp** wild and amenity plants  
from retailer waste

**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from retailers: **Negligible**

- Retailer waste would be disposed to landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. crab apple trees, apple seedlings.

**Exp** wild and amenity plants  
from food service waste

**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from food services: **Negligible**

- Food service waste is disposed into bins and taken to landfills. Seedlings originating from seeds dispersed by birds could be present.

**Exp** wild and amenity plants  
from consumer waste

**Negligible**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest or contaminated packaging material from consumers: **Negligible**

- Consumers who consider apple fruit or cores to be biodegradable indiscriminately discard them in the environment.
- Consumers deposit apple cores into the environment.
- Parks have bins for waste that may not be removed on a daily basis.
- Most consumers are in metropolitan and suburban areas and



their waste is disposed into landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds e.g. crab apple trees, apple seedlings.

- Consumers discard apple cores in the environment or in bins in parks. Bins for waste in parks that may not be removed on a daily basis and these would provide a sheltered environment for the insect to emerge before the fruit desiccates or decays.
- Apple seedlings can establish from discarded apple cores. However, population densities of susceptible wild and amenity apple plants in parks, near recreational facilities and along roadsides may be low.
- Consumers who consider apple cores to be biodegradable indiscriminately discard them in the environment. Spoilt apples or cores discarded into the wild are likely to be isolated.

### **Conclusion—probability of distribution**

The partial probability of distribution from each of the utility points to each of the exposure groups is summarised in Table 106. These were calculated by the simulation model using @risk. The quantitative model evaluated the effect of the ‘volume of trade’ during a specified period when calculating the partial probability of distribution.

**Table 106 Partial probabilities of distribution (PPD)<sup>85</sup> for oystershell scale**

UTILITY POINTS	PPD			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Orchard wholesalers</b>	Negligible	Negligible	Negligible	Negligible
<b>Urban wholesalers</b>	Negligible	Negligible	Negligible	Negligible
<b>Retailers</b>	Extremely low	Extremely low	Extremely low	Negligible
<b>Food services</b>	Negligible	Negligible	Negligible	Negligible
<b>Consumers</b>	Extremely low	Extremely low	Extremely low	Extremely low
<b>Overall PPD</b>	<b>Extremely low</b>	<b>Extremely low</b>	<b>Very low</b>	<b>Extremely low</b>

<sup>85</sup> Partial probability of distribution is actually referring to the probability of entry and was estimated by @risk.

## Probability of establishment or spread

The assessment for the probability of establishment or spread is carried out in the following manner. Firstly, partial probability for establishment and for spread was assessed separately based on the relevant available scientific information. Secondly, the conclusions for the combined partial probability of establishment or spread for each of the four exposure groups are provided at the end of this section. The relevant information for the assessment for the probability of establishment or spread is presented below against the factors listed in ISPM 11, Rev. 1.

### *Partial probability of establishment*

ISPM 11 factor	Relevant information
<b>Availability of suitable hosts, alternate hosts and vectors in the PRA area</b>	<ul style="list-style-type: none"><li>• OSS has a wide range of host plants, mainly deciduous trees. Host plants have been reported from 41 genera in 18 families.</li><li>• The hosts include apples, pears, and stone fruits, particularly plum (European and Japanese) but also cherry, peach, prune, almond, nectarine, quince, currants, blueberry, and walnuts. Willows, birches, elms, alders, poplars, rowans, and other common ornamental trees.</li><li>• Shelter trees are often the most important sources of oystershell scale dispersing in the orchard environment in New Zealand (HortResearch, 1999b).</li><li>• Many of these are grown occur in Australia.(Todd, 1959; Tomkins, 1998)</li></ul>
<b>Suitability of the environment</b>	<ul style="list-style-type: none"><li>• OSS is widely distributed in the Palearctic and Nearctic Regions and has been introduced to Argentina, New Zealand as well as Australia (South Australia, Victoria and Tasmania) (CABI, 2003a).</li><li>• Poole <i>et al.</i> (2001) provided climate matching scenarios using data from where OSS already occurs in Australia using Climex® modelling and the results indicate that there are only limited regions within Western Australia which are suitable for the establishment of OSS.</li></ul>
<b>The potential for adaptation of the pest</b>	<ul style="list-style-type: none"><li>• There are no reports of these scale insects in New Zealand developing resistance to insecticides.</li></ul>
<b>The reproductive strategy of the pest</b>	<ul style="list-style-type: none"><li>• Sexual reproduction is essential in OSS.</li><li>• Successful mating between a male and a female must occur for viable eggs to be produced.</li><li>• The sex ratio is about 1:1, although a high ratio of females to males has been reported in spring in Europe.</li><li>• The female releases a sex pheromone during the day when males are active, which attracts the winged males for mating.</li><li>• Males fly for up to a few days and may locate females after flight or by walking over the bark of the host tree.</li><li>• OSS males and females are able to mate almost immediately after emergence and multiple matings may occur.</li></ul>

ISPM 11 factor	Relevant information
<b>Minimum population needed for establishment</b>	<ul style="list-style-type: none"> <li>• Females have a high fecundity and on reaching adulthood after 30-50 days produce eggs over a period of 2-3 months resulting in a large population buildup.</li> <li>• Female OSS can protect from 1-15 eggs and/or from 1-19 crawlers under their scale covering.</li> <li>• OSS has only one generation per year and the winter is spent mainly as immature second instars.</li> <li>• Mated females of OSS can lay from 100 to 203 eggs each (HortResearch, 1999b). A population can be started from these eggs.</li> </ul>
<b>Cultural practices and control measures</b>	<ul style="list-style-type: none"> <li>• Integrated Pest Management (IPM) programs are utilised in the production of apples in Australia including Western Australia. Many aspects of the IPM are similar to the IFP program used by New Zealand orchardists.</li> <li>• The same insecticidal chemicals are used to control all the scale pest species on apples.</li> <li>• Chemical control involves the use of oils, broad-spectrum insecticides and insect growth regulator compounds in high volume applications to ensure good spray coverage (HortResearch, 1999b).</li> <li>• A significant part of fruit infestations in summer originate from wind-blown scale crawlers moving from shelter and other host plants. Spraying of shelter in spring and/or summer is a useful part of a shelter management programme that assists scale control (HortResearch, 1999b). OSS is an exotic pest, which is attacked by a group of mainly exotic natural enemies. In New Zealand the more important of these are tiny wasps of the family Aphelinidae: <i>Encarsia citrina</i>, and <i>Aphytis mytilaspidis</i> and a predacious mite (<i>Neophyllobius</i> sp.) (HortResearch, 1999b). These species are not known from Western Australia.</li> <li>• Populations of OSS are kept under control in its native range by a large number of parasitoids (CABI, 2003a) most of these parasitoids are lacking in areas where OSS has been introduced resulting in inadequate natural regulation and subsequent outbreaks.</li> </ul>

*Conclusion—partial probability of establishment*

Based on the above evidence, partial probability of establishment for each of the exposure groups is assessed as follows.

Partial probability of establishment for commercial fruit crops: **High**

Partial probability of establishment for nursery plants: **High**

Partial probability of establishment for household and garden plants: **High**

Partial probability of establishment for wild and amenity plants: **High**

**Partial probability of spread**

ISPM 11 factor	Relevant information
<b>Suitability of natural and/or managed environment</b>	<ul style="list-style-type: none"> <li>OSS is already reported from South Australia, Tasmania and Victoria, but is absent from Western Australia. There are similar environments in Western Australia that would be suitable for its spread.</li> <li>Poole <i>et al.</i> (2001) provided climate matching scenarios using data from where OSS already occurs in Australia using Climex® modelling and the results indicate that there are only limited regions within Western Australia which are suitable for the establishment of OSS.</li> <li>Oystershell scale is also present in Asia, Europe, Africa, North America and is introduced to Argentina, New Zealand and Australia (CABI, 2002).</li> </ul>
<b>Presence of natural barriers</b>	<ul style="list-style-type: none"> <li>Several commercial fruit crops of OSS are grown in the southwestern part of Western Australia and there are natural barriers present between some districts. It would be difficult for the mites to disperse from one district to another if unaided.</li> <li>OSS has limited dispersal capabilities, with only the winged adult males and young crawlers of OSS being mobile.</li> </ul>
<b>Potential for movement with commodities or conveyances</b>	<ul style="list-style-type: none"> <li>Long distance dispersal is facilitated by the distribution of infested nursery stock (Beardsley and Gonzalez, 1975).</li> <li>Crawlers landing on orchard pickers' clothing and farm machinery could be assisted in their movement between orchards.</li> </ul>
<b>Intended use of the commodity</b>	<ul style="list-style-type: none"> <li>Apples would be used mostly for consumption by humans and would be widely distributed around the States.</li> <li>If young crawlers have contaminated the fruit, they will be distributed with the commodity around the country.</li> </ul>
<b>Potential vectors of the pest</b>	<ul style="list-style-type: none"> <li>There is no known animal vector for oystershell scale.</li> </ul>
<b>Potential natural enemies</b>	<ul style="list-style-type: none"> <li>Several natural enemies attack oystershell scale in New Zealand including: the parasitic wasps <i>Aphytis mytilaspidis</i>, <i>Encarsia citrina</i>, <i>Epitetraneura zetterstedtii</i>, and <i>Zaomma lambinus</i>, several predatory mites including <i>Hemisarcoptes malus</i>, a ladybird of the genus <i>Rhyzobius</i> (CABI, 2002).</li> <li>Several species of <i>Rhyzobius</i> occur in Western Australia.</li> <li>Other natural enemies such as thrips, spiders and predatory mites in the PRA area, especially generalist predators, may be able to attack OSS.</li> </ul>

*Conclusion—partial probability of spread*

Based on the above evidence, partial probability of spread for each of the exposure groups is assessed as follows.

Partial probability of spread for commercial fruit crops: **Moderate**

Partial probability of spread for nursery plants: **Moderate**

Partial probability of spread for household and garden plants: **Moderate**

Partial probability of spread for wild and amenity plants: **Moderate**

**Combined partial probability of establishment or spread**

The combined partial probability of establishment or spread was determined by combining probabilities of establishment and probabilities of spread using the matrix of ‘rules’ for combining descriptive likelihoods as presented in the method section. The results are indicated in Table 107.

**Table 107 Combined partial probabilities of establishment or spread of oystershell scale**

	<b>Commercial fruit crops</b>	<b>Nursery plants</b>	<b>Household and garden plants</b>	<b>Wild and amenity plants</b>
<b>Establishment</b>	High	High	High	High
<b>Spread</b>	Moderate	Moderate	Moderate	Moderate
<b>PPES<sup>86</sup></b>	Moderate	Moderate	Moderate	Moderate

Additional evidence to support the combined partial probability of establishment or spread for specific exposure groups is provided in the text below.

<b>Commercial fruit crops</b>	<ul style="list-style-type: none"> <li>Commercial fruit crops of OSS are grown in many parts of Western Australia.</li> </ul>
<b>Moderate</b>	<ul style="list-style-type: none"> <li>Oystershell scale has shown its ability to establish or spread in eastern Australia, New Zealand and Argentina.</li> </ul>
<b>Nursery plants</b>	<ul style="list-style-type: none"> <li>OSS attacks many plants that are sold as nursery plants in Australia and is polyphagous on many dicotyledonous shrubs and trees (HortResearch, 1999b).</li> </ul>
<b>Moderate</b>	
<b>Household and garden plants</b>	<ul style="list-style-type: none"> <li>The establishment of OSS in susceptible household and garden plants will be largely dependent on (1) the availability of a wide range of host plants; (2) the extent of Western Australian households growing backyard apple trees and other host plants; and, (3) the willingness of suburban gardeners to adequately control pests and diseases particularly on their fruit trees.</li> </ul>
<b>Moderate</b>	

<sup>86</sup> PPES = partial probability of establishment or spread.

- Climatic limits and the extent of apple trees and other host plants in suburban backyards can have an effect on the establishment or spread of OSS.
- Wild and amenity plants**
- OSS is highly polyphagous and feeds on several plant hosts that grow in wild situations in Western Australia.
- Moderate**

### Assessment of consequences

Oystershell scale is a regional concern only. Thus the following assessment of consequences applies only to the regional level (Western Australia) not national level.

Impact scores allocated for the direct and indirect criteria are shown in Table 108. Available supporting evidence is provided in the text below.

**Table 108 Impact scores for oystershell scale**

Direct impact	Impact scores
Plant life or health	C
Human life or health	A
Any other aspects of environment	A
Indirect impact	
Control or eradication	D
Domestic trade or industry	C
International trade	D
Environment	B
Communities	A

#### **Direct impact**

- Plant life or health – C** Consequences affecting plant life or health are unlikely to be discernable at the regional level and of minor significance at the district level. A rating of ‘C’ was assigned to this criterion.
- OSS is highly polyphagous and has been recorded from hosts in 18 plant families, mainly deciduous trees.
  - The commercial fruit crops of OSS include apples, pears, stone fruits, particularly plum (European and Japanese), cherry, peach, almond, nectarine, quince, currants, blueberry, and walnuts.
  - Fruit quality can be reduced by the presence of discolouration near the calyx or stem-end (HortResearch, 1999b).
  - Some apple varieties often exhibit red marks on the skin where

	<p>the scales have been feeding (McLaren, 1998).</p> <ul style="list-style-type: none"> <li>• Fecundity is high in OSS and in the absence of natural predators and parasites population increase is rapid.</li> <li>• The oystershell scale has one generation per year and temperatures in spring and summer influence the timing of the different life stages (HortResearch, 1999b).</li> <li>• Oystershell scale can reduce plant vigour and crop yield.</li> <li>• Heavy infestations of OSS on the bark and stems of apple trees cause a gradual debilitating effect on the branch, their feeding interfering with the growth of the cambium leading to abnormal phloem and xylem cells, and subsequent desiccation (HortResearch, 1999b).</li> </ul>
<b>Human life or health – A</b>	There are no known direct impacts of OSS on human life or health and the rating assigned to this criterion was therefore ‘A’.
<b>Any other aspects of environmental effects – A</b>	There is no known direct impact of OSS on any other aspects of the environment and a rating of ‘A’ was assigned to this criterion.
<b>Indirect impact</b>	
<b>Control or eradication – D</b>	<p>The indirect impact on new or modified eradication, control, surveillance/monitoring and compensation strategies is of minor significance at regional level. A rating of ‘D’ was assigned to this criterion.</p> <ul style="list-style-type: none"> <li>• Programs to minimise the impact of this pest on host plants are likely to be costly and include pesticide applications, crop monitoring and spraying of shelter-belt trees in spring and/or summer as part of a shelter management programme that assists with control of young dispersing crawlers.</li> <li>• Existing control programs can be effective for some hosts (e.g. broad spectrum pesticide applications) but not all hosts (e.g. where specific integrated pest management programs are used).</li> <li>• An increase in the use of insecticides for its control because of difficulties estimating the optimum time for insecticide application.</li> <li>• Disruption to IPM programs because of the need to re-introduce or increase the use of organophosphate insecticides.</li> <li>• Subsequent increase in cost of production to producers.</li> <li>• Increased costs for crop monitoring and consultant’s advice to the producer.</li> </ul>
<b>Domestic trade or industry – C</b>	The indirect consequences on domestic trade are unlikely to be discernable at the regional level and would be of minor significance at the district level. A rating of ‘C’ was assigned to this criterion.

The presence of OSS on commercial fruit crops could result in:

- trade restrictions in the sale or movement of fruit between districts in Western Australia; and
- consumer expectations and aesthetics ranging from the acceptance of fruit that is slightly affected to outright rejection of imperfect fruit.

**International trade – D** The indirect consequences on international trade are of minor significance at the regional level. A rating of ‘**D**’ was assigned to this criterion.

- Western Australia’s OSS pest free status on international markets would be compromised.

**Environment – B** The indirect consequences on the environment would not be discernible at the national level and would be of minor significance at the local level and a rating of ‘**B**’ was assigned to this criterion.

- Increased insecticide use could cause undesired effects on the environment.
- The introduction of new biocontrol agents could affect existing biological control programs.
- Many of the hosts of the OSS are introduced deciduous trees that are commonly grown as ornamentals or as shelter belt trees and would have little effect on designated environmentally sensitive or protected areas because few if any introduced trees grow or are allowed to continue to grow in such areas.

**Communities – A** The presence of OSS would have limited social effects, if any, and a rating of ‘**A**’ was assigned to this criterion.

### ***Conclusion—consequences***

Based on the decision rule described in the method section, i.e. where the consequences of a pest with respect to one or more criteria are ‘**D**’, the overall consequences are considered to be ‘low’. Therefore the overall consequences of OSS are **low**.

### **Unrestricted annual risk**

Unrestricted annual risk is the result of combining annual probability of entry, establishment or spread with the outcome of overall consequences. Probabilities and consequences are combined using the ‘rules’ shown in the risk estimation matrix in the method section. The unrestricted annual risk estimation for OSS is shown in Table 109.



**Table 109 Risk estimation for oystershell scale**

Overall probability of entry, establishment or spread <sup>87</sup>	<b>Extremely low</b>
Consequences	<b>Low</b>
Unrestricted annual risk	<b>Negligible</b>

As indicated in Table 109, the unrestricted annual risk for oystershell scale is negligible, which is below the appropriate level of protection (ALOP) of very low. Therefore, risk management would not be required for this pest.

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<sup>87</sup> Calculated by @ risk.

## **CONTAMINANTS**

The following risk assessments are for:

- Burnt pine longhorn beetle
- Click beetle
- Wheat bug

## **Burnt pine longhorn beetle**

### **Biology**

The burnt pine longhorn beetle (BPLB), *Arhopalus ferus* (Mulsant) is a cerambycid beetle with four life stages: adult, egg, larva and pupa.

