



**Australian Government**

**Biosecurity Australia**

**Draft pest risk analysis report for  
'*Candidatus Liberibacter psyllae*' in  
fresh fruit, potato tubers, nursery stock and  
its vector the tomato-potato psyllid**



**May 2009**

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Cite this report as:

Biosecurity Australia (2009) *Draft pest risk analysis report for 'Candidatus Liberibacter psyllae'* in fresh fruit, potato tubers, nursery stock and its vector the tomato-potato psyllid. Biosecurity Australia, Canberra.

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*Cover images: Symptoms of infection of 'Candidatus Liberibacter psyllae' in tomato (MAFBNZ 2009) and potato (Suszkiw 2007) and its vector Bactericera cockerelli (MAFBNZ 2008; UCIPM 2009)*

## **Submissions**

This draft pest risk analysis report has been issued to give all interested parties an opportunity to comment and draw attention to any scientific, technical, or other gaps in the data, misinterpretations and errors. Any comments should be submitted to Biosecurity Australia within the comment period stated in the related Biosecurity Australia Advice on the Biosecurity Australia website. Biosecurity Australia will consider any comments in finalising the pest risk analysis.

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## Acronyms and abbreviations

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Acronym or abbreviation	Definition
<b>ALOP</b>	appropriate level of protection
<b>AQIS</b>	Australian Quarantine and Inspection Service
<b>CSIRO</b>	Commonwealth Scientific and Industrial Research Organisation
<b>DAFF</b>	Australian Government Department of Agriculture, Fisheries and Forestry
<b>DNA</b>	Deoxyribonucleic acid
<b>FAO</b>	Food and Agriculture Organization of the United Nations
<b>IPM</b>	Integrated Pest Management
<b>IPPC</b>	International Plant Protection Convention
<b>IRA</b>	import risk analysis
<b>ISPM</b>	International Standard for Phytosanitary Measures
<b>NPPO</b>	National Plant Protection Organisation
<b>NZ</b>	New Zealand
<b>NZMAF</b>	New Zealand Ministry of Agriculture and Forestry
<b>PCR</b>	Polymerase chain reaction
<b>PRA</b>	pest risk analysis
<b>Qld</b>	Queensland
<b>SA</b>	South Australia
<b>SPS</b>	sanitary and phytosanitary
<b>Tas.</b>	Tasmania
<b>USDA</b>	United States Department of Agriculture
<b>Vic.</b>	Victoria
<b>WA</b>	Western Australia



## Summary

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Biosecurity Australia is undertaking a pest risk analysis to assess the quarantine risks posed by '*Candidatus Liberibacter psyllaeus*', which infects solanaceous crops, including tomato, capsicum, eggplant, potato and tamarillo.

The pest risk analysis meets Australia's obligations under the International Plant Protection Convention and the International Standards for Phytosanitary Measures (ISPM No. 13) to review emergency phytosanitary measures that were put in place on 6 June 2008 and revised on 4 December 2008.

The pest risk analysis has identified potato tubers, nursery stock and tomato-potato psyllid infected with '*Ca. L. psyllaeus*' as potential pathways for the introduction of '*Ca. L. psyllaeus*' with an unrestricted risk that exceeds Australia's appropriate level of protection (ALOP).

This draft pest risk analysis report recommends that additional measures be applied to fresh fruit and nursery stock of plants in the Solanaceae family being sourced from areas where '*Ca. L. psyllaeus*' is known to occur.

A combination of risk management measures and operational systems are proposed to reduce the risks associated with the importation of potato tubers, nursery stock and infected tomato-potato psyllids. Specifically, the proposed measures are:

For potato tubers:

- area freedom or
- processing in quarantine approved premises.

For nursery stock:

- area freedom or
- post-entry quarantine and testing for '*Ca. L. psyllaeus*'.

For infected tomato-potato psyllids:

- area freedom or
- systems approach for fruit with pre- and post-harvest measures:
  - application of control measures to ensure low populations of tomato-potato psyllid in crops and
  - washing and brushing to remove all life stages of the psyllid on the fruit or
- application to fruit of a treatment known to be effective against all life stages of the psyllid (including but not limited to methyl bromide fumigation)
- methyl bromide fumigation of nursery stock and
- supporting operational systems to maintain and verify phytosanitary status.

This report contains details of the risk assessments for the import pathways for the introduction of '*Ca. L. psyllaeus*' and the proposed quarantine measures in order to allow interested parties to provide comments and submissions to Biosecurity Australia within the consultation period.

Biosecurity Australia will consider any comments received in finalising the pest risk analysis and quarantine policy recommendations.



# 1 Introduction

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## 1.1 Australia's biosecurity policy framework

Australia's biosecurity policies aim to protect Australia against the risks that may arise from exotic pests<sup>1</sup> entering, establishing and spreading in Australia, thereby threatening Australia's unique flora and fauna, as well as those agricultural industries that are relatively free from serious pests.

The import risk analysis (IRA) process is an important part of Australia's biosecurity policies. It enables the Australian Government to formally consider the risks that could be associated with proposals to import new products into Australia. If the risks are found to exceed Australia's appropriate level of protection (ALOP), risk management measures are proposed to reduce the risks to an acceptable level. But if it is not possible to reduce the risks to an acceptable level, then no trade will be allowed.

Successive Australian Governments have maintained a conservative, but not a zero-risk, approach to the management of biosecurity risks. This approach is expressed in terms of Australia's ALOP, which reflects community expectations through government policy and is currently described as providing a high level of protection aimed at reducing risk to a very low level, but not to zero.

Australia's IRAs are undertaken by Biosecurity Australia using teams of technical and scientific experts in relevant fields, and involves consultation with stakeholders at various stages during the process. Biosecurity Australia provides recommendations for animal and plant quarantine policy to Australia's Director of Animal and Plant Quarantine (the Secretary of the Australian Department of Agriculture, Fisheries and Forestry). The Director or delegate is responsible for determining whether or not an importation can be permitted under the *Quarantine Act 1908*, and if so, under what conditions. The Australian Quarantine and Inspection Service (AQIS) is responsible for implementing appropriate risk management measures.