Adult males are light brown and females are dark brown to black in colour. Females prefer to lay eggs on scorched host material of *Pinus* spp. The eggs are laid in groups of 5-50 in bark crevices as early as 24 hours after fire in New Zealand or in the scales of bark in slightly decaying or recently dead stumps. Larvae hatch in less than 10 days and bore towards the phloem and cambium of tree trunks in New Zealand. Larvae are cerambycid-like, lack well-developed legs and are long lived often taking several years to complete their development within their host tree. The majority of beetles complete their life cycle in 1 year but some are known to take 2 years (ForestResearch, 2001).

### **Risk scenario**

The risk scenario of concern for BPLB is the contamination of pallets. Burnt pine longhorn beetle is a typical hitchhiker organism that lands on timber and other goods while being loaded in New Zealand, especially during the night when they are attracted to lights.

## Probability of importation

The initiating step for the importation scenario for apple fruit is the sourcing of apples from orchards in New Zealand, while the end-point is the release of imported apples from the port of entry. The importation scenario is divided into eight steps and the likelihood of the BPLB being present at each step is summarised in Figure 41. The available evidence supporting the likelihood assessments is provided in the text below.

**Figure 41 The importation steps and the likelihood of the burnt pine longhorn beetle being present at each step**



<b>Importation step 1 (Imp1)</b> <b>Negligible</b>	<p>The likelihood that BPLB is present in the source orchards in New Zealand: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Burnt pine longhorn beetle is not a pest of apple trees.</li> <li>Burnt pine longhorn beetle is found in logs, stumps and standing dead trees of the genus <i>Pinus</i>. The females show a marked preference for fire-scorched host material (Duffy, 1953; Hosking, 1978).</li> </ul>
<b>Importation step 2 (Imp2)</b> <b>Negligible</b>	<p>The likelihood that picked apple fruit is infested with BPLB: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Burnt pine longhorn beetle is not attracted to apples nor is it recorded feeding on apples or apple trees.</li> </ul>
<b>Importation step 3 (Imp3)</b> <b>Negligible</b>	<p>The likelihood that clean fruit is contaminated by BPLB during harvesting and transport of apples to the packing house: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Burnt pine longhorn beetles are not active during the day and their large size and behaviour of taking to flight when disturbed suggests that they would not move onto fruit being picked or transported to the packing house.</li> </ul>
<b>Importation step 4 (Imp4)</b> <b>Negligible</b>	<p>The likelihood that BPLB survives routine processing procedures in the packing house: <b>Negligible</b></p> <p>The following packing house operations may influence the survival of the BPLB.</p> <p><i>Washing</i></p> <ul style="list-style-type: none"> <li>The water in the flotation tank will exacerbate BPLB's natural tendency to leave the fruit whilst in the water bath. As there is no hiding place on an apple fruit for BPLB to hide, it will not remain with the fruit.</li> <li>Given the large size of BPLB, high-volume/high pressure washing will dislodge any BPLB still remaining on the fruit.</li> </ul> <p><i>Brushing</i></p> <ul style="list-style-type: none"> <li>The large size of BPLB would ensure the adult beetles would be brushed off.</li> </ul> <p><i>Waxing</i></p> <ul style="list-style-type: none"> <li>The large size of BPLB would ensure that adult beetles would not be able to remain with fruit during the waxing process.</li> </ul> <p><i>Sorting and grading</i></p> <ul style="list-style-type: none"> <li>The large size of this beetle would make it highly noticeable to the sorters and graders who would remove it.</li> </ul> <p><i>Packaging</i></p> <ul style="list-style-type: none"> <li>Packaging would have little affect on the survival of the beetle. In most cases the packaging of apples is designed to maximise heat discharge from the fruit while minimising loss of moisture.</li> </ul>

*Cold Storage*

- There is no data available on the impact of cold storage on the survival of BPLB adults on apple fruit.

*Summary*

Washing, brushing and waxing together would be able to remove the large, rather distinctive BPLB. The likelihood for Imp4 was assessed as negligible.

**Importation step 5  
(Imp5)**

**Extremely low**

The likelihood that clean fruit is contaminated by BPLB during processing in the packing house: **Extremely low**

- Adult BPLB are large, visible and extremely unlikely to remain with fruit that has been treated in the packing house.
- Burnt pine longhorn beetles fly at night and are strongly attracted to light. They usually shelter in packets of sawn timber during the day suggesting that they seek out hiding places such as those provided by timber pallets (Hosking, 1978). This suggests that there is a chance that BPLB could contaminate pallets that are used in the packing house but the chance is considered as extremely low.

**Importation step 6  
(Imp6)**

**Moderate**

The likelihood that BPLB survives palletisation, quality inspection, containerisation and transportation to Australia: **Moderate**

- The large size of adult BPLB suggests that they would be noticed during quality inspection.
- Burnt pine longhorn beetle's ability to avoid unfavourable conditions by taking to flight suggests that it would not remain with the fruit.
- If present, there is no evidence to suggest that cold storage would be effective in killing BPLB.

*Summary*

If present the adults could be noticed at quality inspection; however, they would be able to survive cold storage during transportation. Therefore, the likelihood for Imp6 was assessed as moderate.

**Importation step 7  
(Imp7)**

**Very low**

The likelihood that clean fruit is contaminated by BPLB during palletisation, quality inspection, containerisation and transportation: **Very low**

- The habit of BPLB to be attracted to lights at night suggests that the adults could be attracted to and fall on containers on the docks at night-time.
- In addition, adult BPLB sheltering in packets of sawn timber during the day (Hosking, 1978) would indicate that there is a chance for adults to seek out and take shelter in the wooden pallets during the palletisation process and this chance is considered as extremely low.

**Importation step 8  
(Imp8)****Negligible**

The likelihood that BPLB survives and remains with fruit after on-arrival minimum border procedures: **Negligible**

- The risk scenario of concern for BPLB is the contamination of pallets.
- Wood packaging and dunnage such as pallets from New Zealand are subject to a full unpack and quarantine inspection and treatment if necessary at an appropriate quarantine approved premises, or are subject to a pre-shipment or on-arrival treatment (AQIS, 2000).
- The large size of BPLB and its tendency to congregate in groups when sheltering during the daytime indicates that they would be detected at a full unpack inspection for wood packaging and dunnage. Burnt pine longhorns have been detected several times on imported timber or in baggage (DAFF-PDI, 2003).

*Summary*

Adults of BPLB congregate in groups in sheltered sites such as pallets during the daytime. If present, they would be detected at the full unpack inspection of wood packaging and dunnage from New Zealand, and treatments such as fumigation would apply, therefore, the likelihood for Imp8 was assessed as negligible.

***Conclusions—probability of importation***

When the above likelihoods were inserted into the simulation model, the probability of importation of burnt pine longhorn beetle from one year of trade was found to be **negligible**.

The risk assessment for this pest stopped here because of the following considerations.

Burnt pine longhorn beetle is not an apple pest not associated with apple fruit. It only contaminates timber pallets. As the calculations in the distribution scenario in the simulation model is based on the numbers of infected/infested apples and BPLB is not associated with fruit, it is inappropriate to subject this pest to the further steps in the model. Instead, if this pest were subjected to a qualitative risk assessment based on the rules for combining qualitative likelihoods described in the method section, the probability of entry, establishment or spread would be negligible even if distribution, establishment or spread were high because the probability of importation is negligible. Consequently, the risk would be very low even if the consequences were extreme.

It was concluded that the unrestricted risk for this species would at most be very low, which would meet Australia's appropriate level of protection (ALOP) of very low. Therefore, risk management would not be required for this pest, except for the existing measures in place as described in Imp8.

## **Click beetle**

### **Biology**

The Click beetle (CB) *Conoderus exsul* Sharp, its larva known as Wireworm, has four life stages: adult (Click beetle), egg, larva (Wireworm) and pupa. Adults are 8.5-13 mm in length and reddish-brown to dark brown in colour covered with a yellowish pubescence. The female is more robust and larger than the male.

A small percentage of larvae mature in the same season while the majority complete their life cycle in the year following. Females lay their eggs in the soil. Newly hatched larvae are whitish turning cream coloured on the second moult. Mature larvae have the head, thorax and apical abdominal segment dark reddish in colour. The pupa forms a cell in the soil and is cream coloured. Under laboratory conditions the larval period ranges from 54 to 103 days, the pupal period ranges from 14 to 18 days (average 15.7 days) while the adult is the short-lived reproductive stage ranging from 25 to 65 days (average 38 days).

### **Risk scenario**

The risk scenario of concern for click beetle is the contamination of pallets. Click beetle is a typical hitchhiker organism that lands on timber and other goods while being loaded in New Zealand, especially during the night when they are attracted to lights.



## Probability of importation

The initiating step for the importation scenario for apple fruit is the sourcing of apples from orchards in New Zealand, while the end-point is the release of imported apples from the port of entry. The importation scenario is divided into eight steps and the likelihood of the Click beetle being present at each step is summarised in Figure 42. The available evidence supporting the likelihood assessments is provided in the text below.

**Figure 42 The importation steps and the likelihood of the click beetle being present at each step**



<p><b>Importation step 1 (Imp1)</b></p> <p><b>Negligible</b></p>	<p>The likelihood that CB is present in the source orchards in New Zealand: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Click beetle is not a pest of apple trees. The larvae are omnivorous, found in the soil feeding on plant roots and soil dwelling arthropods in pastureland (Robertson, 1987).</li> </ul>
<p><b>Importation step 2 (Imp2)</b></p> <p><b>Negligible</b></p>	<p>The likelihood that picked apple fruit is infested with CB: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Click beetle is not attracted to apples nor is it recorded feeding on apples or apple trees.</li> <li>Adult click beetles are attracted to sources of sugar.</li> </ul>
<p><b>Importation step 3 (Imp3)</b></p> <p><b>Negligible</b></p>	<p>The likelihood that clean fruit is contaminated by CB during harvesting and transport of apples to the packing house: <b>Negligible</b></p> <ul style="list-style-type: none"> <li>Click beetle is not active during the day and their behaviour of dropping to the ground and running into vegetation or defensively ‘clicking’ when disturbed suggests that they would not move onto fruit being picked or transported to the packing house.</li> </ul>
<p><b>Importation step 4 (Imp4)</b></p> <p><b>Negligible</b></p>	<p>The likelihood that CB survives routine processing procedures in the packing house: <b>Negligible</b></p> <p>The following packing house operations may influence the survival of the click beetle.</p> <p><i>Washing</i></p> <ul style="list-style-type: none"> <li>The water in the dipping tank will exacerbate the natural tendency of CB adults to leave the fruit whilst in the water bath. As there is no hiding place on apple fruit big enough for CB to hide in it will not remain with the fruit.</li> <li>Given the moderately large size of CB, high-volume/high pressure washing will dislodge any CB still remaining on the fruit.</li> </ul> <p><i>Brushing</i></p> <ul style="list-style-type: none"> <li>The moderately large size of CB would ensure that adult beetles would be brushed off apples during the brushing procedure.</li> </ul> <p><i>Waxing</i></p> <ul style="list-style-type: none"> <li>The moderately large size of CB would ensure that adult beetles would not be able to remain with fruit during the waxing process.</li> </ul> <p><i>Sorting and grading</i></p> <ul style="list-style-type: none"> <li>The moderately large size of this beetle and clicking behaviour will make it very obvious to sorters and graders who would remove it.</li> </ul> <p><i>Packaging</i></p> <ul style="list-style-type: none"> <li>Packaging would have little affect on the survival of the beetle. In most cases the packaging of apples is designed to</li> </ul>

maximise heat discharge from the fruit while minimising loss of moisture.

*Cold Storage*

- There is no evidence that cold storage employed by the packing house prior to transport will be fatal to CB.

*Summary*

Based on the evidence that washing, brushing and waxing together would be able to remove click beetles that are moderately large and active, the likelihood for Imp4 was assessed as negligible.

**Importation step 5  
(Imp5)**

**Extremely low**

The likelihood that CB clean fruit is contaminated by CB during processing in the packing house: **Extremely low**

- Click beetle is moderately large, visible to the naked eye and is unlikely to remain with fruit that has been treated in the packing house.
- Adult click beetle fly at night and are strongly attracted to light.
- Adult CB usually shelter in concealed places during the day suggesting that they would seek out hiding places such as those provided by timber pallets.

**Importation step 6  
(Imp6)**

**Moderate**

The likelihood that CB survives palletisation, quality inspection, containerisation and transportation to Australia: **Moderate**

- The moderately large size of adult CB suggests that they would be easily detected during quality inspection.
- Click beetle's ability to avoid unfavourable conditions by taking to flight suggests that they will not remain with the fruit.
- If present, there is no evidence to suggest that cold storage employed during transportation would be fatal to CB.

*Summary*

If present the adults could be noticed at quality inspection; however, they would be able to survive cold storage during transportation. Therefore, the likelihood for Imp6 was assessed as moderate.

**Importation step 7  
(Imp7)**

**Very low**

The likelihood that clean fruit is contaminated by CB during palletisation, quality inspection, containerisation and transportation: **Very low**

- The moderately large size of the CB makes it easily visible; those remaining associated with the fruit would be detected.
- The habits of adult CB to be attracted to lights at night suggests that the adults could be attracted to and fall on any freight on the docks at night time.
- Adult CB shelter in concealed places during the day

indicating that there is a chance for adults to seek out and take shelter in the wooden pallets during the palletisation process and this chance is considered as extremely low.

**Importation step 8  
(Imp8)**

**Negligible**

The likelihood that CB survives and remains with fruit after on-arrival minimum border procedures: **Negligible**

- The risk scenario of concern for CB is the contamination of pallets.
- Wood packaging and dunnage such as pallets from New Zealand are subject to a full unpack and quarantine inspection and treatment, if necessary at an appropriate quarantine approved premises, or are subject to a pre-shipment or on-arrival treatment (AQIS, 2000).
- The moderately large size of adult CB and their tendency to defensively click when disturbed during the daytime indicate that they would be detected at the full unpack inspection. Click beetle has been detected with the importation of New Zealand apricots (DAFF-PDI, 2003).

*Summary*

Adult click beetles are nocturnal and congregate in groups in sheltered sites such as pallets during the daytime. If present, they would be detected at the full unpack inspection of wood packaging and dunnage from New Zealand, and treatments such as fumigation would apply, therefore, the likelihood for Imp8 was assessed as negligible.

***Conclusions—probability of importation***

When the above likelihoods were inserted into the simulation model, the probability of importation of click beetle from one year of trade was found to be **negligible**.

The risk assessment for this pest stopped here because of the following considerations.

Click beetle is not an apple pest and is not associated with apple fruit. It only contaminates timber pallets. As the calculations in the distribution scenario in the simulation model is based on the numbers of infected/infested apples and CB is not associated with fruit, it is inappropriate to subject this pest to the further steps in the model. Instead, if this pest were subjected to a qualitative risk assessment based on the rules for combining qualitative likelihoods described in the method section, the probability of entry, establishment or spread would be negligible even if distribution, establishment or spread were high because the probability of importation is negligible. Consequently, the risk would be very low even if the consequences were extreme.

It was concluded that the unrestricted risk for this species would at most be very low, which would meet Australia's appropriate level of protection (ALOP) of very low. Therefore, risk management would not be required for this pest, except for the existing measures in place as described in Imp8.

## **Wheat Bug**

### **Biology**

The wheat bug, *Nysius huttoni* White, is a sap-sucking bug with three life stages: adult, egg and nymph. The adult stage of this insect is about 4 mm long and brownish grey with a distinctive silvery grey triangle on its abdominal apex. Wheat bug lays clusters of eggs in cracks in the soil. The eggs are elongate, oval and are normally in batches. The immature stage or nymph is like a miniature adult without wings.

### **Risk scenario**

The risk scenario of concern for the wheat bug is the infestation of apples by adults during picking and any ensuing contamination of pallets in the packing house. Wheat bug is a typical hitchhiker organism and post-harvest passenger pest.

### **Probability of importation**

The initiating step for the importation scenario for apple fruit is the sourcing of apples from orchards in New Zealand, while the end-point is the release of imported apples from the port of entry. The importation scenario is divided into eight steps and the likelihood of the wheat bug being present at each step is summarised in Figure 43. The available evidence supporting the likelihood assessments is provided in the text below.

**Figure 43 The importation steps and the likelihood of the wheat bug being present at each step**



<b>Importation step 1 (Imp1)</b>	The likelihood that the wheat bug is present in the source orchards in New Zealand: <b>Very Low</b> .
<b>Very low</b>	<ul style="list-style-type: none"> <li>• Wheat bugs live on or very close to the ground usually under leaf litter or small stones during spring and summer (Eyles, 1965).</li> <li>• Wheat bugs tend to shelter more under grass straw and leaf litter in autumn (Eyles, 1965).</li> <li>• Large populations of wheat bug can infest trees in commercial orchards. There is limited evidence that wheat bugs damage fruit in commercial orchards, particularly in Canterbury (HortResearch, 1999b).</li> </ul>

### Summary

Based on above evidence that wheat bug can infest trees in commercial orchards, the likelihood for Imp1 was assessed as very low.

<b>Importation step 2 (Imp2)</b>	The likelihood that picked apple fruit is infested with wheat bug: <b>Extremely low</b> .
<b>Extremely low</b>	<ul style="list-style-type: none"> <li>• Large populations of wheat bug would result in a chance for some bugs either staying with the apple fruit when it is picked or falling into the harvesting bags and bins.</li> </ul>
<b>Importation step 3 (Imp3)</b>	The likelihood that clean fruit is contaminated by wheat bug during harvesting and transport of apples to the packing house: <b>Low</b> .
<b>Low</b>	<ul style="list-style-type: none"> <li>• Wheat bug shelters under weeds, particularly wire weed and twin cress, growing on hard usually metallised ground such as loading areas and yards around orchard sheds. From these protected situations wheat bug can readily move into bins of fruit, or pallets of packed trays awaiting loading (Sale, 2003).</li> <li>• If present in the orchards or surrounding areas, wheat bugs would be able to take shelter in or under bins that are kept on the ground of the orchard before transportation to the packing house.</li> <li>• The mobility of wheat bugs means that they would be able to move around in the bin of apples to avoid disturbance.</li> <li>• MAFNZ (2000b) list adult life stage of this species as orchard or packing house contaminants.</li> </ul>

<b>Importation step 4 (Imp4)</b>	The likelihood that wheat bug survives routine processing procedures in the packing house: <b>Very low</b> .
<b>Very low</b>	The following packing house operations can influence the viability of the wheat bug.

### Washing

- Wheat bug is not attached to the fruit and is mobile. The

flotation dump and high-volume/high-pressure washing would be effective in removing wheat bug from the fruit.

*Brushing*

- Wheat bug will attempt to avoid disturbance and unfavourable conditions, such as brushing, by running or flying away.

*Waxing*

- Wheat bug will attempt to avoid disturbance and unfavourable conditions, such as waxing, by running or flying away.

*Sorting and grading*

- The active movements and congregating behaviour of wheat bugs would attract the attention of sorters and graders who would remove any remaining bugs.

*Packaging*

- Packaging would have little effect on the viability of the bug. In most cases the packaging of apples is designed to maximise heat discharge from the fruit while minimising loss of moisture.

*Cold Storage*

- Wheat bug undergoes quiescence during the winter in New Zealand with at least some adults surviving the winter period (Eyles, 1965). Therefore the bugs will be able to survive temporary cold storage at the temperatures employed by the packing house.

*Summary*

Based on the evidence that washing is effective in removing adult wheat bug, the likelihood for Imp4 was assessed as very low.

**Importation step 5  
(Imp5)**

**Negligible**

The likelihood that clean fruit is contaminated by wheat bug during processing in the packing house: **Negligible**.

- Wheat bug is mobile and not strongly attached to the apple fruit.
- The total number of wheat bugs would not increase, although dislodged wheat bugs would be able to move about and find hiding places on other apple fruit as well as in the packing house.

**Importation step 6  
(Imp6)**

**High**

The likelihood that wheat bug survives palletisation, quality inspection, containerisation and transportation to Australia: **High**.

- Wheat bugs are visible to the naked eye and they would be detected during normal pre-export inspection.
- Wheat bug overwinters in New Zealand in a quiescent



	state (Eyles, 1965) indicating that the species could survive cold storage during transportation.
<b>Importation step 7 (Imp7)</b>	The likelihood that clean fruit is contaminated by wheat bug during palletisation, quality inspection and transportation: <b>Negligible</b> .
<b>Negligible</b>	<ul style="list-style-type: none"> <li>The total number of wheat bugs would not increase, although their mobility suggests that there is a chance that adults would seek out and take shelter in cartons or pallets during the palletisation process.</li> </ul>
<b>Importation step 8 (Imp8)</b>	The likelihood that wheat bug survives and remains with fruit after on-arrival minimum border procedures: <b>High</b> .
<b>High</b>	<ul style="list-style-type: none"> <li>Two risk scenarios of concern are known for the wheat bug: the infestation of apple fruit and contamination of pallets.</li> <li>The on-arrival minimum border procedures as described in the method section would not be effective in detecting the wheat bug remaining with the fruit.</li> <li>However, the risk of contamination of pallets would be addressed because wood packaging and dunnage such as pallets from New Zealand are subject to a full unpack and quarantine inspection and treatment if necessary at an appropriate quarantine approved premises, or are subject to a pre-shipment or on-arrival treatment.</li> <li>The mobility of wheat bugs and their tendency to move when disturbed indicate that they would be detected at full unpack inspection. Wheat bug has been detected at preclearance on New Zealand apples being exported to the USA in 2002 (MAFNZ, 2003b).</li> </ul>

### Summary

Based on the above evidence that the risk of wheat bug remaining with the fruit would not be addressed by the on-arrival minimum border procedures, the likelihood for Imp8 was assessed as high.

### Conclusions—probability of importation

When the above likelihoods were inserted into the simulation model, the probability of importation of wheat bug from one year of trade was found to be **very low**.

### Probability of distribution

The initiating step for the distribution scenario is the release of imported apples from the port of entry, while the last step is the pest being distributed (as a result of the processing, sale or disposal of these apple fruit) in a viable state to an endangered area and subsequently being transferred to a suitable host.

In order to assess the probability of distribution, the distribution scenario is addressed in three subheadings below. First is a brief description of sequences of events leading to a successful exposure of the pest from infested/infected apple to a susceptible host plant. Second is the

assessment of partial probability of distribution of the pest in relation to each of the exposure groups. Third is the conclusion for the probability of distribution.

### **Sequence of events for successful exposure**

The sequence of events that has to be completed for a successful exposure of a susceptible host to the pest is summarised below.

The wheat bug is considered to be a post-harvest passenger pest of apple. The insect stage associated with the apple is the adult that may or may not be mated. Handling and consumption would cause some mortality. If the adults survive cold storage, they could enter the environment by flight from unpacking and repacking facilities or retailers (utility points), on discarded fruit in waste, at landfills where the waste is disposed, and during transportation of purchased apples from retailers to households.

A successful exposure of wheat bug to a host means that a mated female would need to lay her eggs in the soil and the hatched nymphs need to find a host.

### **Partial probability of distribution**

The partial probability of distribution (PPD) was estimated separately for each of the four exposure groups: commercial fruit crops; nursery plants; household and garden plants; and, wild and amenity plants.

The details and the method of calculation for the PPD of the four exposure groups are explained in the method section and the results are presented in a series of tables and figures below. The information from these tables and figures was used to assess the probability of distribution of wheat bug to all the exposure groups.

Table 110 indicates the proportions of the five utility points near each of the exposure groups of wheat bug. The wheat bug is polyphagous and has a very broad range of hosts including wild (e.g. shepherd's purse) and cultivated crucifers (e.g. rape), strawberries, sheep's sorrel, lucerne, wheat, several clover species (e.g. *Trifolium dubium*, *T. pratense*, *T. subteranneum*, *T. repens*) and several pasture grass species (including paspalum and perennial ryegrass).

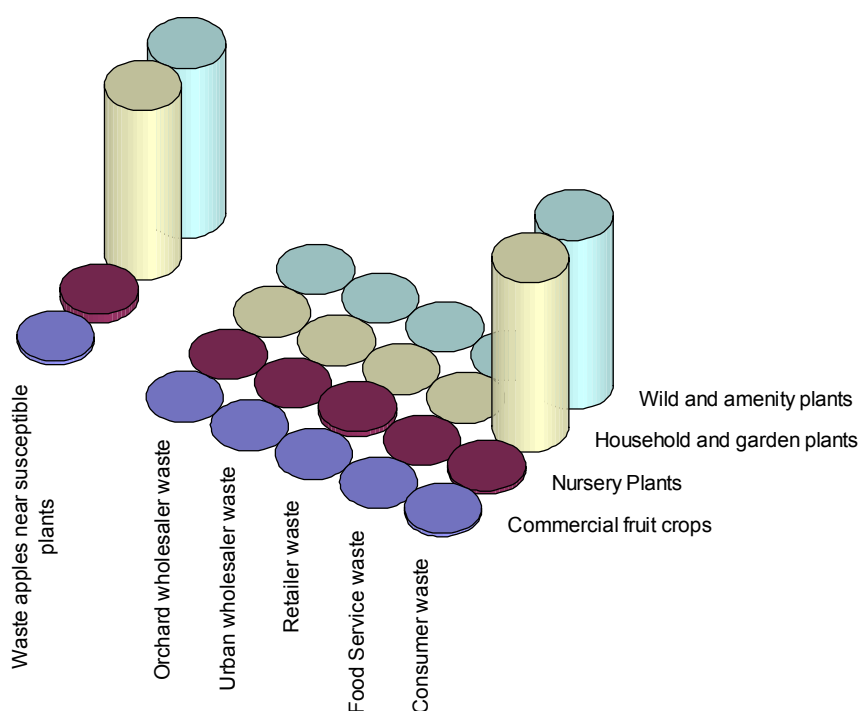
**Table 110 The proportions of utility points near host plants susceptible to wheat bug in the four exposure groups**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Proximity</b> Orchard wholesalers	Very low	Extremely low	Extremely low	Extremely low
<b>Proximity</b> Urban wholesalers	Extremely low	Extremely low	Extremely low	Extremely low
<b>Proximity</b> Retailers	Extremely low	Very low	Extremely low	Extremely low

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Proximity</b> Food services	Extremely low	Extremely low	Extremely low	Extremely low
<b>Proximity</b> Consumers	Extremely low	Extremely low	Very low	Very low

Table 111 gives a pictorial representation of the relative amounts of infested/infected apples, an escaped pest or contaminated packaging material discharged or discarded from different utility points near each of the exposure groups of apple leafcurling midge.

**Table 111 Pictorial representation of the relative amounts of infested/infected apple waste<sup>88</sup> from utility points to near exposure groups of wheat bug**



<sup>88</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or an escaped pest, or contaminated packaging material.

Table 112 is the summary of the probability that exposure of the host plants would result from discharge or discard of a single infested/infected apple, or pest, or contaminated packaging material from different utility points. Evidence is provided in the text below under different exposure groups.

**Table 112 The probability of exposure of susceptible host plants of wheat bug from discharge or discard of a single infested/infected apple, or pest, or contaminated packaging material from different utility points**

UTILITY POINTS	EXPOSURE GROUPS			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Exp</b> Orchard <sup>89</sup> wholesaler waste	Extremely low	Extremely low	Extremely low	Extremely low
<b>Exp</b> Urban wholesaler waste	Extremely low	Extremely low	Extremely low	Extremely low
<b>Exp</b> Retailer waste	Extremely low	Extremely low	Extremely low	Extremely low
<b>Exp</b> Food service waste	Extremely low	Extremely low	Extremely low	Extremely low
<b>Exp</b> Consumer waste	Extremely low	Extremely low	Extremely low	Extremely low

### *Commercial fruit crops*

#### *Commercial fruit crops near utility points*

The proportions of the five utility points near commercial fruit crops of wheat bug are shown in Table 110. The commercial crops for wheat bug are wheat, brassicas and strawberries that are located in different areas to fruit crops such as apple, pear and stonefruit. For wheat bug the proximity estimates were based on proximity to grain and vegetable crops as well as fruit crops. It was estimated that commercial fruit crops are very unlikely to be located near orchard wholesalers, and extremely unlikely to be near urban wholesalers, retailers, food service and consumers as most of these are in metropolitan areas.

The relative amount of infested/infected apples, or pests, or contaminated packaging material discharged or discarded from different utility points to near nursery plants of wheat bug is indicated in Table 111.

#### *Exposure to host*

The commercial fruit crops of the wheat bug include brassicas, wheat and strawberries.

A successful exposure of wheat bug to its hosts means that a mated female would need to lay her eggs in the soil and the hatched nymphs need to find a host. The chance for this to happen depends on several factors, including the level of infestation/infection, suitability of the soil

<sup>89</sup> As indicated in the method section, waste includes discharged or discarded infested/infected apples, or an escaped pest, or contaminated packaging material.

for egg laying, mortality during egg development, and availability and susceptibility of suitable hosts.

As shown in Table 112, it was considered that the probability that exposure of commercial fruit crops would result from discharge or the discarding of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would all be extremely low. Other supporting evidence is provided in the text below.

**Exp** commercial fruit crops  
from orchard wholesaler waste

**Extremely low**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from orchard wholesalers: **Extremely low**.

- Commercial crops such as brassicas, wheat and strawberries are readily available in commercial farms.

**Exp** commercial fruit crops  
from urban wholesaler waste

**Extremely low**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from urban wholesalers: **Extremely low**.

- Commercial fruit crops are not located in urban areas.
- Urban wholesaler waste is disposed into bins and taken to landfills. Commercial fruit crops are unlikely to be located adjoining these sites.

**Exp** commercial fruit crops  
from retailer waste

**Extremely low**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from retailers: **Extremely low**.

- Most retailers are located in urban areas and are not close to commercial fruit crops.
- Retailer waste may be used for composting in rural areas and some of these sites may be near commercial orchards.

**Exp** commercial fruit crops  
from food service waste

**Extremely low**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from food services: **Extremely low**.

- Most food service outlets are located in metropolitan and suburban areas and are not close to commercial fruit crops. Waste produced by food service outlets in metropolitan and suburban areas is generally disposed of in landfills remote from commercial fruit crops.

**Exp** commercial fruit crops  
from consumer waste  
**Extremely low**

The probability that exposure of commercial fruit crops would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from consumers: **Extremely low**.

- The majority of consumers are located in metropolitan and suburban areas. Waste produced by people in metropolitan areas and some in urban areas is generally disposed of in landfills. Commercial fruit crops would usually not be adjoining these sites.
- Households and population densities around commercial orchards are very low.
- Some consumer waste in suburban and rural areas may be utilised for composting. Commercial fruit crops can be close to compost heaps.

*Nursery plants*

*Nursery plants near utility points*

The proportions of the five utility points near nursery plants of wheat bug are shown in Table 110. It was estimated that nursery plants are very unlikely to be located near retailers and extremely unlikely to be near orchard wholesalers, urban wholesalers, food services and consumers.

The relative amount of waste apples discharged or discarded near nursery plants of wheat bug is indicated in Table 111.

*Exposure to host*

The nursery plants of the wheat bug include brassicas, broom, strawberries and various grasses. A successful exposure of wheat bug to its hosts means that a mated female would need to lay her eggs in the soil and the hatched nymphs need to find a host. The chance for this to happen depends on several factors, including the level of infestation/infection, suitability of the soil for egg laying, mortality during egg development, and availability and susceptibility of suitable hosts.

As shown in Table 112, it was considered that the probability that exposure of nursery plants would result from discharge or the discarding of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would be extremely low or negligible. Other supporting evidence is provided in the text below.

**Exp** nursery plants from  
orchard wholesaler waste  
**Extremely low**

The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from orchard wholesalers: **Extremely low**.

- Nurseries would not be located near wholesaler waste disposal sites.

<p><b>Exp</b> nursery plants from urban wholesaler waste</p> <p><b>Extremely low</b></p>	<p>The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from urban wholesalers: <b>Extremely low</b>.</p> <ul style="list-style-type: none"> <li>There are rare instances of nurseries being located near urban waste dumps.</li> </ul>
<p><b>Exp</b> nursery plants from retailer waste</p> <p><b>Extremely low</b></p>	<p>The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from retailers: <b>Extremely low</b>.</p> <ul style="list-style-type: none"> <li>Nursery plants are for sale in major retail outlets.</li> <li>Retail garden nurseries have a high density of a range of plant materials in a small area. They often maintain a high hygienic standard, usually fogging with insecticide, to prevent insect and mite attacks.</li> <li>A number of fresh food markets will have nursery plants near apple fruit. However, there are a limited number of nurseries associated with fresh food markets that also maintain or store actively growing apple trees.</li> <li>Most of the waste from retail outlets and urban retailers is collected on a regular basis and disposed of in landfill.</li> </ul>
<p><b>Exp</b> nursery plants from food service waste</p> <p><b>Extremely low</b></p>	<p>The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from food services: <b>Extremely low</b>.</p> <ul style="list-style-type: none"> <li>Most food service industries are located in urban areas. There are instances of nurseries being located near food services.</li> <li>However, food service industry waste is disposed of in bins and taken to landfills. Nursery plants are unlikely to be near these sites.</li> </ul>
<p><b>Exp</b> nursery plants from consumer waste</p> <p><b>Extremely low</b></p>	<p>The probability that exposure of susceptible nursery plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from consumers: <b>Extremely low</b>.</p> <ul style="list-style-type: none"> <li>Most consumers are in metropolitan and suburban areas and their waste is generally disposed of in landfills.</li> <li>Nurseries are generally not located near these sites.</li> </ul>

### *Household and garden plants*

#### *Household and garden plants near utility points*

The proportions of the five utility points near household and garden plants of wheat bug are shown in Table 110. It was estimated that household and garden plants are very unlikely to be near consumers, and extremely unlikely to be near orchard wholesalers, urban wholesalers, retailers and food services.

The relative amount of waste apples discharged or discarded near household and garden plants of wheat bug is indicated in Table 111.

*Exposure to host*

The household and garden plants of the wheat bug include broom, strawberries, clovers, various grasses and annual weeds. A successful exposure of wheat bug to its hosts means that a mated female would need to lay her eggs in the soil and the hatched nymphs need to find a host. The chance for this to happen depends on several factors, including the level of infestation/infection, suitability of the soil for egg laying, mortality during egg development, and availability and susceptibility of suitable hosts.

As shown in Table 112, it was considered that the probability that exposure of household and garden plants would result from discharge or the discarding of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would be extremely low or negligible. Other supporting evidence is provided in the text below.

**Exp** household and garden  
plants from orchard wholesaler  
waste

**Extremely low**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from orchard wholesalers: **Extremely low**.

- Orchard wholesale waste sites are mostly located within the orchard premises and are not located near household and garden plants.

**Exp** household and garden  
plants from urban wholesaler waste

**Extremely low**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from urban wholesalers: **Extremely low**.

- Urban wholesaler waste is disposed of in landfill sites, which are generally not near residential properties.

**Exp** household and garden  
plants from retailer waste

**Extremely low**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from retailers: **Extremely low**.

- Retailer waste would be disposed of in landfills, which are generally not near residential properties.