More information about Australia's biosecurity framework is provided in Appendix C of this report and in the *Import Risk Analysis Handbook 2007* located on the Biosecurity Australia website [www.biosecurityaustralia.gov.au](http://www.biosecurityaustralia.gov.au).

## 1.2 This pest risk analysis

### 1.2.1 Background

In June 2008, New Zealand notified its trading partners that a new '*Candidatus Liberibacter* sp.' had been confirmed to be affecting tomato and capsicum crops grown in greenhouses in the North Island. This was the first confirmed report of a '*Ca. Liberibacter* sp.' affecting solanaceous crops (Liefting *et al.* 2008a).

The presence of this new, undescribed '*Ca. Liberibacter* sp.' and the potential for its introduction into Australia via imports of host commodities resulted in Australia

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<sup>1</sup> A pest is any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2007b)

introducing emergency quarantine measures on 6 June 2008 for tomato (*Lycopersicon esculentum*), capsicum (*Capsicum annum*), eggplant (*Solanum melongena*), tamarillo (*Solanum betaceum*) and other related fruits and nursery stock from New Zealand. The bacterium has subsequently been identified in potatoes in New Zealand (Liefting *et al.* 2008a) and the United States of America (USA) (Munyaneza *et al.* 2007; Cranshaw 1993), and in tamarillo and cape gooseberry in New Zealand (Liefting *et al.* 2008b).

Consistent with Australia's international obligations, Biosecurity Australia commenced a pest risk analysis (PRA) for the bacterium to assess the risks posed by the importation of host commodities including tomato, capsicum, eggplant and tamarillo, and its vector the tomato-potato psyllid *Bactericera cockerelli* (Sulc).

Following the detection of the new '*Ca. Liberibacter sp.*', the New Zealand Ministry of Agriculture and Forestry (NZMAF) began a research program to characterise the pathogen and provide additional information that would enable an assessment of the phytosanitary risk posed by various pathways. This pest risk analysis reviews the research undertaken by NZMAF and other information available on this pathogen and its vector.

Hansen *et al.* (2008) designated '*Ca. L. psyllae*' as the name of the bacterium affecting solanaceous crops, while Liefting *et al.* (2009) have proposed the name '*Ca. L. solanacearum*' for this bacterium. Biosecurity Australia will use the name '*Ca. L. psyllae*' in this report, as it is the earlier name.

Tomato-potato psyllid *Bactericera cockerelli* is known to vector '*Ca. L. psyllae*' (Hansen *et al.* 2008). Although *B. cockerelli* is mostly found on members of the Solanaceae, it has been reported on plants in the *Amaranthaceae*, *Asclepiadaceae*, *Asteraceae*, *Brassicaceae*, *Chenopodiaceae*, *Convolvulaceae*, *Fabaceae*, *Lamiaceae*, *Lycophyllaceae*, *Malvaceae*, *Menthaceae*, *Pinaceae*, *Poaceae*, *Polygonaceae*, *Ranunculaceae*, *Rosaceae*, *Salicaceae*, *Scrophulariaceae*, *Violaceae* and *Zygophyllaceae* families (Pletsch, 1947; Wallis, 1955). These hosts include a range of cultivated and non-cultivated plants that are widely distributed in Australia (APNI 2008).

As a result of work undertaken by New Zealand to better understand the disease and its vector and a series of site visits conducted by Biosecurity Australia representatives, Biosecurity Australia has revised the emergency measures to allow trade to recommence, while the PRA is being finalised. The revised emergency measures commenced on 10 December 2008 and allowed imports of tomato and capsicum, subject to demonstrated control of the psyllid population in production sites (greenhouses) and mandatory methyl bromide fumigation.

### 1.2.2 Scope

This PRA assesses the biosecurity risks of the importation of '*Ca. L. psyllae*' in the following pathways:

- fruits of solanaceous crops permitted entry into Australia (cape gooseberry, capsicum, chilli, eggplant, melon pear, tomato, tamarillo and tomatillo)
- potato tubers for human consumption
- nursery stock and

- tomato-potato psyllid (*Bactericera cockerelli*).

The risk for these pathways was assessed using information on the biology, epidemiology and impact of 'Ca. L. psyllae'. The possible transmission of the bacterium in seed in fruit was considered as part of the fruit pathway assessment.

Phytosanitary conditions exist for the import of fruit and nursery stock of solanaceous species into Australia. These conditions include:

- pre-clearance or on-arrival inspection by the Australian Quarantine and Inspection Service (AQIS) of fruit of from specified countries and
- methyl bromide fumigation and growth in post-entry quarantine for nursery stock from any country.

However, this pest risk analysis does not consider these specific phytosanitary measures during the pest risk assessments for the four pathways. Phytosanitary measures already in place are considered during the development of risk management measures, if they are required following the pest risk assessments.

This PRA proposes measures that could be used to reduce the risk of the importation of 'Ca. L. psyllae' to meet Australia's ALOP. These measures will form the basis for any recommended amendments to the import policy for commodities that are, or were, permitted access to Australia and are known or potential hosts of 'Ca. L. psyllae'.

The PRA considers fresh fruit that is free of trash commercially produced in greenhouses or the field. The PRA does not consider the impact of *B. cockerelli* in the absence of 'Ca. L. psyllae', as it is already an actionable pest for Australia due to the direct damage its feeding causes on host plants.

### 1.2.3 Existing policy

Before emergency measures were imposed, Australia permitted the importation of a range of fresh fruit, seed and nursery stock of Solanaceous crops. Crops, for which AQIS has imposed emergency measures, and their current import conditions, are listed in Table 1.1. Conditions C18152 and C18159 were applied to nursery stock from New Zealand in response to the detection of 'Candidatus Liberibacter sp.'. These conditions can be viewed on the AQIS Import Conditions (ICON) database available at <http://www.aqis.gov.au/icon>. Of these nine crops, cape gooseberry, capsicum, chilli, potato, tamarillo and tomato are known hosts of 'Ca. L. psyllae' (Table 1.1).