**Exp** household and garden  
plants from food service waste

**Extremely low**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from food services: **Extremely low**.

- Food service industries are unlikely to have host plants susceptible to wheat bug within their premises.
- Waste from food services is disposed of in landfills sites.



**Exp** household and garden  
plants from consumer waste

**Extremely low**

The probability that exposure of susceptible household plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from consumers: **Extremely low**

- Most consumers are in metropolitan and suburban areas and their waste is usually disposed into landfills that are generally not near household and garden plants.
- However, utilisation of waste to make compost is becoming a common practice in some suburban and rural households rather than disposing of all waste into landfill.
- Some hosts of wheat bug are commonly grown as garden plants in the temperate regions of Australia.

*Wild and amenity plants*

*Wild and amenity plants near utility points*

The proportions of the five utility points near household and garden plants of wheat bug are shown in Table 110. It was estimated that household and garden plants are very unlikely to be near consumers, and extremely unlikely to be near orchard wholesalers, urban wholesalers, retailers and food services.

The relative amount of waste apples discharged or discarded near wild and amenity plants of wheat bug is indicated in Table 111.

Exposure to host

The wild and amenity plants of the wheat bug include broom, annual weeds, clovers and various grasses. A successful exposure of wheat bug to its hosts means that a mated female would need to lay her eggs in the soil and the hatched nymphs need to find a host. The chance for this to happen depends on several factors, including the level of infestation/infection, suitability of the soil for egg laying, mortality during egg development, and availability and susceptibility of suitable hosts.

As shown in Table 112, it was considered that the probability that exposure of wild and amenity plants would result from discharge or the discarding of a single infested/infected apple, an escaped pest, or contaminated packaging material from different utility points would be extremely low or negligible. Other supporting evidence is provided in the text below.

**Exp** wild and amenity plants  
from orchard wholesaler waste

**Extremely low**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from orchard wholesalers: **Extremely low**.

- Orchard wholesale waste sites are mostly located within the orchard premises and some wild and amenity plants such as various grasses and clover susceptible to wheat bug could be close to orchard wholesalers.
- Susceptible feral plants such as various grasses may be present near orchard wholesalers' waste disposal sites.

**Exp** wild and amenity plants  
from urban wholesaler waste

**Extremely low**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from urban wholesalers: **Extremely low**.

- Urban wholesale waste is disposed of in landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds.

**Exp** wild and amenity plants  
from retailer waste

**Extremely low**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from retailers: **Extremely low**.

- Retailer waste would be disposed of in landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds.

**Exp** wild and amenity plants  
from food service waste

**Extremely low**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from food services: **Extremely low**.

- Food service waste is disposed of in bins and taken to landfills. Seedlings originating from seeds dispersed by birds could be present.

**Exp** wild and amenity plants  
from consumer waste

**Extremely low**

The probability that exposure of susceptible wild plants would result from discharge or discard of a single infested/infected apple, an escaped pest, or contaminated packaging material from consumers: **Extremely low**.

- Most consumers are in metropolitan and suburban areas and their waste is disposed of in landfills. Susceptible hosts may grow in the wild near these sites as a result of dispersal of seeds by birds.
- Consumers discard apple cores in the environment or in bins in parks. Bins for waste in parks may not be removed on a daily basis and, if so, would provide a sheltered environment for the insect.
- Seedlings of apple and other host plants can establish from discarded fruit or seeds. However, population densities of susceptible wild and amenity plants in parks, near recreational facilities and along roadsides may be low.
- Consumers who consider apple cores to be biodegradable indiscriminately discard them in the environment. Spoiled apples or cores discarded into the wild are likely to be isolated.

### ***Conclusion—probability of distribution***

The partial probability of distribution from each of the utility points to each of the exposure groups is summarised in Table 113. These were calculated by the simulation model using

@risk. The quantitative model evaluated the effect of the ‘volume of trade’ during a specified period when calculating the partial probability of distribution.

**Table 113 Partial probabilities of distribution (PPD)<sup>90</sup> for wheat bug**

UTILITY POINTS	PPD			
	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Orchard wholesalers</b>	Extremely low	Extremely low	Extremely low	Extremely low
<b>Urban wholesalers</b>	Extremely low	Extremely low	Extremely low	Extremely low
<b>Retailers</b>	Very low	Low	Very low	Very low
<b>Food services</b>	Very low	Very low	Very low	Very low
<b>Consumers</b>	Low	Low	High	High
<b>Overall PPD</b>	<b>Low</b>	<b>Moderate</b>	<b>High</b>	<b>High</b>

### Probability of establishment or spread

The assessment for the probability of establishment or spread is carried out in the following manner. Firstly, partial probability for establishment and for spread was assessed separately based on the relevant available scientific information. Secondly, the conclusions for the combined partial probability of establishment or spread for each of the four exposure groups are provided at the end of this section. The relevant information for the assessment for the probability of establishment or spread is presented below against the factors listed in ISPM 11, Rev. 1.

#### *Partial probability of establishment*

ISPM 11 factor	Relevant information
<b>Availability of suitable hosts, alternate hosts and vectors in the PRA area</b>	<ul style="list-style-type: none"> <li>Wheat bug is an adaptable feeder and it can feed on almost any cultivated plant as well as a variety of annual weeds (Eyles, 1965; Gurr, 1957).</li> <li>Many of these host plants are widely available in Australia.</li> </ul>
<b>Suitability of the environment</b>	<ul style="list-style-type: none"> <li>The wheat bug is endemic to New Zealand and occurs throughout the country (Eyles and Ashlock, 1969; Gurr, 1952), where climatic conditions are similar to those of Australia.</li> <li>The environment (e.g. suitability of climate, soil, pest and host competition) in Australia would therefore be suitable for the</li> </ul>

<sup>90</sup> Partial probability of distribution is actually referring to the probability of entry, and was estimated by @risk.

ISPM 11 factor	Relevant information
<b>The potential for adaptation of the pest</b>	<p>establishment of wheat bug.</p> <ul style="list-style-type: none"> <li>The success of the wheat bug may be linked with flexibility in behaviour and habitat used arising from a series of options during the life cycle. 'It is mobile and polyphagous, feeding on a succession of annual weeds and crops; eggs are buried in the ground or attached to seed heads; adults exploit resources at the breeding site or emigrate to new habitats; second generation adults may diapause or reproduce; migrants to overwintering sites may choose from large areas of relatively exposed habitat or restricted numbers of very sheltered sites. One at least of these options will allow survival under harsh conditions while other options allow exploitation of good conditions' (Farrell and Stufkens, 1993).</li> <li>As an agricultural pest, the wheat bug is difficult to control because it breeds and overwinters in fallow land outside commercial crops.</li> <li>Wheat bug usually overwinters as an adult (Gurr, 1952) and undergoes reproductive diapause, which is induced by shortening day lengths during late summer (Farrell and Stufkens, 1993).</li> </ul>
<b>The reproductive strategy of the pest</b>	<ul style="list-style-type: none"> <li>Wheat bug only reproduces sexually and produces three or four generations per season in the field (Eyles, 1965).</li> <li>Wheat bug survives the winter period in New Zealand by overwintering as adults in a quiescent state (Eyles, 1965).</li> <li>There is a courtship period ranging from five minutes to three days with previously unmated adults but thereafter the courtship period is brief or non-existent (Eyles, 1965).</li> <li>Females oviposit as soon as the ovaries mature (Eyles, 1965).</li> </ul>
<b>Minimum population needed for establishment</b>	<ul style="list-style-type: none"> <li>If the female finds a suitable site to lay its eggs in the soil, a new population can start from the nymphs hatched from these eggs.</li> </ul>
<b>Cultural practices and control measures</b>	<ul style="list-style-type: none"> <li>Pest control programs are similar between New Zealand and Australia. Integrated Pest Management (IPM) and Integrated Fruit Production (IFP) programs are utilised in the production of Australian apples (APAL, 2003). Similarly New Zealand orchardists employ IFP in the production of their fruit (Anonymous, 2002b; ENZA, 2003).</li> <li>New Zealand growers are encouraged to 'keep areas around packhouses or areas used for standing bins weed free' to minimise the wheat bug risk (Sale, 2003).</li> </ul>

*Conclusion—partial probability of establishment*

Based on the above evidence, partial probability of establishment for each of the exposure groups is assessed as follows.

Partial probability of establishment for commercial fruit crops: **High**.

Partial probability of establishment for nursery plants: **Moderate**.

Partial probability of establishment for household and garden plants: **High**.

Partial probability of establishment for wild and amenity plants: **High**.

### ***Partial probability of spread***

<b>ISPM 11 factor</b>	<b>Relevant information</b>
<b>Suitability of natural and/or managed environment</b>	<ul style="list-style-type: none"> <li>Wheat bug occurs all over New Zealand including Chatham and Three Kings Islands (Eyles and Ashlock, 1969). There are similar environments in Australia that would be suitable for its spread.</li> </ul>
<b>Presence of natural barriers</b>	<ul style="list-style-type: none"> <li>Both the adult male and female are winged and are capable of flight.</li> <li>The commercial crops of wheat bugs are located in many parts of Australia. Natural barriers such as arid areas, climatic differentials and long distances exist between these areas. There is little information on the ability of wheat bug to spread beyond natural barriers. The long distances existing between the main Australian commercial crops would make it difficult for wheat bug to disperse directly from one area to another unaided.</li> <li>The highly polyphagous nature of this species should enable individuals to locate suitable hosts in the intervening areas.</li> </ul>
<b>Potential for movement with commodities or conveyances</b>	<ul style="list-style-type: none"> <li>Wheat bug has been intercepted on apples being exported to the USA from New Zealand in 2002 (MAFNZ, 2003b). This shows that wheat bug can be moved around with harvested fruit.</li> </ul>
<b>Intended use of the commodity</b>	<ul style="list-style-type: none"> <li>Apples would be used mostly for consumption by humans and would be widely distributed around the country.</li> <li>If wheat bug has contaminated the fruit, they will be transferred with the fruit around the country.</li> </ul>
<b>Potential vectors of the pest</b>	<ul style="list-style-type: none"> <li>Wheat bug does not require a vector for its spread as adults are capable of independent flight.</li> </ul>
<b>Potential natural enemies</b>	<ul style="list-style-type: none"> <li>There is no information of parasitoids of wheat bug and the relevance of potential natural enemies in Australia is not known.</li> </ul>

### ***Conclusion—partial probability of spread***

Based on the above evidence, partial probability of spread for each of the exposure groups is assessed as follows.

Partial probability of spread for commercial fruit crops: **High**

Partial probability of spread for nursery plants: **High**

Partial probability of spread for household and garden plants: **High**

Partial probability of spread for wild and amenity plants: **High**

**Combined partial probability of establishment or spread**

The combined partial probability of establishment or spread was determined by combining probabilities of establishment and probabilities of spread using the matrix of ‘rules’ for combining descriptive likelihoods as presented in the method section. The results are indicated in Table 114.

**Table 114 Combined partial probabilities of establishment or spread of wheat bug**

	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
<b>Establishment</b>	High	Moderate	High	High
<b>Spread</b>	High	High	High	High
<b>PPES<sup>91</sup></b>	High	Moderate	High	High

Additional evidence to support the combined partial probability of establishment or spread for specific exposure groups is provided in the text below.

<b>Commercial fruit crops</b>	<ul style="list-style-type: none"> <li>Wheat bug is an important pest of wheat (Gurr, 1957) and <i>Brassica</i> crops (Ferguson, 1994).</li> </ul>
<b>High</b>	<ul style="list-style-type: none"> <li>Commercial crops of these two hosts are widely distributed in Australia.</li> </ul>
<b>Susceptible nursery plants</b>	<ul style="list-style-type: none"> <li>Hosts such as cruciferous plants (<i>Brassica</i> species) and strawberry seedlings are widely sold in Australian nurseries for the household gardener.</li> </ul>
<b>Moderate</b>	<ul style="list-style-type: none"> <li>Seedlings are available only during a limited period of the year particularly in spring in temperate regions.</li> </ul>
<b>Susceptible household and garden plants</b>	<ul style="list-style-type: none"> <li>Many of the host plants listed for wheat bug grow in Australian household gardens as annual weeds, so there are numerous hosts available.</li> </ul>
<b>High</b>	
<b>Susceptible wild and amenity plants</b>	<ul style="list-style-type: none"> <li>Since wheat bug is a temperate endemic New Zealand insect, climatic factors would affect its establishment or spread in Australia.</li> </ul>
<b>High</b>	<ul style="list-style-type: none"> <li>Many host plants of wheat bug are found growing wild in Australia, such as species of <i>Rumex</i>, <i>Polygonum</i>, <i>Trifolium</i> and <i>Medicago</i>.</li> </ul>

<sup>91</sup> PPES = partial probability of establishment or spread.

- Wheat bugs are capable of short flight, and feed on numerous commercial crops as well as annual weeds.

## Assessment of consequences

Impact scores allocated for the direct and indirect criteria are shown in Table 115. Available supporting evidence is provided in the text below.

**Table 115 Impact scores for wheat bug**

Direct impact	Impact scores
Plant life or health	E
Human life or health	A
Any other aspects of the environment	A
Indirect impact	
Control or eradication	D
Domestic trade or industry	D
International trade	D
Environment	B
Communities	A

### Direct impact

#### Plant life or health – E

Consequences affecting plant life or health are of minor significance at the national level. Thus a rating of ‘E’ was assigned to this criterion.

- Wheat bug is polyphagous feeding on 18 species of plant both economic (such as wheat, brassicas, clovers and lucerne) and non-economic (Eyles, 1965).
- Wheat is the most important crop for Australian agriculture.
- There is limited evidence that wheat bug damages fruit in commercial orchards, particularly in Canterbury. Fruit damage is characterised by a pimple, often within a shallow depression. More severe fruit distortion is suspected if the wheat bugs cause damage during the flowering period (HortResearch, 1999b).
- All life stages are present throughout the year in New Zealand. Three or four overlapping generations occur annually in the field.

#### Human life or health – A

There are no known direct impacts of wheat bug on human life or health and the rating assigned to this criterion was therefore ‘A’.

**Any other aspects of environmental effects**  
– A

There are no known direct impacts of wheat bug on any other aspects of the environment and a rating of ‘A’ was assigned to this criterion.

**Indirect impact**

**Control or eradication**  
– D

The indirect impact on new or modified eradication, control, surveillance/monitoring and compensation strategies is unlikely to be discernable at the national level and of minor significance at the regional level. A rating of ‘D’ was assigned to this criterion.

- In New Zealand wheat bug is controlled by the application of organophosphate insecticides.
- Although the wheat bug has been reasonably well-studied in New Zealand, it would be essential to provide resources to study the pest under Australian conditions should it become established in Australia.
- As the wheat bug feeds on many hosts around the orchard it would be difficult to control once it became established.

**Domestic trade – D**

The indirect consequences on domestic trade are unlikely to be discernable at the national level and of minor significance at the regional level. A rating of ‘D’ was assigned to this criterion.

- The presence of wheat bug in Australia could result in trade restrictions in the movement of fruit between States.

**International trade – D**

The indirect consequences on international trade are unlikely to be discernable at the national level and of minor significance at the regional level. A rating of ‘D’ was assigned to this criterion.

- Wheat bug is considered as a quarantine pest of New Zealand apple exported to the USA and consignments on which this pest are detected are denied entry to this market (Lay-Yee *et al.*, 1997).
- If wheat bug were to establish in Australia, it would also become a quarantine pest for Australian produce.
- Consumers in the European Community (including the UK) expect the production of food to be based on environmentally friendly techniques that promote sustainable methods with minimal impact on the environment and reduced use of pesticides (Batchelor *et al.*, 1997; Lo *et al.*, 1997). The establishment of wheat bug in Australia would result in an increase in the use of pesticides for their control that would result in consumers in the premium European markets rejecting Australian produce on the basis of environmentally unsustainable practices.

**Environment – B**

The indirect consequences on the environment would not be discernable at the national level and of minor significance at the local level and a rating of ‘B’ was assigned to this criterion.

- The impact on the environment caused by wheat bug can result



from its chemical control, or feeding damage on native plants.

- Control of wheat bug is primarily dependent on the application of insecticides in conventional New Zealand orchards.
- Insecticide use would increase if the wheat bug became established in Australia and this would have an undesirable impact on the environment.
- The establishment or spread of wheat bug in native vegetation would result in a cost for environmental restoration associated with an eradication program.
- The introduction of wheat bug into a new environment such as Australia may lead to competition for resources with native species.

#### **Communities – A**

There are no recorded social effects resulting from the presence of wheat bug and a rating of ‘A’ was assigned to this criterion.

#### ***Conclusion—consequences***

Based on the decision rule described in the method section, i.e. where the consequences of a pest with respect to one or more criteria are ‘E’, the overall consequences are considered to be ‘moderate’. Therefore the overall consequences of wheat bug are **moderate**.

#### **Unrestricted annual risk**

Unrestricted annual risk is the result of combining annual probability of entry, establishment or spread with the outcome of overall consequences. Probabilities and consequences are combined using the ‘rules’ shown in the risk estimation matrix in the method section. The unrestricted annual risk estimation for wheat bug is shown in Table 116.

**Table 116 Risk estimation for wheat bug**

Overall probability of entry, establishment or spread <sup>92</sup>	<b>High</b>
Consequences	<b>Moderate</b>
Unrestricted annual risk	<b>Moderate</b>

As indicated in Table 116, the unrestricted annual risk for wheat bug is moderate, which is above Australia's appropriate level of protection (ALOP) of very low. Therefore, risk management would be required for this pest.

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<sup>92</sup> Calculated by @risk.

## RISK MANAGEMENT FOR QUARANTINE PESTS

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This section evaluates risk management options available to manage the pest risk identified in the risk assessment to meet Australia's ALOP. This included the risk of pests for the whole of Australia and those pests of specific concern to Western Australia.

In the *Risk Assessment for Quarantine Pests* the unrestricted risk of each quarantine pest was estimated, to ascertain whether it exceeded Australia's ALOP ('very low'). In cases where the unrestricted risk was found to be 'very low' or 'negligible', the risk was considered acceptable, and it was concluded that no risk management measures were required for that pest. The unrestricted biosecurity risk in relation to the importation of apples from New Zealand was estimated to exceed Australia's ALOP for certain pests and it was concluded that risk management measures would be required. Those pests are:

### **Whole of Australia**

- Fire blight (*Erwinia amylovora*).
- European canker (*Nectria galligena*).
- Apple leafcurling midge (*Dasineura mali*).
- Brownheaded leafroller (*Ctenopseustis herana*).
- Brownheaded leafroller (*Ctenopseustis. obliquana*).
- Greenheaded leafroller (*Planotortrix excessana*).
- Greenheaded leafroller (*Planotortrix octo*).
- Wheat bug (*Nysius huttoni*).

### **Western Australia**

- Apple scab (*Venturia inaequalis*).
- Codling moth (*Cydia pomonella*).

## GENERAL INTRODUCTION

The phytosanitary measures discussed below are predicated on the application the industry's orchard, packing house and transport management practices described in the information provided by the New Zealand Ministry of Agriculture and Forestry (MAFNZ), including the Integrated Fruit Production (IFP) Manual. These practices are discussed in the datasheets and risk assessments for individual pests. Therefore, while many of these measures are currently performed on a voluntary basis such practices will be mandatory for export to Australia.

The measures examined below for fire blight, European canker, apple scab, apple leafcurling midge, leafrollers, wheat bug and codling moth together with the necessary procedures required to implement the measures, are the proposed import conditions for New Zealand apples. As a result the import conditions are detailed in the section entitled *Draft Operational Framework*.

In the section Method for Import Risk Analysis, it was noted that certain procedures performed by AQIS on-arrival (Imp8) for quarantine pests associated with apples would be

considered part of the minimum on-arrival border procedures. It is important to note that it is only appropriate for the unrestricted risk assessments to take into account the minimum border procedures used by relevant government agencies and not those measures approved by such agencies that are intended to mitigate risks associated with the commodity itself. The minimum procedures include verifying that the commodity is as described in the shipping documents and identifying external and internal contaminations of containers and packaging. Wood packaging and dunnage such as pallets from New Zealand are subject to a full unpack, quarantine inspection and treatment if necessary at an appropriate quarantine approved premises, or are subject to a pre-shipment or on-arrival treatment (AQIS, 2000). In order to have least trade restrictive measures, the starting point for evaluation of the restricted risk management options first considered the use of a 600-unit inspection in detecting quarantine pests requiring risk management, and the subsequent remedial actions or treatments that might be applied if a pest is intercepted.

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

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

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

### **FIRE BLIGHT**

New Zealand would export mature apples free from visible fire blight symptoms and trash. As previously described, production procedures and pest management practices in apple orchards and packing house processes used in New Zealand are intended to ensure that apples for export are free from visible symptoms of fire blight and trash. The freedom of fruit from visible fire blight symptoms and trash would be verified by inspection.

The risk pathways of concern for fire blight with apples for export are epiphytic infestation or endophytic infection of fruit with *E. amylovora*. Such fruit rarely express symptoms. Therefore inspection at Imp6 or Imp8 cannot be used in evaluation of options to reduce the likelihood of entry, establishment or spread.

A sensitivity analysis of the unrestricted risk scenario for fire blight found the number of infested/infected fruits likely to be imported to be influenced by the following ordered elements:

- Imp 5—the likelihood that clean fruit is contaminated by *E. amylovora* during processing in the packing house;
- Imp3—the likelihood that clean fruit is contaminated by *E. amylovora* during harvesting and transport to the packing house;
- Imp4—the likelihood that *E. amylovora* survives the routine processing procedures in the packing house; and,
- Imp2—the likelihood that picked fruit is infested/infected with *E. amylovora*.

Therefore measures that could reduce the likelihood allocated to these steps were sought.

Sourcing apples for export from areas established, maintained and verified free from *E. amylovora* (pest free areas) in accordance with the guidelines outlined in ISPM 4 would reduce the likelihood of several of these steps to negligible and thereby mitigate the risks. However this option was not considered feasible given the pest is widely distributed in apple growing areas of New Zealand and there is no feasible way to verify if the bacteria are present in the orchard or not.

However, individual apple orchards in New Zealand can be maintained free from fire blight disease symptoms (areas free from disease symptoms) by various management practices. Such orchards are known to have lower levels of bacteria associated with fruit than orchards where symptoms are evident. Similarly, treatment with chlorine and cold storage of apples has been reported to reduce bacterial numbers. Therefore the following options were evaluated to mitigate the risk of fire blight:

- Source apples for export from individual orchards free from fire blight disease symptoms (areas free from disease symptoms)
- Disinfest apples for export with 100 ppm chlorine for one minute at pH 5–6 (chlorine treatment)
- Store apples for export at a cool temperature of 0–4°C for six weeks (cold storage)
- Combinations of areas free from disease symptoms, chlorine treatment or cold storage (systems approaches).

### **Areas free from disease symptoms**

Areas free from disease symptoms as distinct from pest free areas could be established and maintained following the guidelines described in the ISPM 4 and 10. An area free from disease symptoms could be a place of production (an orchard managed as a single unit) or a production site (a designated block within an orchard) for which freedom from fire blight symptoms is established, maintained and verified by MAFNZ.

Endophytic infection of fruit has been recorded, albeit rarely from fruit sourced from infected orchards (van der Zwet *et al.*, 1990) but it has not been recorded in orchards free from symptoms of fire blight in New Zealand. Endophytic populations of *E. amylovora* were not recovered from mature fruit at harvest (Dueck, 1974a; Roberts *et al.*, 1989; Roberts, 2002). Therefore, the risk associated with export fruit sourced from orchards free from symptoms would be limited to surface contamination of fruit and infested calyxes. However, in studies conducted by Clark *et al.* (1993), using a specific DNA hybridisation method with a detection

level of about  $10^2$  cfu per calyx and 60,000 immature apple fruit were tested from orchards free of fire blight symptoms, *E. amylovora* was not detected. Such fruit, when mature would not have bacteria in the calyxes but may have surface contaminants. Such research is evidence that, sourcing fruit from areas free from disease symptoms would reduce the likelihood that picked fruit is infected or infested (Imp2). The model indicates that it would change the very low likelihood rating assigned to Imp2 in the unrestricted risk assessment to extremely low. With lower bacterial populations in areas free from disease symptoms, the likelihood that clean fruit is contaminated during picking or transport to the packing house (Imp3) could be expected to be reduced to extremely low. This is because the orchard would be free from cankers and infected leaves, which could otherwise provide bacterial ooze for contamination of fruit. Similarly, the likelihood that clean fruit is contaminated during the processing in the packing house (Imp5) would also be extremely low for export apples sourced from symptom-free areas.

When the modified likelihoods for Imp2, Imp3 and Imp5 were placed in the model, and the assessment for fire blight was repeated, the restricted annual likelihood of entry, establishment or spread was found to be low (Table 117). When this was combined with the estimate of consequences of high for fire blight, the restricted risk for this pest was found to be low, which still exceeds Australia's ALOP. Therefore, the use of areas free from visible fire blight symptoms for sourcing export apples would not be an effective risk management measure by itself.

**Table 117 Effect of orchards free from fire blight symptoms**

Step	Unrestricted likelihood	Restricted likelihood
<b>Imp2</b>	Very low	<b>Extremely low</b>
<b>Imp3</b>	Very low	<b>Extremely low</b>
<b>Imp5</b>	Very low	<b>Extremely low</b>
<b>PEES</b>	Low	<b>Very low</b>
<b>Risk estimate</b>	Moderate	<b>Low</b>

### **Chlorine treatment**

Chlorine is known to have strong biocidal properties against a wide range of living organisms (Dychdala, 1991). It is used as a disinfectant in drinking water and washing applications, for reducing microbial contamination of food products and for general surface disinfestation. In relation to post-harvest handling of fruit and vegetables, chlorine treatments are usually targeted against organisms that cause spoilage and those that affect human health. Chlorine is highly effective against non-spore-forming bacteria but also, to a lesser extent, against spore-forming-bacteria, fungi, algae, protozoa and viruses (Sykes, 1958; Dychdala, 1991). Hale and Clark (1992) demonstrated that chlorine treatment at 100 ppm is effective in killing *E. amylovora*.

Chlorine treatment could be applied in the routine packing house process by incorporating chlorine in the floatation tanks and maintaining the chlorine concentration at a minimum of

100 ppm. In the unrestricted risk assessment for fire blight, the effect of chlorine treatment at the importation step 4 (Imp4) was assessed knowing that this measure is not adopted by all packing houses and the chlorine concentration varies across packing houses. If all packing houses were to use minimum of 100 ppm chlorine treatment, then the risk of *E. amylovora* being present in/on apples for export would be reduced. Bacteria occurring as surface contaminants on the fruit and associated soil, trash, etc. would be killed when exposed for one minute to 100ppm chlorine treatment in the packing house. However, the chlorine treatment would not be fully effective against bacteria protected in the tissue, including those occurring in infested calyxes or in symptomless infected fruit.

Therefore, Chlorine treatment would reduce the likelihood allocated to steps Imp4 and Imp5. Because chlorine treatment would kill *E. amylovora* on the fruit surface and to some extent in the calyx, the likelihood that the pest would survive on apples following the treatment at the Imp4 step would become low as compared with the moderate rating in the unrestricted risk assessment for fire blight.

Chlorine treatment would also have a significant effect on the likelihood of contamination of clean fruit in the packing house (Imp5) given that the treatment would kill *E. amylovora* on the surface of fruit and in the dump tank. Any bacteria surviving the chlorine treatment, i.e., particularly those in infested calyxes or within symptomless fruit, would generally not be a source of contamination of other clean fruit at this step. The likelihood that clean fruit treated with chlorine would be contaminated (Imp5) would become extremely low.

Although chlorine can eliminate all bacteria in some situations, there is evidence that its effectiveness could be only partial in horticultural and agricultural situations. There is also some doubt about the efficacy of chlorine on bacteria in the calyxes because air pockets could prevent access of chlorine especially in closed-calyx fruit. Hence, Imp4 and Imp5 were lowered only one step, and not further, when chlorine was considered.

When the modified likelihoods for Imp4 and Imp5 were placed in the model, and the assessment for fire blight was repeated, the restricted annual likelihood of entry, establishment or spread was found to be very low (Table 118). When this was combined with the estimate of consequences of high for fire blight, the restricted risk for this pest was found to be low, which still exceeds Australia's ALOP. The use of the chlorine treatment alone would, therefore, not be an effective risk management measure.

**Table 118 Effect of chlorine treatment on *E. amylovora***

Step	Unrestricted likelihood	Restricted likelihood
Imp4	Moderate	Low
Imp5	Very low	Extremely low
PEES	Low	Very low
Risk estimate	Moderate	Low

### **Cold storage**

The level of infection and infestation of apple fruit by *E. amylovora* declines over time during storage, normally at low temperatures of 0–4°C (Sholberg *et al.*, 1988; Hale and Taylor, 1999; Roberts, 2002; Taylor and Hale, 2003).

In the unrestricted risk assessment for fire blight, the effect of cold storage at the importation step 4 (Imp4) was assessed knowing that cold storage for short and varying periods occurs in all packing houses. However, it is known that cold storage will reduce the survival of *E. amylovora* in calyxes of both inoculated (Hale and Taylor, 1999; Taylor and Hale, 2003) and naturally infested fruit (Hale and Taylor, 1999). Consequently, if all packing houses were required to adopt cold storage for a six-week period, then this measure will reduce the bacteria present on the surface and in the calyx region of fruit (Taylor and Hale, 2003). However, the effect of cold storage on internal infection is unknown, and there is no evidence that cold storage alone would completely eliminate all bacteria in the calyx. Therefore, with cold storage alone in place, the likelihood that bacteria would survive routine packing house operations would become low.

When the modified likelihood for Imp4 was placed in the model, and the assessment for fire blight was repeated, the restricted annual likelihood of entry, establishment or spread was found to be low (Table 119). When this was combined with the estimate of consequences of high for fire blight, the restricted risk for this pest was found to be moderate, which still exceeds Australia's ALOP. The use of cold storage alone would, therefore, not be an effective risk management measure.

**Table 119 Effect of cold storage on *E. amylovora***

Step	Unrestricted likelihood	Restricted likelihood
Imp4	Moderate	Low
PEES	Low	Low
Risk estimate	Moderate	Moderate

### **Systems approaches**

Systems approaches comprise the integration of different risk management measures, at least two of which act independently, and which cumulatively achieve the appropriate level of protection (ISPM 14). An advantage of the systems approach is the ability to address variability and uncertainty by modifying the number and strength of measures to provide the desired level of protection and confidence. Because none of the individual measures discussed above, on their own reduced the risk of fire blight to within Australia's ALOP, the following systems approaches were examined.

- Areas free from disease symptoms and chlorine treatment: Source apples for export from orchards free from fire blight disease symptoms (areas free from disease symptoms) and disinfest apples for export with chlorine (chlorine treatment)



- Areas free from disease symptoms and cold storage: Source apples for export from orchards free from fire blight disease symptoms (areas free from disease symptoms) and store apples for export at a low temperature (cold storage)
- Chlorine treatment and cold storage: Disinfest apples for export with chlorine (chlorine treatment) and store apples for export at a low temperature (cold storage)
- Areas free from disease symptoms and chlorine treatment and cold storage: Source apples for export from orchards free from fire blight disease symptoms (areas free from disease symptoms), disinfest apples for export with chlorine (chlorine treatment) and store apples for export at a low temperature (cold storage).

### **Areas free from disease symptoms and chlorine treatment**

The combination of these two measures was examined to reduce the risk of fire blight at steps Imp2, Imp3, Imp4 and Imp5, as described above.

Although apple trees may not show fire blight symptoms, *E. amylovora* could be present at low levels in areas free from disease symptoms (Imp2). There is therefore a likelihood that leaves would have an extremely low level of bacterial population, which may result in contamination of clean fruit at harvest (Imp3). Although chlorine would kill surface bacteria, it would partially reduce the bacteria in the calyx or symptomless infected fruit. Because chlorine is only partially effective, bacteria can survive (Imp4) and contaminate clean fruit during routine processing in the packing house (Imp5).

This systems approach using these measures reduced the restricted risk estimate to low, which still exceeds Australia's ALOP (Table 120)

**Table 120 Effect of areas free from disease symptoms/chlorine treatment on *E. amylovora***

Step	Unrestricted likelihood	Restricted likelihood
Imp2	Very low	<b>Extremely low</b>
Imp3	Very low	<b>Extremely low</b>
Imp4	Moderate	<b>Low</b>
Imp5	Very low	<b>Extremely low</b>
PEES	Low	<b>Very low</b>
<b>Risk estimate</b>	Moderate	<b>Low</b>

### **Areas free from disease symptoms and cold storage**

The combination of these two measures was examined to reduce the risk of fire blight at steps Imp2, Imp3, Imp4 and Imp5, as described above.

Imp2, Imp 3 and Imp5 would not be altered by cold treatment, and sourcing fruit for export from areas free from disease symptoms would not alter Imp4.

This systems approach reduced the restricted risk estimate to low, which still exceeds Australia's ALOP (Table 121).

**Table 121 Effect of areas free from disease symptoms and cold storage on *E. amylovora***

Step	Unrestricted likelihood	Restricted likelihood
Imp2	Very low	Extremely low
Imp3	Very low	Extremely low
Imp4	Moderate	Low
Imp5	Very low	Extremely low
PEES	Low	Very low
<b>Risk estimate</b>	Moderate	Low

### **Chlorine treatment and cold storage**

The combination of these two measures was examined to reduce the risk of fire blight at steps Imp4 and Imp5.

As explained previously, chlorine treatment alone would reduce Imp5 to extremely low. The combination of chlorine treatment and cold storage would reduce Imp4 to very low because both chlorine and cold treatment would independently reduce the likelihood that *E. amylovora* would survive the packing house procedures. Whilst Imp4 for chlorine treatment for cold storage would be low it was considered that the combination of these measures would reduce Imp4 to very low because some bacteria that would survive the chlorine would be killed by cold storage.

However, this systems approach only reduced the restricted risk estimate to low, which still exceeds Australia's ALOP (Table 122).

**Table 122 Effect of chlorine treatment and cold storage on *E. amylovora***

Step	Unrestricted likelihood	Restricted likelihood
Imp4	Moderate	Very low
Imp5	Very low	Extremely low
PEES	Low	Very low
<b>Risk estimate</b>	Moderate	Low

### **Areas free of disease symptoms and chlorine treatment and cold storage**

The combination of these three measures would reduce the risk of fire blight at steps Imp2, Imp4 and Imp5.

The effect of sourcing fruit from export areas free from disease symptoms on Imp2 and Imp3 was explained previously. The likelihood of Imp4 and Imp5 would be reduced by the combination of chlorine treatment has been discussed before. These likelihoods would be further reduced if apples for export were sourced from an area free from disease symptoms. Death of bacteria in cold storage is time-dependant. The number of viable *E. amylovora* cells would be reduced to a negligible level by sourcing apples carrying low levels of *E. amylovora* and keeping them in cold storage for six weeks. Taylor and Hale (2003) showed that *E. amylovora* on apple calyxes infected with  $10^2$  cfu decreased to non-culturable levels in eight days in cold storage and *E. amylovora* was not detected by PCR after cold storage for 20 days.

This systems approach would reduce the restricted risk estimate to very low, which meets Australia's ALOP (Table 123).