**Table 1.1: Import conditions for Solanaceous crops**

Solanaceous crop	Ca L. psyllae host?	ICON Conditions		
		Fresh/Frozen Fruit permitted?	Seed permitted?	Nursery Stock permitted?
<i>Capsicum annum</i> L. Capsicum	Yes (Liefting <i>et al.</i> 2009; MAFBNZ 2008)	Yes (C6000, C9015, C6107, C6018, C5188, C5187, C9754, C18331)	Yes (C7100, C7179, C7180)	No
<i>Capsicum frutescens</i> L. Chilli	Yes (MAFBNZ 2008)	Yes (C6000, C9015, C5188, C5187)	Yes (C7100, C7179, C7180)	No

Solanaceous crop	Ca <i>L. psyllae</i> host?	ICON Conditions		
		Fresh/Frozen Fruit permitted?	Seed permitted?	Nursery Stock permitted?
<i>Lycopersicon esculentum</i> Mill Tomato	<b>Yes</b> (Hansen <i>et al.</i> 2008; MAFBNZ 2008)	<b>Yes</b> (C9963, C18331, C18333, C6000, C9835, C6904, C6900, C8690, C8694, C6977)	<b>Yes</b> (C18144, C17837)	<b>No</b>
<i>Physalis ixocarpa</i> Brot. ex Hornem. Tomatillo	<b>Unknown</b>	<b>Yes</b> (C5188, C5187)	<b>Yes</b> (C7162, C7100, C7179, C7180)	<b>Yes</b> (C7427, C7300, C18152)
<i>Physalis peruviana</i> L. Cape gooseberry	<b>Yes</b> (Liefting <i>et al.</i> 2008b; MAFBNZ 2008)	<b>Yes</b> (C9989)	<b>Yes</b> (C7162, C7100, C7179, C7180)	<b>Yes</b> (C7427, C7300, C18152)
<i>Solanum betaceum</i> Cav. Tamarillo	<b>Yes</b> (Liefting <i>et al.</i> 2008b; MAFBNZ 2008)	<b>Yes</b> (C5187, C5188)	<b>Yes</b> (C7100, C7179, C7180)	<b>Yes</b> (C7330, C7331, C7300, C7436, C18152)
<i>Solanum melongena</i> L. Eggplant	<b>Unknown</b>	<b>Yes</b> (C9744, C5187, C5188)	<b>Yes</b> (C7100, C7179, C7180)	<b>Yes</b> (C7436, C18152)
<i>Solanum muricatum</i> Aiton Pepino	<b>Unknown</b>	<b>Yes</b> (C5187, C5188)	<b>No</b>	<b>Yes</b> (C7436, C18152)
<i>Solanum tuberosum</i> L. Potato	<b>Yes</b> (Hansen <i>et al.</i> 2008; MAFBNZ 2008)	<b>No</b> (C6066)	<b>Yes</b> (C7161, C17837)	<b>Yes</b> (C7322, C7323, C7300, C18159)



## 2 Method for pest risk analysis

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In accordance with the International Plant Protection Convention, the technical component of a plant import risk analysis (IRA) is termed a pest risk analysis (PRA). Biosecurity Australia has conducted this PRA in accordance with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for Pest Risk Analysis* (FAO 2007) and ISPM 11: *Pest Risk Analysis for Quarantine Pests, including analysis of environmental risks and living modified organisms* (FAO 2004).

A PRA is 'the process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it' (FAO 2008). A pest is 'any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products' (FAO 2008).

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

Unrestricted risk is estimated taking into account the existing commercial production practices of the exporting country and that minimal on-arrival verification procedures will apply. Restricted risk is estimated with phytosanitary measure(s) applied. A phytosanitary measure is 'any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests' (FAO 2008).

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

PRAs are conducted in three consecutive stages.

### 2.1 Stage 1: Initiation

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

For '*Ca. L. psyllae*', careful consideration was given to the potential pathways for entry of the bacterium and its vector *B. cockerelli* into Australia.

For this PRA, the 'PRA area' is defined as all of Australia.

### 2.2 Stage 2: Pest risk assessment

A pest risk assessment (for quarantine pests) is: 'the evaluation of the probability of the introduction and spread of a pest and of the likelihood of associated potential economic consequences' (FAO 2008).

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

#### 2.2.1 Pest categorisation

Pest categorisation is a process to examine, for each pest, whether the criteria for a quarantine pest are satisfied. A quarantine pest is defined as 'a pest of potential

economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled' (FAO 2008). The process of pest categorisation is summarised by the IPPC in the five elements outlined below:

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

The results for pest categorisation for '*Ca. L. psyllae*' are given at the start of the Chapter 5.

### 2.2.2 Assessment of the probability of entry, establishment and spread

Details of how to assess the probability of entry, probability of establishment and probability of spread of a pest are given in ISPM 11 (FAO 2004). A summary of this process is given below, followed by a description of the qualitative methodology used in this IRA.

#### Probability of entry

The probability of entry describes the probability that a quarantine pest will enter Australia as a result of trade in a given commodity, be distributed in a viable state in the PRA area and subsequently be transferred to a host. It is based on pathway scenarios depicting necessary steps in the sourcing of the commodity for export, its processing, transport and storage, its use in Australia and the generation and disposal of waste. In particular, the ability of the pest to survive is considered for each of these various stages.

For the purpose of considering the probability of entry, Biosecurity Australia divides this step of this stage of the PRA into two components:

- **Probability of importation:** the probability that a pest will arrive in Australia when a given commodity is imported
- **Probability of distribution:** the probability that the pest will be distributed, as a result of the processing, sale or disposal of the commodity, in the PRA area and subsequently transfer to a susceptible part of a host.

Factors considered in the probability of importation include:

- distribution and incidence of the pest in the source area
- occurrence of the pest in a life-stage that would be associated with the commodity
- volume and frequency of movement of the commodity along each pathway
- seasonal timing of imports
- pest management, cultural and commercial procedures applied at the place of origin

- speed of transport and conditions of storage compared with the duration of the lifecycle of the pest
- vulnerability of the life-stages of the pest during transport or storage
- incidence of the pest likely to be associated with a consignment
- commercial procedures (e.g. refrigeration) applied to consignments during transport and storage in the country of origin, and during transport to Australia.

Factors considered in the probability of distribution include:

- commercial procedures (e.g. refrigeration) applied to consignments during distribution in Australia
- dispersal mechanisms of the pest, including vectors, to allow movement from the pathway to a host
- whether the imported commodity is to be sent to a few or many destination points in the PRA area
- proximity of entry, transit and destination points to hosts
- time of year at which import takes place
- intended use of the commodity (e.g. for planting, processing or consumption)
- risks from by-products and waste.

### **Probability of establishment**

Establishment is defined as the 'perpetuation for the foreseeable future, of a pest within an area after entry' (FAO 2004). In order to estimate the probability of establishment of a pest, reliable biological information (lifecycle, host range, epidemiology, survival, etc.) is obtained from the areas where the pest currently occurs. The situation in the PRA area can then be compared with that in the areas where it currently occurs and expert judgement used to assess the probability of establishment.

Factors considered in the probability of establishment in the PRA area include:

- availability of hosts, alternative hosts and vectors
- suitability of the environment
- reproductive strategy and potential for adaptation
- minimum population needed for establishment
- cultural practices and control measures.

### **Probability of spread**

Spread is defined as 'the expansion of the geographical distribution of a pest within an area' (FAO 2004). The probability of spread considers the factors relevant to the movement of the pest, after establishment on a host plant or plants, to other susceptible host plants of the same or different species in other areas. In order to estimate the probability of spread of the pest, reliable biological information is obtained from areas where the pest currently occurs. The situation in the PRA area is then compared with that in the areas where the pest currently occurs and expert judgement used to assess the probability of spread.

Factors considered in the probability of spread include:

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

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

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

**Table 2.1: Nomenclature for qualitative likelihoods**

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

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

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

to give the overall likelihood for the probability of entry, establishment and spread of 'very low'.

**Table 2.2: Matrix of rules for combining qualitative likelihoods**

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

### *Time and volume of trade*

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

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

The use of a one year volume of trade has been taken into account when setting up the matrix that is used to estimate the risk and therefore any policy based on this analysis does not simply apply to one year of trade. Policy decisions that are based on Biosecurity Australia's method that uses the estimated volume of one year's trade are consistent with Australia's policy on appropriate level of protection and meet the Australian Government's requirement for ongoing quarantine protection. Of course, if there are substantial changes in the volume and nature of the trade in specific commodities then Biosecurity Australia has an obligation to review the risk analysis and, if necessary, provide updated policy advice.

In assessing the volume of trade in this PRA, Biosecurity Australia assumed that a substantial volume of trade will occur.

### **2.2.3 Assessment of potential consequences**

The objective of the consequence assessment is to provide a structured and transparent analysis of the likely consequences if the pests or disease agents were to enter, establish and spread in Australia. The assessment considers direct and indirect pest effects and their economic and environmental consequences. The requirements for assessing

potential consequences are given in Article 5.3 of the SPS Agreement (WTO 1995), ISPM 5 (FAO 2008) and ISPM 11 (FAO 2004).

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

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

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

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

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

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

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

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

Values were translated into a qualitative impact score (A–G)<sup>2</sup> using Table 2.3.

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<sup>2</sup> In earlier qualitative IRAs, the scale for the impact scores went from A to F and did not explicitly allow for the rating 'indiscernible' at all four levels. This combination might be applicable for some criteria. In this report, the impact scale of A-F has changed to become B-G and a new lowest category A

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

<b>Impact score</b>	<b>G</b>	Major significance	Major significance	Major significance	Major significance
	<b>F</b>	Major significance	Major significance	Major significance	Significant
	<b>E</b>	Major significance	Major significance	Significant	Minor significance
	<b>D</b>	Major significance	Significant	Minor significance	Indiscernible
	<b>C</b>	Significant	Minor significance	Indiscernible	Indiscernible
	<b>B</b>	Minor significance	Indiscernible	Indiscernible	Indiscernible
	<b>A</b>	Indiscernible	Indiscernible	Indiscernible	Indiscernible
		<b>Local</b>	<b>District</b>	<b>Region</b>	<b>Nation</b>
<b>Geographic scale</b>					

The overall consequence for each pest is achieved by combining the qualitative impact scores (A–G) for each direct and indirect consequence using a series of decision rules (Table 2.4). These rules are mutually exclusive, and are assessed in numerical order until one applies.

**Table 2.4: Decision rules for determining the overall consequence rating for each pest**

<b>Rule</b>	<b>The impact scores for consequences of direct and indirect criteria</b>	<b>Overall consequence rating</b>
1	Any criterion has an impact of 'G'; or more than one criterion has an impact of 'F'; or a single criterion has an impact of 'F' and each remaining criterion an 'E'.	Extreme
2	A single criterion has an impact of 'F'; or all criteria have an impact of 'E'.	High
3	One or more criteria have an impact of 'E'; or all criteria have an impact of 'D'.	Moderate
4	One or more criteria have an impact of 'D'; or all criteria have an impact of 'C'.	Low
5	One or more criteria have an impact of 'C'; or all criteria have an impact of 'B'.	Very Low
6	One or more but not all criteria have an impact of 'B', and all remaining criteria have an impact of 'A'.	Negligible

## 2.2.4 Estimation of the unrestricted risk

Once the above assessments are completed, the unrestricted risk can be determined for each pest or groups of pests. This is determined by using a risk estimation matrix (Table 2.5) to combine the estimates of the probability of entry, establishment and spread and the overall consequences of pest establishment and spread. Therefore, risk is the product of likelihood and consequence.

('indiscernible' at all four levels) was added. The rules for combining impacts in Table 2.4 were adjusted accordingly.