**Table 123 Effect of areas free from disease symptoms and chlorine treatment and cold storage on *E. amylovora***

Step	Unrestricted likelihood	Restricted likelihood
Imp2	Very low	<b>Extremely low</b>
Imp3	Very low	<b>Extremely low</b>
Imp4	Moderate	<b>Extremely low</b>
Imp5	Very low	<b>Negligible</b>
PEES	Low	<b>Extremely low</b>
<b>Risk estimate</b>	Moderate	<b>Very low</b>

### **Conclusions: risk management for fire blight**

There were no individual measures identified that would by themselves reduce the risk associated with fire blight to within Australia's ALOP.

Risk was then estimated using various combinations of the three risk management measures discussed above and the results are summarised in Table 124. It was found that the risk associated with *E. amylovora* would be reduced below Australia's ALOP only by the combination of all these measures. The overall effect of a systems approach is based on the combination of the efficacy of the required independent measures. It would therefore be necessary to ensure that measures are in place to establish, maintain and verify that the areas from which fruit would be sourced are free from visible disease symptoms. The concentration of available chlorine in the dump tank must be maintained at a minimum of 100 ppm for a minimum period of one minute, pH adjusted to 5–6, and fruit cold-stored at 0–4°C for a minimum period of six weeks.

**Table 124 Risk management options for fire blight showing effect of areas free of disease symptoms, chlorine treatment and cold storage**

Areas free of disease symptoms	Chlorine treatment	Cold storage	Risk estimate
+	-	-	Low
-	+		Low
-	-	+	Moderate
+	+	-	Low
+	-	+	Low
-	+	+	Low
+	+	+	Very low

+ = *measure applied*.

- = *measure not applied*.

## EUROPEAN CANKER

New Zealand would export mature apples free from disease symptoms and trash. As previously described, production procedures and pest management practices in apple orchards and packing house processes used in New Zealand would ensure that apples for export are free from visible symptoms of European canker. The freedom of fruit from visible European canker symptoms and trash would be verified by inspection.

However, the risk pathway of concern for apples for export with regard to European canker is symptomless infection and infestation of fruit that cannot be detected by inspection. Therefore inspection at Imp6 and Imp8 cannot be used in the evaluation of options to reduce the risk resulting from symptomless infection or infestation by *N. galligena*.

A sensitivity analysis of the unrestricted risk scenario for European canker found the number of infested/infected fruits imported to be most influenced by the following in that order:

- Imp5—the likelihood that clean fruit is contaminated by *N. galligena* during processing in the packing house;
- Imp6—the likelihood that *N. galligena* survives palletisation, quality inspection, containerisation and transportation to Australia;
- Imp8—the likelihood that *N. galligena* survives and remains with the fruit after on-arrival minimum border procedures;
- Imp4—the likelihood that *N. galligena* survives the routine processing procedures in the packing house; and,
- Imp2—the likelihood that picked fruit is infested/infected with *N. galligena*.

Sensitivity to Imp6 and Imp8 is resulting from the moderate and high likelihood allocated to these two steps respectively, which in turn was due to the fact that inspection cannot detect

symptomless infection and infestation. Therefore as said earlier, it is not possible to mitigate the annual risk through management of Imp6 and Imp8.

In the unrestricted risk assessment for European canker Imp4 was assessed considering all the procedures that take place in New Zealand's packing houses. This includes the use of sanitisers and short-term cold storage by some packing houses. There is no evidence in the literature showing any ability of these procedures to mitigate symptomless infection. Therefore, it is not feasible to seek measures to reduce the likelihood allocated to Imp4.

Therefore, the following options were evaluated to mitigate the annual risk by reducing the likelihood allocated to Imp2 and Imp5. Imp1 will also be influenced by the first option.

- Source apples for export from orchards free from *N. galligena* (pest free areas).
- Source apples for export from orchards free from European canker disease symptoms (disease free areas).

### **Pest free areas**

Freedom from *N. galligena* within apple orchards from which apples for export to Australia would be sourced would influence likelihoods for steps Imp1, Imp2 and Imp5 in the importation pathway.

Area freedom, as described in the IPPC ISPM 4 and 10 and as discussed above, would require, among other things, systems by MAFNZ to establish, maintain and verify freedom, including assurance that the pest was absent at the time of harvest and that it had not been reported within a specified before harvest. Freedom from European canker could be established by regular inspections during the growing season and be subject to audit.

It was considered that under area freedom arrangements, the likelihood that *N. galligena* would be present in an orchard from which apples would be sourced (Imp1), the likelihood that picked fruit would be infected/infested with the pest (Imp2), or the likelihood that clean fruit is contaminated during processing in the packing house (Imp5) would be negligible. When these modified (restricted) likelihoods were placed in the risk simulation model, and the assessment for European canker repeated, the restricted annual likelihood of entry, establishment or spread was found to be very low. When this was combined with the estimate of consequences of moderate for European canker, the restricted risk for European canker was found to be negligible. Because this satisfies Australia's ALOP, apples could safely be imported from pest free areas.

The efficacy of pest free areas as a risk management option for European canker is summarised in Table 125.

**Table 125 European canker: effect of establishment of pest free areas**

Step	Unrestricted likelihood	Restricted likelihood
Imp1	Low	Negligible
Imp2	Extremely low	Negligible
Imp5	Extremely low	Negligible
PEES	Low	Extremely low
Risk estimate	Low	Negligible

While the option of a pest free area is available as a measure for European canker, delimitation, establishment and maintenance of pest free areas for European canker would need to be relevant to the biology of *N. galligena* including its means of spread, as well as the characteristics of a production place (orchard) or site (block within a place of production).

Nursery stock appears to be a major pathway of spread for European canker in New Zealand. Recent detections in Nelson (Murdoch, 2002) and Hawke's Bay (Wilton, 2002b) are considered to have been as a result of this pathway.

Studies in the UK have confirmed that infection that enters orchards through nursery stock can remain symptomless for 3–4 years (Lovelidge, 2003; McCracken *et al.*, 2003b). This observation would make it difficult to establish and confirm pest free areas. Therefore, this measure may not be a technically feasible option.

### **Areas free from disease symptoms**

This measure would require that apple production areas, including places or sites of production, free from European canker disease symptoms are established, maintained and verified by MAFNZ. New Zealand could use various measures to maintain disease free status of a production area, including use of cultural practices or fungicide sprays.

MAFNZ would be required to provide assurances that the disease had not been reported in areas deemed to be free from disease symptoms in the current growing season and that apples for export are free from symptoms of European canker. Freedom from European canker could be established by regular inspections during the growing season and be subject to audit.

In the unrestricted risk assessment for European canker, the likelihood of canker infection occurring on apple fruit was considered to be extremely low in commercial orchards in New Zealand. Apples sourced from areas free from disease symptoms would therefore be relatively less likely to be infected or infested with *N. galligena* when compared with apples produced under the unrestricted risk scenario. It was considered that the likelihood that picked fruit is infected or infested with *N. galligena* (Imp2) would be extremely low for fruit sourced from orchards, which were maintained free from European canker disease symptoms in the current growing season. It is not considered negligible in this instance because it has been claimed that the disease that gets into trees through nurseries can remain symptomless for 3–4 years (Lovelidge, 2003, McCracken *et al.*, 2003b).

The likelihood that clean fruit is contaminated during processing in the packing house (Imp5) would be negligible for export apples sourced from areas free of disease symptoms.

When the modified likelihoods for Imp2 and Imp5 were used in the model, and the assessment for European canker was repeated, the restricted annual likelihood of entry, establishment or spread was found to be very low (Table 126). When this was combined with the estimate of consequences of moderate for European canker, the restricted risk for this pest was found to be very low, which is within Australia's ALOP. Therefore the use of areas free from disease symptoms for sourcing export apples would be an effective risk management measure for *N. galligena*.

**Table 126 European canker: effect of establishment of disease free areas**

Step	Unrestricted likelihood	Restricted likelihood
Imp2	Very low	Extremely low
Imp5	Extremely low	Negligible
PEES	Low	Very low
<b>Risk estimate</b>	Low	Very low

### **Conclusions: risk management for European canker**

The risk of *N. galligena* could be managed to an acceptable level within Australia's ALOP by sourcing apples for export from areas free from disease symptoms (orchards or blocks free from symptoms of European canker). This risk management strategy would be technically feasible in New Zealand. It is proposed that areas free from disease symptoms would be established and maintained by MAFNZ and be would be subject to audit tests.

## **APPLE SCAB**

Risk management measures for apple scab (*Venturia inaequalis*) would be required only for imports of New Zealand apples into Western Australia as the disease is already present in other parts of Australia where it is not subject to official control. The pathogen is likely to be imported into Western Australia as conidia on scabby or pin-point lesions on the fruit and not be detected by inspection. In addition, symptomless infections of fruit can develop into lesions and produce conidia after imported fruit has been released from quarantine.

Sensitivity analysis indicated the number of infected/infested apples imported (Importation pathway) to be most influenced by the following in that order:

- Imp4—the likelihood that *V. inaequalis* survives the routine processing procedures in the packing house;
- Imp2—the likelihood that picked fruit is infested/infected with *V. inaequalis*; and,
- Imp5—the likelihood that clean fruit is contaminated by *V. inaequalis* during processing in the packing house.

In the unrestricted risk assessment for apple scab Imp4 was assessed considering all the procedures that take place in New Zealand's packing houses. This includes the use of

sanitisers and short-term cold storage by some packing houses. There is no evidence in the literature showing any ability of these procedures to mitigate symptomless infection. Therefore, it is not feasible to seek measures to reduce the likelihood allocated to Imp4.

The likelihood allocated to Imp2 and Imp5 could be reduced by the following options.

- Source apples for export from orchards free from *V. inaequalis* (pest free areas).
- Source apples for export from orchards free from apple scab disease symptoms (disease free areas).

### **Pest free areas**

Freedom from *V. inaequalis* within apple orchards from which apples for export to Australia would be sourced would affect likelihoods for several steps (Imp1, Imp2, Imp3 and Imp5) in the importation pathway.

Area freedom as described in the IPPC ISPM 4 and 10 and as discussed above, would require, among other things MAFNZ to have , systems to establish, maintain and verify freedom, including assurance that the pest was absent at the time of harvest and that it had not been reported within a specified period prior to harvest. Freedom from apple scab could be verified by inspections during the growing season and be subject to audit.

It was considered that under area freedom arrangements, the likelihood that *V. inaequalis* would be present in a orchards from which apples would be sourced (Imp1), the likelihood that an apple fruit would be infected with the pest (Imp2), the likelihood that clean fruit is contaminated during picking or transport to the packing house (Imp3), or the likelihood that clean fruit is contaminated during processing in the packing house (Imp5) would be negligible. When these modified (restricted) likelihoods were placed in the risk simulation model, and the assessment for apple scab repeated, the restricted annual likelihood of entry, establishment or spread was found to be extremely low. When this was combined with the estimate of disease consequences, the restricted risk for apple scab was found to be negligible. Because this restricted risk is acceptable, apples could safely be imported from pest free areas.

The efficacy of pest free areas as a risk management strategy for apple scab is summarised in Table 127.

**Table 127 Apples scab: effect of establishment of pest free areas**

Step	Unrestricted likelihood	Restricted likelihood
Imp1	High	Negligible
Imp2	Very low	Negligible
Imp3	Extremely low	Negligible
Imp5	Extremely low	Negligible
PEES	Low	Extremely low
<b>Risk estimate</b>	Low	Negligible



However, while area freedom is available as a risk management measure for apple scab, delimitation, establishment and maintenance of a pest free area would need to be relevant to the biology of *V. inaequalis*, including its means of spread, as well as the characteristics of a production place (orchard) or site (block within a place of production). As such, this measure may not be a technically feasible option because *V. inaequalis* is widely distributed in New Zealand and it can be disseminated, among other things, by wind over distances of around 50 metres or more.

### **Areas free from disease symptoms**

This measure would require that apple production areas, including places or sites of production, free from apple scab disease symptoms are established, maintained and verified by MAFNZ, as previously described for fire blight. New Zealand could use various measures to maintain symptom-free status of a production area. This would include use of cultural practices or fungicide sprays to prevent infection by *V. inaequalis* spores that could be blown into designated areas free from disease symptoms from outside sources of inoculum, for example, apple or other host plants of the pest.

MAFNZ would be required to provide assurances that the disease had not been reported in areas free from disease symptoms in the current growing season and that apples for export are free from symptoms of apple scab. Freedom from apple scab could be established by inspections during the growing season and be subject to audit.

In the unrestricted risk assessment for apple scab, the likelihood of scab infection occurring on apple fruit was considered to be very low in commercial orchards in New Zealand. It was also discussed that apples develop resistance to scab infection when they mature (Keitt and Jones, 1926). Mature apples sourced from areas free from disease symptoms would therefore be relatively less likely to be infected or infested with *V. inaequalis* when compared with apples produced under the unrestricted risk scenario. It was considered that the likelihood that picked fruit is infected or infested with *V. inaequalis* (Imp2) would be extremely low for fruit sourced from orchards, which were maintained free from apple scab disease symptoms in the current growing season.

The likelihood of contamination of clean fruit at Imp3 would be negligible for fruit sourced from disease free areas. The likelihood that clean fruit is contaminated during the processing in the packing house (Imp5) would be negligible for export apples sourced from disease free areas.

When the modified likelihoods for Imp2, Imp3 and Imp5 were placed in the model, and the assessment for apple scab was repeated, the restricted annual likelihood of entry, establishment or spread was found to be very low (Table 128). When this was combined with the estimate of consequences of moderate for apple scab, the restricted risk for this pest was found to be very low, which is acceptable. The use of areas free from disease symptoms for sourcing export apples would, therefore, be an effective risk management measure for *V. inaequalis*.

**Table 128 Apple scab: effect of areas free from disease symptoms**

Step	Unrestricted likelihood	Restricted likelihood
Imp2	Very low	Extremely low
Imp3	Extremely low	Negligible
Imp5	Extremely low	Negligible
PEES	Low	Very low
Risk estimate	Low	Very low

**Conclusions: risk management for apple scab**

Risk management for *V. inaequalis* is only necessary for apple imports into WA. The risk of *V. inaequalis* could be managed to an acceptable level by sourcing apples for export from areas free from disease symptoms (orchards or blocks free from symptoms of apple scab disease). It would be technically more difficult to establish and maintain pest free areas in New Zealand that would comply with the guidelines described in ISPM 4 and 10. Sourcing apples for export from areas free from disease symptoms would be more feasible but would require MAFNZ to put in place systems for establishing, maintaining and verifying disease free status of the designated areas.

**APPLE LEAFCURLING MIDGE**

The risk scenario of concern for ALCM is the mature larvae and pupae on apple fruit. The mature larvae and pupae are inside a tough and white silken cocoon and attached to the stem-end or calyx-end of the apple fruit. Mature larvae are bright orange-red in colour and pupae brown in colour and thus they are clearly visible. Therefore, inspection at Imp6 and Imp8 was evaluated for its effectiveness in detecting ALCM.

ALCM is considered a quarantine pest by Australia, therefore, growers and producers in New Zealand are expected, as part of the IFP program, to monitor and control this pest so that fruit presented for export is free of ALCM.

Phytosanitary actions will be taken where verification inspections onshore or offshore find that the fruit is not free of ALCM. Such action could be: withdrawing the consignment from export to Australia, re-export of the consignment from Australia, destruction of the consignment, or, treatment of the consignment to ensure that the pest is no longer viable.

**Verification inspection**

Verification inspection of fruit is to inspect 600 units of randomly selected sample from a homogeneous consignment (or lot). This would provide a confidence level of 95% that not

more than 0.5% of the units in the consignment are infested/infected by the pest. The inspection can be undertaken in New Zealand (Imp6) or in Australia (Imp8).

In the unrestricted risk assessment, the likelihood for Imp6 or Imp8 was **high** because inspection was absent. If no mature larvae or pupae of ALCM are detected at the verification inspection, the consignment would pass inspection and the likelihood of Imp6 or Imp8 would be **very low**.

When the modified likelihood of very low for Imp6 or Imp8 was placed in the model respectively, and the assessment for ALCM was repeated, the restricted overall probability of entry, establishment or spread (PEES) was found to be very low (Table 129). When this was combined with the estimate of consequences of ALCM, the restricted risk for this pest was found to be negligible, which is within Australia's ALOP.

**Table 129 Apple leafcurling midge: Restricted likelihood for consignments that pass verification inspection**

Step	Unrestricted likelihood	Restricted likelihood
Imp6 or Imp8	High	Very low
PEES	Moderate	Very low
Risk estimate	Low	Negligible

### **Conclusion: risk management for apple leafcurling midge**

Consignments inspected and found to be free of ALCM will not require risk management measures to be applied.

When a consignment is found to be infested/infected with ALCM at inspection in New Zealand, the risk will be managed to an acceptable level within Australia's ALOP by the following phytosanitary action:

- withdrawing the consignment from export to Australia.

Alternatively, when a consignment is found to be infested/infected with ALCM at inspection on arrival in Australia, the risk will be managed to an acceptable level within Australia's ALOP by the following phytosanitary actions:

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

### **LEAFROLLERS (4 SPECIES)**

There are four species of leafrollers.

- Brownheaded leafroller (*Ctenopseustis herana*).
- Brownheaded leafroller (*C. obliquana*).
- Greenheaded leafroller (*Planotortrix excessana*).
- Greenheaded leafroller (*P. octo*).

The risk scenario of concern for these leafrollers is the larvae being present on or occasionally inside the apple fruit. Larvae of these leafrollers are visible, 20–25 mm long. External frass or webbing produced by larvae are also visible. However, where the external frass or webbing is removed, there would be a chance that visual inspection may not detect the larvae inside the fruit. However, it was considered that this is very unlikely because there would still be entry holes on the fruit to indicate the presence of the larvae inside. Therefore, inspection at Imp6 and Imp8 was evaluated for its effectiveness in detecting these leafrollers.