When interpreting the risk estimation matrix, note the descriptors for each axis are similar (e.g. low, moderate, high) but the vertical axis refers to likelihood and the horizontal axis refers to consequences. Accordingly, a 'low' likelihood combined with 'high' consequences, is not the same as a 'high' likelihood combined with 'low' consequences – the matrix is not symmetrical. For example, the former combination would give an unrestricted risk rating of 'moderate', whereas, the latter would be rated as a 'low' unrestricted risk.

**Table 2.5: Risk estimation matrix**

Likelihood of pest entry, establishment and spread	High	Negligible risk	<b>Very low risk</b>	Low risk	Moderate risk	High risk	Extreme risk
	Moderate	Negligible risk	<b>Very low risk</b>	Low risk	Moderate risk	High risk	Extreme risk
	Low	Negligible risk	Negligible risk	<b>Very low risk</b>	Low risk	Moderate risk	High risk
	Very low	Negligible risk	Negligible risk	Negligible risk	<b>Very low risk</b>	Low risk	Moderate risk
	Extremely low	Negligible risk	Negligible risk	Negligible risk	Negligible risk	<b>Very low risk</b>	Low risk
	Negligible	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Negligible risk	<b>Very low risk</b>
		Negligible	Very low	Low	Moderate	High	Extreme
Consequences of pest entry, establishment and spread							

### 2.2.5 Australia's appropriate level of protection (ALOP)

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

Like many other countries, Australia expresses its ALOP in qualitative terms. Australia's ALOP, which reflects community expectations through government policy, is currently expressed as providing a high level of sanitary or phytosanitary protection aimed at reducing risk to a very low level, but not to zero. The band of cells in Table 2.5 marked 'very low risk' represents Australia's ALOP.

## 2.3 Stage 3: Pest risk management

Pest risk management describes the process of identifying and implementing phytosanitary measures to manage risks to achieve Australia's ALOP, while ensuring that any negative effects on trade are minimised.

The conclusions from pest risk assessment are used to decide whether risk management is required and if so, the appropriate measures to be used. Where the unrestricted risk estimate exceeds Australia's ALOP, risk management measures are required to reduce this risk to a very low level. The guiding principle for risk management is to manage risk to achieve Australia's ALOP. The effectiveness of any proposed phytosanitary measure (or combination of measures) is evaluated, using the same approach as used to



evaluate the unrestricted risk, to ensure it reduces the restricted risk for the relevant pest or pests to meet Australia's ALOP.

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

Examples given of measures commonly applied to traded commodities include:

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

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



### 3 Pathways

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The import of plant commodities provides pathways for the introduction of exotic insects and pathogens into Australia. The identification of '*Ca. L. psyllaeus*' in solanaceous crops in New Zealand and the USA raised concerns about the introduction of this pathogen with imports of these crops. Import conditions have been in place to allow the entry of fruit of cape gooseberry, capsicum, chilli, eggplant, pepino, tamarillo, tomatillo and tomato from New Zealand and capsicum from the USA. In addition, seed of cape gooseberry, capsicum, chilli, eggplant, potato, tamarillo, tomatillo and tomato has been permitted and nursery stock of cape gooseberry, eggplant, pepino, potato, tamarillo and tomatillo has been allowed to be imported through post-entry quarantine.

In this PRA, information on '*Ca. L. psyllaeus*' and its vector *B. cockerelli* was reviewed and the following pathways were identified for the introduction of this pathogen into Australia:

#### 3.1 Pathway 1 – Fruit (including seed)

Fresh fruit, which may include some stem material as in the case of truss tomatoes, presents one pathway by which '*Ca. L. psyllaeus*' could be introduced to Australia. Both the plant and fruit can be infected. The bacterium has been detected in leaves, stem and tomato fruit. Moreover, fruit showing no symptoms of the disease can be infected. There are no human health risks known to be associated with handling or consuming infected fruit (MAFBNZ 2008).

Should infected fruit be imported, the bacterium could possibly be spread to other hosts through mechanisms such as insects feeding on the fruit and/or stem material, contact between fruit and host plants, or intentional or incidental propagation of infected seed.

The risk of entry of '*Ca. L. psyllaeus*' through infected fruit is considered in the first of the pathway analyses.

#### 3.2 Pathway 2 – Potato tubers

Potato tubers for human consumption are a potential pathway by which '*Ca. L. psyllaeus*' could be introduced to Australia. The bacterium has been found in potato tubers and the growth of infected tubers can lead to infected plants (MAFBNZ 2008). While imported for human consumption, tubers may be intentionally planted, or disposed of in the environment, leading to the growth of plants infected with '*Ca. L. psyllaeus*'.

While potato tubers are not currently permitted into Australia, New Zealand is currently seeking access for potato tubers for processing in Australia.

The risk of entry of '*Ca. L. psyllaeus*' through infected potato tubers is considered in the second of the pathway analyses.

#### 3.3 Pathway 3 – Nursery stock

Nursery stock is a likely avenue for the movement of exotic insects and pathogens to and within Australia. Apart from nursery stock of host species being a pathway for the

importation of '*Ca. L. psyllaeus*', nursery stock could support all stages of the pathogen's vector, the tomato-potato psyllid.

Infected nursery stock is one of the most important sources for introducing the bacterium to new areas as nursery stock is imported for the specific purpose of propagation. While all medium and high risk nursery stock undergoes post-entry quarantine on arrival in Australia, when undertaking the unrestricted risk analysis in this PRA, it is assumed that no quarantine measures have been applied to the nursery stock.

The risk of entry of '*Ca. L. psyllaeus*' through infected nursery stock is considered in the third of the pathway analyses.

### **3.4 Pathway 4 – Tomato-potato psyllid**

*Bactericera cockerelli* is the vector for '*Ca. L. psyllaeus*', which causes the diseases psyllid yellows in solanaceous crops (cape gooseberry, capsicum, chilli, tamarillo, potato and tomato) and zebra chip in potato chips (NZCOP 2008). Psyllids may be associated with any aerial part of the plant, and while they feed primarily on leaves, psyllids and their eggs may also be present on stems or fruit. Therefore, there is potential to introduce infected psyllids into Australia with the importation of fruit or nursery stock. This risk has been considered separately to the risk for fruit and nursery stock so that risks specific to psyllid transmission can be appropriately considered.

The risk of entry of '*Ca. L. psyllaeus*' through infected psyllids is considered in the fourth of the pathway analyses.

## 4 Pest information

### 4.1 Summary

<b>Scientific name</b>	<i>Candidatus Liberibacter psyllaeus</i>
<b>Vector</b>	<i>Bactericera cockerelli</i> (Sulc) [Hemiptera: Psyllidae]
<b>Known hosts</b>	<i>Capsicum annuum</i> L. <i>Capsicum frutescens</i> L. <i>Lycopersicon esculentum</i> Mill <i>Physalis peruviana</i> L. <i>Solanum betaceum</i> Cav. <i>Solanum tuberosum</i> L.
<b>Distribution</b>	North America and New Zealand

### 4.2 'Candidatus *Liberibacter psyllaeus*'

The genus '*Candidatus Liberibacter*' is composed of gram-negative bacteria belonging to the alpha subdivision of the proteobacteria (Bové 2006, Jagoueix *et al.* 1996). The genus was thought to contain three species infecting species in the Rutaceae (Lopes and Frare 2008), which differ in their vector specificity and environmental tolerances (Bové 2006):

- *Candidatus Liberibacter africanus* — African Huanglongbing
- *Candidatus Liberibacter americanus* — American Huanglongbing
- *Candidatus Liberibacter asiaticus* — Asian Huanglongbing.

In June 2008, New Zealand notified its trading partners that a new '*Candidatus Liberibacter* sp.' was affecting tomato and capsicum crops in the North Island. This was the first confirmed report of a '*Ca. Liberibacter* sp.' affecting solanaceous crops (Liefting *et al.* 2008a). Subsequently, psyllid yellows of potato and tomato was found to be caused by the same bacterium in the USA, which was described as '*Candidatus Liberibacter psyllaeus*' by Hansen *et al.* (2008).

'*Candidatus L. psyllaeus*' causes the diseases psyllid yellows in solanaceous crops and zebra chip in potato tubers.

#### 4.2.1 Psyllid yellows

Psyllid yellows was thought to be caused by the saliva of *Bactericera cockerelli* (Hansen *et al.* 2008). The factor in the saliva that caused psyllid yellows was thought to be a toxin produced by the psyllid (Blood *et al.* 1933; Richards and Blood 1933). Hansen *et al.* (2008) characterised and described the causative agent of psyllid yellows as the bacterium '*Ca. L. psyllaeus*'. Psyllid salivary toxins are not implicated in the aetiology of the disease as the disease has been successfully transmitted by grafting in greenhouse trials (De Boer *et al.* 2007).

The symptoms of '*Ca. L. psyllauros*' infection vary in severity and are influenced by host, cultivar, temperature and growing conditions (glasshouse or field grown, soil moisture and nutrients) (Liefting *et al.* 2009). It has also been noted that '*Ca. L. psyllauros*' infected plants may be asymptomatic (MAFBNZ 2008).

### Tomato

In tomato, symptoms observed by Liefting *et al.* (2009) in greenhouse crops included spiky, chlorotic apical growth with purpling of the midveins depending on the cultivar, general mottling of the leaves, curling of the midveins, overall stunting of the plants, and in some cultivars fruit deformation. Fruit may be misshapen, with a strawberry like appearance, and uneven development of fruit locules. In some cases, there is no fruit set at all (Figure 4.1).



**Figure 4.1: Symptoms of psyllid yellows in tomato plants (MAFBNZ 2008)**

### Capsicum

Capsicum plants develop chlorotic or pale green leaves, sharp tapering of leaf apex (spiky appearance) leading to leaf cupping, short internodes and petioles and apical meristem necrosis and/or flower abortion and an overall stunting (Figure 4.2). The symptoms on capsicum also vary with cultivar and growing conditions (glasshouse or field grown).





**Figure 4.2: Symptoms of psyllid yellows in capsicum plants (Liefting *et al.* 2009)**

### Potato

Foliar symptoms of psyllid yellows in potato include stunting, chlorosis, and swollen nodes causing a “zig-zag” appearance of the upper growth, proliferated auxiliary buds, aerial tubers and leaf scorching leading to early dieback (Gudmestad and Secor 2007).

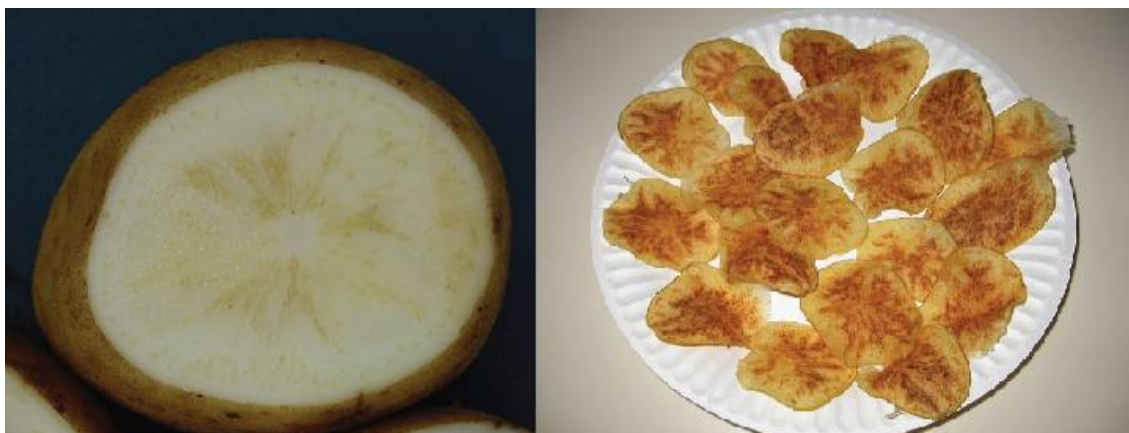
Below-ground symptoms include enlarged lenticels of the underground stem, collapsed stolons, brown discoloration of the vascular ring and necrotic flecking of internal tuber tissues (Gudmestad and Secor 2007). Symptoms also include smaller tubers, an increase in the number of tubers and shorter stolons. Furthermore, tubers tend to be misshapen, have a rough skin and suffer a loss of dormancy resulting in premature sprouting. Therefore, tuber chaining and internal sprouting are common. Sprouts are spindly, hairy and very weak. These tubers are unacceptable for planting (UNL 2009).