The four species of leafrollers are considered quarantine pests by Australia, therefore, growers and producers in New Zealand are expected, as part of the IFP program, to monitor and control these pests so that fruit presented for export is free of these leafrollers.

Phytosanitary actions will be taken where verification inspections onshore or offshore find that the fruit is not free of leafrollers. Such actions could be: withdrawing the consignment from export to Australia, re-export of the consignment from Australia, destruction of the consignment, or, treatment of the consignment to ensure that the pest is no longer viable.

### **Verification inspection**

Verification inspection of fruit is to inspect 600 units of randomly selected sample from a consignment (or lot). This would provide a confidence level of 95% that not more than 0.5% of the units in the consignment are infested/infected by the pest. The inspection can be undertaken in New Zealand (Imp6) or in Australia (Imp8).

In the unrestricted risk assessment, the likelihood for Imp6 or Imp8 was **high** because inspection was absent. If no larvae or frass, or entry hole of leafrollers are detected at the verification inspection, the consignment would pass inspection and the likelihood of Imp6 or Imp8 would be considered to be **low**. (Note that the likelihood was low not very low because the very unlikely chance that visual inspection may not detect the larvae inside the fruit was taken into account).

When the modified likelihood of low for Imp6 or Imp8 was placed in the model respectively, and the assessment for the leafrollers was repeated, the restricted overall probability of entry, establishment or spread (PEES) was found to be very low (Table 130). When this was combined with the estimate of consequences of the leafrollers, the restricted risk for this pest was found to be very low, which meets Australia's ALOP.

**Table 130 Leafrollers: Restricted likelihood for consignments that pass verification inspection**

Step	Unrestricted likelihood	Restricted likelihood
Imp6 or Imp8	High	Low
PEES	Moderate	Low
Risk estimate	Low	Very Low

**Conclusion: risk management for leafrollers**

Consignments inspected and found to be free of these leafrollers will not require risk management measures to be applied.

When a consignment is found to be infested/infected with the leafrollers at inspection in New Zealand, the risk will be managed to an acceptable level within Australia's ALOP by the following phytosanitary action:

- withdrawing the consignment from export to Australia.

Alternatively, when a consignment is found to be infested/infected with the leafrollers at inspection on arrival in Australia, the risk will be managed to an acceptable level within Australia's ALOP by the following phytosanitary actions:

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

**WHEAT BUG**

The risk scenario of concern for wheat bug is the contamination by adults of apple fruit and pallets. The risk of contamination of pallets would be addressed because wood packaging and dunnage such as pallets from New Zealand are subject to a full unpack and quarantine inspection and treatment if necessary at an appropriate quarantine approved premises, or are subject to a pre-shipment or on-arrival treatment. The measures discussed below are to address the risk of contamination of the fruit by wheat bugs.

Wheat bug is not considered as a pest in apple orchards and therefore, growers and producers in New Zealand are not expected, as part of the IFP program, to monitor and control this pest. Therefore, the following options were evaluated for wheat bug:

- Pest prevalence monitoring and control; and,
- Verification inspection.

Phytosanitary actions will be taken where verification inspections onshore or offshore find that the fruit is not free of wheat bug. Such actions could be: withdrawing the consignment from export to Australia, re-export of the consignment from Australia, destruction of the consignment, or, treatment of the consignment to ensure that the pest is no longer viable.

**Pest prevalence monitoring and control**

The factors relevant to the ability of wheat bug to contaminate clean fruit include the pest prevalence in and around the orchards and packing house during harvest. Wheat bug shelters under weeds, particularly wire weed and twin cress, growing on hard ground such as loading areas and yards around orchard and packing house. From these protected situations wheat bug can readily move into bins of fruit, or pallets of packed trays awaiting loading. Pest monitoring prior to harvest would provide an indication of the prevalence of the wheat bug in the orchards and surrounding areas.

In the unrestricted risk assessment, the likelihood that clean fruit is contaminated by wheat bug during harvesting and transport of apples to the packing house (Imp3) was **low**. It was

considered that the likelihood that clean fruit is contaminated by wheat bug during harvesting and transport of apples to the packing house (Imp3) would be reduced to **very low** if effective hygiene practices were implemented to reduce weeds that harbour wheat bug.

When the modified likelihood for Imp3 was placed in the model, and the assessment for wheat bug was repeated, the restricted overall annual likelihood of entry, establishment or spread was found to be **moderate** (Table 131). When this was combined with the estimate of consequences of wheat bug, the restricted risk for this pest was found to be moderate, which is still above Australia's ALOP.

**Table 131 Wheat Bug: effects of pest prevalence monitoring and control**

Step	Unrestricted likelihood	Restricted likelihood
Imp3	Low	Very low
PEES	High	Moderate
<b>Risk estimate</b>	Moderate	Moderate

### **Verification inspection**

Verification inspection of fruit is to inspect 600 units of randomly selected sample from a consignment (or lot). This would provide a confidence level of 95% that not more than 0.5% of the units in the consignment are infested/infected by the pest. The inspection can be undertaken in New Zealand (Imp6) or in Australia (Imp8).

In the unrestricted risk assessment, the likelihood for Imp6 or Imp8 was **high** because inspection was absent. If wheat bugs is detected at the verification inspection, the consignment would pass inspection and the likelihood of Imp6 or Imp8 would be **very low**.

When the modified likelihood of very low for Imp6 or Imp8 was placed in the model respectively, and the assessment for ALCM was repeated, the restricted overall probability of entry, establishment or spread (PEES) was found to be very low (Table 132). When this was combined with the estimate of consequences of wheat bug, the restricted risk for this pest was found to be low, which is still above Australia's ALOP.

**Table 132 Wheat Bug: Restricted likelihood for consignments that pass verification inspection**

Step	Unrestricted likelihood	Restricted likelihood
Imp6 or Imp8	High	Very Low
PEES	High	Low
<b>Risk estimate</b>	Moderate	Low

### **Combinations of Pest prevalence monitoring and control and verification inspection**

As pest prevalence monitoring and control alone discussed above was considered to be insufficient in reducing the risk of this pest to meet Australia's ALOP, the combinations of this measure with verification inspection are examined below.

When both Pest prevalence monitoring and control and Verification inspection were implemented, the modified likelihood for both Imp3 and Imp6 or Imp8 would become **very low**. When these modified ratings were placed in the model respectively, and the assessment for wheat bug was repeated, the restricted overall annual likelihood of entry, establishment or spread was found to be **very low** (Table 133). When this was combined with the estimate of consequences of wheat bug, the restricted risk for this pest was found to be very low, which meets Australia's ALOP.

**Table 133 Wheat Bug: pest prevalence monitoring and control and pre-export inspection in New Zealand**

Step	Unrestricted likelihood	Restricted likelihood
Imp3	Low	Very low
Imp6 or Imp8	High	Very Low
PEES	High	Very Low
<b>Risk estimate</b>	Moderate	Very Low

### **Conclusion: risk management for wheat bug**

As discussed above, pest prevalence monitoring and control alone would be insufficient to reduce the unrestricted risk to an acceptable level within Australia's ALOP. However, combination of this measure with verification inspection would be sufficient to manage the risk of wheat bug.

After pest prevalence monitoring and control is implemented, consignments inspected and found to be free of wheat bug will not require risk management measures to be applied.

After pest prevalence monitoring and control is implemented, when a consignment is found to be infested/infected with wheat bug at inspection in New Zealand, the risk will be managed to an acceptable level within Australia's ALOP by the following phytosanitary action:

- withdrawing the consignment from export to Australia.

Alternatively, after pest prevalence monitoring and control is implemented, when a consignment is found to be infested/infected with wheat bug at inspection on arrival in Australia, the risk will be managed to an acceptable level within Australia's ALOP by the following phytosanitary actions:

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

## **CODLING MOTH**

Risk management measures for codling moth would be required only for imports of New Zealand apples into Western Australia. Imports of New Zealand apples into areas of Australia where codling moth is present would not require management measures.

The risk concern for codling moth in this IRA is the larva living inside the apple fruit. The larva enters the fruit at any point on its surface, though more often through the exposed side. It tunnels to the seeds, which are eaten, and extensive damage is done in and around the core. The tunnels usually contain frass (faecal pellets), though some frass is removed to the outside where it protrudes from the entry hole. Although the larva inside the fruit can not be seen but the damage they cause on the fruit, or frass they produced, or their entry hole would be visible. However, where the external frass or webbing are removed, there would be a chance that visual inspection may not detect the larva. However, it was considered that this is very unlikely because there would still be entry holes on the fruit (usually on exposed side) to indicate the presence of the larvae inside. Therefore, inspection at Imp6 and Imp8 was considered to be adequate to detect codling moth.

The codling moth is considered a quarantine pest for Western Australia, therefore, growers and producers in New Zealand are expected, as part of the IFP program, to monitor and control these pests so that fruit presented for export to Western Australia is free of codling moth.

Phytosanitary actions will be taken where verification inspections onshore or offshore find that the fruit is not free of codling moth. Such actions could be: withdrawing the consignment from export to Western Australia, re-export of the consignment from Western Australia, destruction of the consignment, or, treatment of the consignment to ensure that the pest is no longer viable.

### **Verification inspection**

Verification inspection of fruit is to inspect 600 units of randomly selected sample from a consignment (or lot). This would provide a confidence level of 95% that not more than 0.5% of the units in the consignment are infested/infected by the pest. The inspection can be undertaken in New Zealand (Imp6) or in Western Australia (Imp8).

In the unrestricted risk assessment, the likelihood for Imp6 or Imp8 was **high** because inspection was absent. If no larvae or frass, or entry hole of codling moth are detected at the verification inspection, the consignment would pass inspection and the likelihood of Imp6 or Imp8 would be considered to be **low**. (Note that the likelihood was low not very low because the very unlikely chance that visual inspection may not detect the larvae was taken into account).

When the modified likelihood of low for Imp6 or Imp8 was placed in the model respectively, and the assessment for codling moth was repeated, the restricted overall probability of entry, establishment or spread (PEES) was found to be very low (Table 134). When this was combined with the estimate of consequences of codling moth, the restricted risk for this pest was found to be very low, which meets the ALOP.



**Table 134 Codling Moth: Restricted likelihood for consignments that pass verification inspection**

Step	Unrestricted likelihood	Restricted likelihood
Imp6 or Imp8	High	Low
PEES	Moderate	Low
<b>Risk estimate</b>	Low	Very Low

**Conclusion: risk management for codling moth**

Consignments inspected and found to be free of codling moth will not require risk management measures to be applied.

When a consignment is found to be infested/infected with the leafrollers at inspection in New Zealand, the risk will be managed to an acceptable level within the ALOP by the following phytosanitary action:

- withdrawing the consignment from export to Western Australia.

Alternatively, when a consignment is found to be infested/infected with the leafrollers at inspection on arrival in Western Australia, the risk will be managed to an acceptable level within the ALOP by the following phytosanitary actions:

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

**CONCLUSION OF RISK MANAGEMENT FOR ALL PESTS**

The risk assessment identified six insects, one bacterium and one fungus associated with the importation of apples from New Zealand that require management measures to reduce the risk to an acceptable level. In addition, one insect and one fungus require measures for importation into Western Australia as these pests, although present in other parts of Australia, are not present in Western Australia where measures are in place to maintain area freedom.

Inspection does not mitigate the risk of a pest but it is the remedial actions or treatments that can be taken based on the results of the inspection that would reduce a pest risk. Table 135 provides a summary of the management measures and phytosanitary procedures for all pests.

**Table 135 Management measures or phytosanitary procedures for all pests**

No.	Measure or phytosanitary procedure	Fire blight	European canker	Apple leafcurling midge	Leafrollers	Wheat bug	Apple scab	Codling moth
1	Areas free of disease symptoms	+	+				+	
2	Areas with low pest prevalence					+		
3	Chlorine treatment	+						
4	Cold storage	+						
5	Verification inspection in New Zealand			+	+	+		+
6	Verification inspection on-arrival in Australia			+	+	+		+
7	On-arrival verification procedures	+	+	+	+	+	+	+
8	Options for rejected consignments			+	+	+	+	+

The biosecurity measures proposed to manage the identified risks from the above quarantine pests are summarised below. These measures were considered to be the least trade restrictive and to manage risks to a level within Australia's appropriate level of protection, which is very low.

**Measures and phytosanitary procedures applied to all pests comprise:**

- registration of export orchards, exporters and packing houses;
- packing, labelling and storage compliance;
- phytosanitary certification by MAFNZ;
- verification inspection in New Zealand or Australia; and,
- on-arrival verification procedures by the Australian Quarantine and Inspection Service (AQIS) for compliance with packaging requirements and import conditions.

**Measures and phytosanitary procedures for specific quarantine pests comprise:***Fire blight*

- MAFNZ to provide assurance that apples are sourced from areas free of disease symptoms determined, for example, by surveillance.
- chlorine treatment of fruit; and,
- cold storage treatment of fruit.

*European canker*

- MAFNZ to provide assurance that apples are sourced from areas free of disease symptoms determined, for example, by surveillance.

*Apple leafcurling midge*

- If apple leafcurling midge is found during the verification inspection the consignment will be either:
  - withdrawn from export to Australia; or
  - re-exported from Australia; or
  - destroyed; or
  - treated to ensure that the pest is no longer viable.

*Leafrollers (four species)*

- If a leafroller is found during the verification inspection the consignment will be either:
  - withdrawn from export to Australia; or
  - re-exported from Australia; or
  - destroyed; or
  - treated to ensure that the pest is no longer viable.

*Wheat bug*

- sourcing apples from areas with low pest prevalence and preventing contamination during handling and processing. Low pest prevalence is determined by data from monitoring and control of the pest by growers or by pre-harvest inspection or surveillance by MAFNZ;
- the application of effective treatment(s) to reduce the pest in and around orchards and packing houses where inspection and surveillance have detected populations; and,
- if wheat bug is found during the verification inspection the consignment will be either:
  - withdrawn from export to Australia; or
  - re-exported from Australia; or
  - destroyed; or
  - treated to ensure that the pest is no longer viable.

*Apple scab*

- MAFNZ to provide assurance that apples are sourced from areas free of disease symptoms determined, for example, by surveillance.

*Codling Moth*

- If codling moth is found during the verification inspection the consignment will be either:
  - withdrawn from export to Western Australia; or
  - re-exported from Western Australia; or
  - destroyed; or
  - treated to ensure that the pest is no longer viable.

The quarantine conditions described below are based on the conclusions from this IRA. Specifically, they are based on the risk management options discussed in the previous section *Risk Management for Quarantine Pests*. The conditions are predicated on minimum standards achieved by orchard, packing house and transport management practices outlined in information provided by MAFNZ and the application of the Integrated Fruit Production (IFP) program. These practices are discussed in the Method for Import Risk Analysis and in the various pest risk assessments.

Biosecurity Australia considers that the quarantine conditions (risk management measures together with phytosanitary procedures) proposed in this section are the least trade restrictive means of ensuring that Australia's ALOP would be met and are commensurate with the identified risks. The numbers in parentheses relate to the measure or operational step as shown in Table 135.

Biosecurity Australia invites technical comments on the economic and practical feasibility of the measures. Equivalent measures to managing risk can also be evaluated. Those seeking to propose alternative risk management measures should provide a submission for consideration; such proposals are welcome and should include supporting scientific data that explain the extent to which alternative measures would meet Australia's ALOP.

### **Recognition of the competent authority**

New Zealand's Ministry of Agriculture, Fisheries and Forestry (MAFNZ) is the designated National Plant Protection Organization (NPPO) under the International Plant Protection Convention (IPPC). MAFNZ is the official plant protection organisation the responsibilities of which include, inspection of plants and plant products moving in international trade, and the issuing of certificates relating to phytosanitary condition and origin of consignments of plants and plant products.

### **Systems for monitoring and surveillance in orchards and packing houses**

All export apple orchards in New Zealand are required to control pests and diseases based on the guidelines provided by the IFP program. Fruit is subject to quality assurance and quarantine inspection.

MAFNZ will ensure that pest surveillance and monitoring activities are undertaken in orchards to maintain freedom from disease symptoms for fire blight, European canker and apple scab and low pest prevalence (practical freedom) of the wheat bug. Implementation of cultural, chemical and biological control measures would be required to maintain disease freedom and low pest prevalence. In addition, measures specified to reduce the pest levels in the packing house will have to be implemented.

## **Pre-export conditions**

### **Import Permit (7)<sup>93</sup>**

- A valid 'Permit to Import Quarantine Material' is required to be obtained from the Australian Quarantine and Inspection Service (AQIS).

### **Quarantine Entry (7)**

- A Quarantine Entry must be lodged with AQIS for import of consignments of fresh apple fruit. An importer or their agent or broker may lodge the Quarantine Entry.

### **Export conditions (1)**

- The conditions will apply to sea and air shipments of fresh apple fruit. Apples will be grown in approved commercial orchards or designated export areas (DEAs) in New Zealand. Registered packing houses will pack fruit for export to Australia.

### **Export orchards (1)**

- All apples for export must be sourced only from registered export orchards.
- MAFNZ is required to register all growers and the orchards involved in the export program prior to the commencement of exports. A unique number must identify each grower and orchard. This will enable trace-back in the event of non-compliance with import conditions. MAFNZ will maintain a register of orchards or DEAs 'Approved for Export to Australia' consisting of information on pest status and disease management. Copies of the registration records must be available for audit by DAFF<sup>94</sup>/MAFNZ, as required.
- MAFNZ will ensure that all export orchards are operating within the Integrated Fruit Production (IFP) Program.