Leaf scorching and premature sprouting symptoms of psyllid yellows are shown in Figure 4.3.



**Figure 4.3: Foliar scorching and premature tuber sprouting symptoms of psyllid yellows in potato plants (Secor 2006; Cranshaw 2004)**

Zebra chip is the name given to symptoms of psyllid yellows in fried potato chips (Munyaneza *et al.* 2007). The characteristic symptoms of zebra chip are a striped pattern of discolouration in fried cross-sections of potato tubers (Figure 4.4).



**Figure 4.4: Symptoms of zebra chip disease develop when potato chips are fried (Munyaneza *et al.* 2007)**

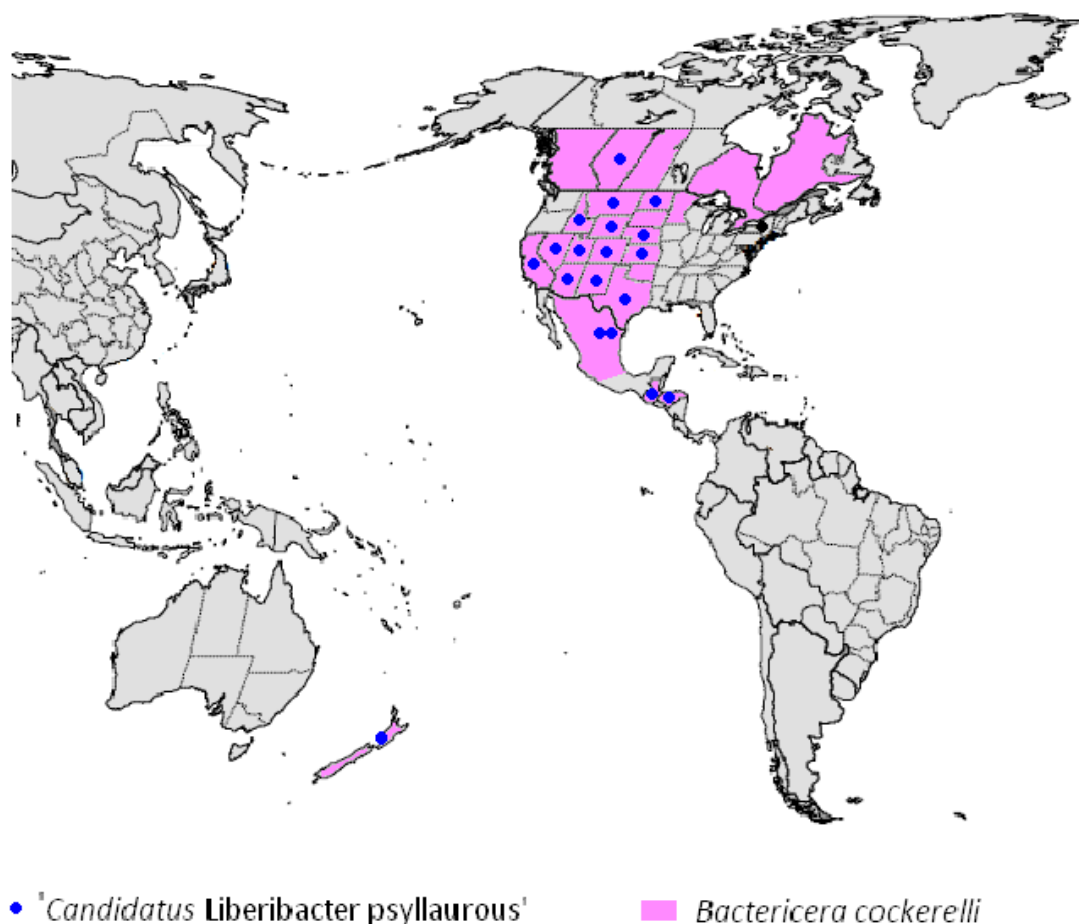
### **4.3 Distribution of '*Candidatus Liberibacter psyllaeus*' and *Bactericera cockerelli***

'*Candidatus L. psyllaeus*' occurs in Arizona, California, Colorado, Idaho, Kansas, Nebraska, New Mexico, Montana, North Dakota, Nevada, Texas, Utah and Wyoming in the USA; Alberta in Canada; Coahuila and Nuevo Leon in Mexico; Guatemala; Honduras; and New Zealand (Carter 1939; MAFBNZ 2008; Munyaneza *et al.* 2007; Abdullah 2007).

The distribution of *B. cockerelli* includes California, Arizona, New Mexico, Colorado, Wyoming, Idaho, Minnesota, Montana, North Dakota, South Dakota, Nebraska, New Mexico, Kansas, Oklahoma, Nevada, Texas, and Utah in the USA (Blood *et al.* 1933; Carter 1950; Pletsch 1947; Ferguson *et al.* 2003). It has been reported in Canada in Alberta, Saskatchewan, British Columbia, Quebec and Ontario (Ferguson *et al.* 2003). The psyllid has been reported from Mexico in Durango, Tamaulipas, and Michiocan and as far south as Mexico City (D.F) and Rio Frio in Puebla (Pletsch 1947; Cranshaw 1993) and in Guatemala and Honduras (Abdullah 2008). Recently, this psyllid was detected in the Auckland region of New Zealand, with subsequent surveys detecting it throughout the north island and over the northern half of the south island (MAFBNZ 2008). Texas, southern New Mexico, Arizona, California and northern Mexico are desert breeding areas of *B. cockerelli* (Al-Jabr 1999).