### **Areas free from disease symptoms (1)**

- Apple fruit will only be permitted from approved orchards free of disease symptoms in the current year for fire blight (*E. amylovora*) and European canker (*N. galligena*) and for apple scab (*V. inaequalis*) in the case of exports to Western Australia.
- The orchards free of disease symptoms for fire blight, European canker and apple scab for export to Western Australia would be established under the auspices of MAFNZ, immediately before harvest of fruit intended for export to Australia.
- MAFNZ would ensure the availability of administrative infrastructure, competent personnel and other resources necessary to meet the requirements of the orchard freedom from fire blight, European canker and apple scab based on disease symptoms.
- If symptoms of fire blight, and European canker, and, for export to Western Australia apple scab, symptoms are detected in an orchard registered for export, the affected orchard shall be suspended from the export program.

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<sup>93</sup> The number refers to the management measure in Table 135.

<sup>94</sup> This may include representatives from Biosecurity Australia (BA) or the Australian Quarantine and Inspection Service (AQIS)

**Pest prevalence monitoring and control (2)**

- Apples must be sourced from areas with low pest prevalence for wheat bug.
- Orchards with low pest prevalence of wheat bug would be established by MAFNZ, immediately before harvest of fruit intended for export to Australia.
- MAFNZ would ensure the availability of administrative infrastructure, competent personnel and other resources necessary to meet the requirements to ensure that wheat bug doesn't contaminant fruit harvested for export to Australia.
- If wheat bug is detected in an orchard registered for export or in the surrounding area, the affected orchard and immediate surrounds shall undertake treatment to reduce the incidence of the pest. This will include the removal of weeds and other plant materials that are known to harbour the pest.

**Packing houses (1, 2, 3)**

- MAFNZ will register all exporters and export packing houses before exports commence to maintain quarantine integrity of the commodity, and provide for traceability of consignments should non-compliance with import conditions occur.
- Registered exporters and packing houses must process all apples for export to Australia. Biosecurity Australia requires that packing houses registered for export of apples source fruit only from registered growers and orchards.
- The manager of the packing house will ensure that equipment and storage areas used for handling export apples are clean and are practically free from quarantine pests or other regulated articles before being used to process export fruit.
- The packing house must maintain hygiene standards and weed control to reduce the potential contamination of picked fruit.
- MAFNZ will inspect packing houses during the packing and storage of export apples to monitor and verify that the necessary requirements, including measures to prevent contamination of fruit and packing materials with quarantine pests and other regulated articles, are met.
- MAFNZ will conduct audit checks on approved packing houses to monitor the measures taken to prevent mixing or substituting non-export apples with apples destined for export to Australia.
- The solution in the flotation (dump) tank in the packing station will be continuously maintained at a minimum of 100ppm available chlorine, pH kept between 5 and 6 and kept substantially free of organic matter. The use of a suitable wetting agent may improve the application, and thereby the efficacy of chlorine. Concentration of chlorine will be monitored by an approved technique and records will be audited by MAFNZ.
- Operation of participating packing stations will be approved under ISO 9002 Certification or an approved equivalent.
- MAFNZ will suspend exports from non-compliant packing houses.
- MAFNZ will make available to AQIS, on request, information on its supervisory activities in relation to packing houses.

### **Packaging and labelling (5)**

- All apples for export must be free from trash, extraneous matter and pests of quarantine concern to Australia. Trash refers to soil, splinters, twigs, leaves and other plant material (other than fruit stalks).
- No unprocessed packing material of plant origin will be permitted. Packaging material will include export cartons, trays, bins, any material used to line export cartons or bins, and pallets upon which cartons are stacked, any strapping or other material associated with the export pallet. All packaging (except bins and pallets) must be new.
- All wood material used in packaging of apples must comply with the conditions stipulated in 'Cargo containers: quarantine aspects and procedures' and as contained in the AQIS ICON database.
- Identification of origin of fruit will be displayed on each carton – including orchard identification number (as per register), block identification number, packing house number, date of packing, packing line number, packer identification number and MAFNZ Inspection stamp number. Box stamping requirements will only be necessary for consignments consisting of individual boxes and not complete pallets.
- Palletised product is to be identified by attaching a uniquely numbered pallet card to each pallet or part pallet to enable trace back to registered orchards and packing houses.

### **Storage (4)**

- All packed cartons that are not immediately transported to the wharf must be cold-stored at 0-4°C in the short-term in approved premises practically free from quarantine pests.
- Packed product and packaging is to be protected from pest contamination during and after packing, and during movement between locations.
- Apple fruit for export to Australia must be stored for a minimum period of 6 weeks at 0-4°C. The period in cold storage is to be verified by MZMAF.
- Apple fruit inspected and certified by MAFNZ for export to Australia must be securely stored and segregated from fruit for other destinations, to prevent mixing.
- Security of the consignment is to be maintained until release from quarantine in Australia.

### **Loading and transport**

- Packed cartons will be immediately loaded into a shipping container, or, onto a vehicle and transported to the wharf.
- If packed fruit is not containerised at a packing house, the vehicle cargo area will be covered to prevent contamination with quarantine pests.
- If fruit is not containerised, palletised fruit at the wharf will be stored separately from domestic or other export fruit in areas practically free from quarantine pests.
- Cartons, containers, pallets, transportation vehicle cargo areas, and ship or aircraft holds will be practically free from quarantine pests.
- A consignment will not be split or have its packaging changed while in transit between or while in another country en route to Australia.

**Note:** A consignment is the number of cartons of apples covered by one phytosanitary certificate shipped via one port in New Zealand to a designated port in Australia for one consignee on the same vessel on the same day. An inspection 'lot' is all apple fruit packed for



export to Australia each day by each registered packing house or appropriate configurations as otherwise agreed by Biosecurity Australia/AQIS and MAFNZ.

### **Phytosanitary inspection (5)**

- MAFNZ is to inspect all consignments in accordance with official procedures for all visually detectable quarantine pests and trash. Sample rates must achieve a 95 per cent confidence level that not more than 0.5 per cent of the units (fruit) in the consignment are infected. This equates to a level of zero units infected by quarantine pests in a random sample of 600 units from the homogenous 'lot' in the consignment. The 600-unit sample must be selected randomly from every 'lot' in the consignment. Inspection will require that each fruit in that sample be individually examined. Limited destructive sub-sampling may be required if rots or arthropod pest damage were suspected. The full 600 units selected for inspection will be completed regardless of whether detections are found during the inspection. All fruit will be removed from each selected carton and the empty carton examined for trash.
- If during inspection pests of quarantine concern to Australia or trash were found, fruit from that 'lot' would need to be withdrawn from export unless the 'lot' were able to be traced back to the offending orchard. In this case, only the offending orchard would need to be withdrawn from export. It would result in removal of that orchard from the export program for the remainder of the export season. 'Lots' that fail inspection must be clearly identified with a label indicating that the 'lot' is rejected for export to Australia. Rejected product must be segregated from other apples that are either awaiting inspection or have passed inspection. Fruit not meeting Australian quarantine conditions is not eligible for export to Australia.
- If an organism is detected on New Zealand apples that has not been categorised, it will require assessment to determine its quarantine status and if phytosanitary action is required. The detection of any significant pests of quarantine concern not already identified in the analysis may, depending on the circumstances, result in the suspension of trade while a review is conducted to ensure that measures are implemented that continue to provide the appropriate level of phytosanitary protection for Australia.
- An appropriate Phytosanitary Certificate endorsed by MAFNZ and other relevant documents will accompany each apple fruit consignment.
- MAFNZ will verify that fruit for Australia has been sourced from registered orchards, and complies with Australia's quarantine conditions.
- The relevant Notice of Intent (NOI) number(s) to export apples, annotated with the pallet card numbers of pallets will be included in the consignment.
- Timber packaging and pallets must be certified on the NOI to export apples as having complied with Australian requirements.
- The shipping container number(s) and container seal number(s) must be supplied by MAFNZ.

### **Phytosanitary certification (5, 7)**

- MAFNZ is to issue a phytosanitary certificate for each consignment after completion of the pre-export inspection. Each phytosanitary certificate is to contain the following information:

Additional declarations:

*'The apples in this consignment have been produced in New Zealand in accordance with the conditions governing the entry of fresh apple fruit from New Zealand to Australia.'*

### **Notification**

- MAFNZ will notify AQIS immediately of any notifiable non-compliance, including detection of fire blight symptoms in a registered orchard and details of deregistered orchards.

### **Post-import measures**

#### **Verification of phytosanitary documents (7)**

- AQIS will undertake a documentation compliance examination for consignment verification purposes before release from quarantine.
- The importer must have a valid import permit.
- The shipment must have a phytosanitary certificate that identifies registered orchards and bears the additional declaration.
- No land bridging of consignments will be permitted unless the goods have cleared quarantine.
- Any shipment with incomplete documentation, or certification that does not conform to conditions may be refused entry, with the option of re-export or destruction. AQIS would notify MAFNZ immediately of such action, if taken.

#### **Inspection (5, 8)**

- All consignments will be subject to inspection by AQIS.
- The AQIS officer will select at random from each consignment 600 fruit for inspection. Where a consignment incorporates more than a single 'lot', then each individual 'lot' would be sampled.
- A nil tolerance will apply to quarantine pests and other regulated articles.
- A nil tolerance will apply to trash and extraneous materials, fruit that is not in mature or is damaged.
- If quarantine pests are detected the consignment will be
  - re-exported from Australia; or
  - destroyed; or
  - treated to ensure that the pest is no longer viable.

### **Audits**

- DAFF or MAFNZ may, by mutual agreement, audit the pathway of imported apple fruit at any time.

### **Review of import conditions**

- AQIS may review conditions at any time and may, in consultation with MAFNZ, suspend the importation of apples, if deemed necessary by phytosanitary considerations. A suspension would be reviewed following a joint AQIS, BA and MAFNZ investigation.
- DAFF, in consultation with MAFNZ, will review the import requirements, if circumstances or information warrant such action.

### **Movement of fruit into Western Australia**

- State legislation in Western Australia currently prohibits the importation of apples from other States and Territories in Australia. Biosecurity Australia considers that the risk management measures proposed in this draft IRA report appropriately manage the risks associated with the importation of apples from New Zealand into all States and Territories of Australia. The Western Australian authorities and DAFF will consider specific issues regarding entry of apples into that State.

### **Work plan**

- A draft work plan will be developed between DAFF and MAFNZ following the finalisation of this revised draft IRA.

### **Review of policy**

This policy may be reviewed after the first year or anytime where there is reason to believe that the phytosanitary risk of importing apples to Australia has altered.



## **FURTHER STEPS IN THE IMPORT RISK ANALYSIS PROCESS**

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The administrative process adopted by DAFF requires that the following steps be undertaken:

- release of the revised draft IRA paper for stakeholder comment;
- comment to be received within 60 days;
- consideration of stakeholder comments on the revised draft IRA paper ;
- further stakeholder consultation as necessary;
- preparation of the final IRA paper;
- submission of IRA recommendations to the Director of Animal and Plant Quarantine;
- consideration of the recommendations by the Director of Animal and Plant Quarantine and final determination;
- release of the final IRA paper;
- consideration of appeals, if any; and
- if there are no appeals or the appeals are rejected, adoption of appropriate quarantine policy.

Stakeholders will be advised of any significant variation to the process.

Biosecurity Australia is committed to a thorough risk analysis of the proposed importation of apples from New Zealand. This analysis requires that technical information be gathered from a wide range of sources. If you have information relevant to this IRA process for apples from New Zealand, please provide it as quickly as possible<sup>95</sup>.

### **Acknowledgements**

Biosecurity Australia wishes to acknowledge the extensive work of the Import Risk Analysis Team on this *Revised Draft IRA Report*. Others who deserve special acknowledgement are the technical working group members, and the many scientists, government personnel and apple industry people from Australia and overseas who have contributed in various ways, including collecting and providing technical information.

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<sup>95</sup> Contact details for stakeholder contributions are provided in the accompanying Plant Biosecurity Policy Memorandum (PBPM).



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## **Comment on the Risk Assessment on *Neofabraea malicorticis*, the cause of Bull's-eye rot**

### **Background**

In the revised draft IRA (see Part B), *Neofabraea malicorticis* (syn. *Pezicula malicorticis*) is recorded as being present in Australia, based on published information (APPD, 2004). It is also present in New Zealand (CABI, 2003a). Although this pathogen affects fruit and is on the pathway, it was not considered further in the pest risk assessment, because it did not qualify as a quarantine pest according to the definition of a quarantine pest (ISPM 11. Rev.1).

A study was undertaken by Dr. James H. Cunnington, Primary Industries Research Victoria, Department of Primary Industries, Victoria, Australia, to re-examine herbarium specimens to confirm the identity of all Australian specimens belonging to *N. malicorticis* – *N. perennans* group. Eight isolates were used in the study.

This study was in progress at the time of finalising the revised draft IRA. At that time identification of four isolates was completed. Three isolates from Victoria were identified as *Neofabraea perennans* and another as an undescribed species.

When this revised draft was in the final stages of preparation, a member of the pathogen TWG submitted the manuscript of a paper entitled 'Three *Neofabraea* species on pome fruit in Australia' to Biosecurity Australia. This paper was submitted for publication to the Australasian Plant Pathology. If Biosecurity Australia were to conduct a pest risk assessment, it would require some time to collate the information before doing the PRA. In order to expedite the release of the revised draft IRA, IRAT suggested a preliminary risk assessment to be undertaken on *N. malicorticis*, and include it as an addendum to the IRA, to seek views from stakeholders so that this issue can be addressed fully in the final IRA.

### **Risk Scenario**

The risk scenario of particular relevance to *N. malicorticis* is that associated with internal rots that may not show external symptoms.

### **Risk Assessment**

Based on the information provided by Cunnington (2004), *N. malicorticis* is a potential quarantine pest because this pathogen is in New Zealand but not in Australia. A risk assessment cannot be undertaken until technical information on the prevalence and severity of the pest, and orchard management measures undertaken in New Zealand to control this pest are known. These issues will be addressed in the final IRA. In the interim comments are sought from stakeholders on the potential threat of this disease to the Australian pome fruit industry.

### **Draft datasheet .**

**Species: *Neofabraea malicorticis* H.S. Jackson (1913) [Dermateaceae: Helotiales]**

Synonyms and changes in combination: *Cryptosporiopsis curvispora* (Peck) Gremmen (1959).

Until recently, the genus *Neofabraea* was considered a synonym of the genus *Pezicula* (Verkley, 1999; de Jong et al., 2001). In Europe, both *N. malicorticis* and *N. perennans* have been considered as *N. malicorticis*, but in North America species distinction has been maintained (de Jong et al., 2001).

Common names: Bull's-eye rot, anthracnose canker (de Jong et al., 2001).

Hosts: Serviceberry (*Amelanchier* spp.), apple (*Malus* spp.), flowering quince (*Chaenomeles japonica*), hawthorn (*Crataegus* spp.), quince (*Cydonia oblonga*), peach (*Prunus persica*), apricot (*P. armeniaca*), pear (*Pyrus* spp.) rose (*Rosa* spp.), mountain ash (*Sorbus* spp.) ((Anonymous, 2004b) CBS Fungi database, accessed on 13/02/04).

Plant parts affected: Stem and fruit.

Distribution: North America (west), Denmark, Netherlands, Portugal and New Zealand (Verkley, 1999).

Note: Records show that *Pezicula malicortis*, classified, as a synonym of *N. malicorticis* was present in Australia. However, Cunnington (2004) concluded after re-examining the all-Australian herbarium specimens that *N. malicorticis* was not present in Australia (Verkley, 1999).

Biology: Apothecia erumpent through the upper dark tissue of the acervular stromata of the previous year. Asci have eight ascospores. Under favourable conditions ascospores are discharged to cause infection. When conditions are not favourable ascospores germinate within the asci with hyphae that penetrate the ascus tip, developing phialides that liberate typical conidia. Masses of conidia are formed on the surface under humid conditions

The pathogen enters through wounds caused by pruning or uninjured bark in the autumn but cankers will not appear until spring. The cankers are active for one year but the fungus can live in dead canker tissues and produces large numbers of conidia. Over the years, the disease spreads outwards from the center, leaving concentric rings of dead bark. Cankers are most abundant on smaller branches but may be on larger limbs or trunks.

The first sign of an infection is the appearance of small, circular, reddish brown spots on the bark extending to the underlying tissue. Cankers grow in the spring and cracks delimiting the canker from surrounding healthy tissue. The surface of the canker becomes shrunken and shrivelled as surrounding tissue continues to grow during the summer. During summer, numerous fruiting bodies or pustules (acervuli) appear on the canker surface, first at the centre of the canker and later in the margins. Spores that mature at the end of the summer or early autumn are disseminated by rain and wind.

Fruit becomes infected when in contact with spores any time between petal-fall and harvest. Infection is most common in the spring and late autumn. Rots occur in storage. Infection initially appears as brown, depressed, circular spots in storage. As the disease spreads fruiting bodies are produced in its centre, often in concentric rings, which gives the name 'bull's eye' to the rot ((Anonymous, 2004a) On line: plant disease control, Oregon State University, accessed on 13/02/04).

Economic impact: The infection caused by *N. malicorticis* on stems may cause girdling and may result in death of limbs or may cause fruit rot in storage ((Anonymous, 2004a) On line: plant disease control, Oregon State University, accessed on 13/02/04).

Control: Sanitation methods such as use of clean plant material free of visible symptoms and pruning infected tissue would provide long term control of the disease. Application of fungicides (e.g. Bordeaux mixture, Mancozeb) before autumn would reduce infection ((Anonymous, 2004a) On line:plant disease control, Oregon State University, accessed on 13/02/04).

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