The distribution of '*Ca. L. psyllaeus*' and *B. cockerelli* is shown in Figure 4.5.





**Figure 4.5: Distribution of 'Candidatus *Liberibacter psyllaeus*' and *Bactericera cockerelli***

## 4.4 Transmission of 'Candidatus *Liberibacter psyllaeus*'

### 4.4.1 Psyllid transmission

Under natural conditions, the following psyllids vector the known 'Candidatus *Liberibacter*' species:

- *Bactericera cockerelli* (Sulc) (tomato-potato psyllid) vectors 'Candidatus *L. psyllaeus*' (Hansen *et al.* 2008)
- *Diaphorina citri* Kuwayama (Asian citrus psyllid) vectors 'Ca. *L. americanus*' and 'Ca. *L. asiaticus*' (Bové 2006; Yamamoto *et al.* 2006)
- *Trioza erythrae* (Del Guercio) (African citrus psyllid) vectors 'Ca. *L. africanus*' (Bové 2006).

The reason for this vector specificity is not known. *Diaphorina citri* and 'Ca. *L. asiaticus*' and *T. erythrae* and 'Ca. *L. africanus*' are present in Mauritius, Reunion Island, Saudi Arabia and Yemen (Aubert 1987; Bové 2006). While experiments have shown that both *D. citri* and *T. erythrae* can transmit 'Ca. *L. africanus*' and 'Ca. *L. asiaticus*' (Masson *et al.* 1976; Lallemand *et al.* 1986; Aubert 1987), *T. erythrae*

vectors '*Ca. L. africanus*' at higher altitudes and *D. citri* vectors '*Ca. L. asiaticus*' at lower altitudes in these countries (Aubert 1987; Bové 2006).

Psyllids acquire '*Candidatus Liberibacter*' species through feeding on infected hosts and are then able to transmit the bacterium to additional hosts as they feed and inject saliva (Bové 2006).

Using polymerase chain reaction (PCR) screening of eggs and egg transfer experiments, Hansen *et al.* (2008) reported transovarial transmission of '*Ca. L. psyllaourous*' in *B. cockerelli*. They also reported that the levels of '*Ca. L. psyllaourous*' infection of *B. cockerelli* life stages differed significantly between potato- and tomato-reared psyllids (Hansen *et al.* 2008).

Vector trials in New Zealand showed that *B. cockerelli* could transmit '*Ca. L. psyllaourous*' from infected tomato fruit without stalks or calyxes, as well as infected tomato fruit with stalks and calyxes (truss tomatoes), to healthy capsicum plants. An initial study found the bacterium could be spread from infected tomato fruit with stalks and calyxes but not from infected tomato fruit without stalks and calyxes (Workman *et al.* 2008). However, subsequent trials showed *B. cockerelli* could transmit '*Ca. L. psyllaourous*' from infected tomato fruit without stalks or calyxes (Jones *et al.* 2008a), as well as infected tomato fruit with stalks and calyxes (Jones *et al.* 2008b).

### Vector biology

*Bactericera cockerelli* (Sulc) (tomato-potato psyllid) is a small winged insect, about 3 mm long, belonging to the family Psyllidae (Wright *et al.* 2006). The tomato-potato psyllid was first documented by Sulc (1909) from nymphs found on capsicum in North America.

Adult *B. cockerelli* are dark in colour with a distinctive white band near the front of their abdomen. Females lay their eggs on all parts of the leaf, but prefer to oviposit along the edge of leaves (Figure 4.6). The eggs are attached to the leaf by a short filament or stalk, and are superficially similar to lacewing eggs (Neuroptera: Hemerobiidae and Chrysomelidae). The eggs are oblong and are a shiny yellow, becoming orange as the embryo develops. Female psyllids can lay more 500 eggs during an average period of 21 days. Eggs hatch within a few days.

*Bactericera cockerelli* nymphs are small and pale in colour. They can survive as nymphs for up to 90 days but usually take only 14–21 days before developing into adults. The entire duration of the lifecycle is 4–5 weeks, but this varies considerably depending on hosts and temperature. There are usually 3–4 generations per season. Psyllid populations can increase in numbers rapidly in warm conditions (UNL 2009).

*Bactericera cockerelli* has been found on a wide range of species in 20 plant families, it has only been recorded breeding on plants from three families: Solanaceae, Convolvulaceae and Lamiaceae (Wallis 1955). Preferred hosts include tomato, potato, capsicum and eggplant. A list of the known hosts of tomato-potato psyllid is presented in Appendix A. The psyllid uses its piercing mouth parts to extract plant juices from foliage. Excess sugar, which the insect ingests, is excreted as small waxy beads of psyllid sugar (Clark 2005).



**Figure 4.6: *Bactericera cockerelli* adult, nymphs and eggs (UCIPM 2009)**

#### **4.4.2 Graft transmission**

Grafting is a common production practice in commercial tomato crops. Graft transmission trials in New Zealand indicate that '*Ca. L. psyllaeus*' is graft-transmissible. These trials support the argument that the disease observed in New Zealand is caused by graft-transmissible '*Ca. L. psyllaeus*', rather than resulting from abiotic stress (Liefting 2008b).

#### **4.4.3 Dodder transmission**

There is no information on dodder transmission of '*Ca. L. psyllaeus*' but it has been demonstrated for '*Ca. L. asiaticus*'. Young dodder (*Cuscuta* sp.) shoots connected to citrus infected by '*Ca. L. asiaticus*' were draped over tomato plants and attached to stems. Tomato plants were then detached from the citrus, with most of the dodder removed, and one month later showed symptoms of citrus greening (Duan *et al.* 2008).

#### **4.4.4 Seed transmission**

It has generally been considered that seed transmission of phloem-limited pathogens, such as '*Candidatus Liberibacter* species' and phytoplasmas, is unlikely because of the lack of direct contact between phloem sieve elements of plants and the developing embryos of seed.

Research has been undertaken in New Zealand on the potential for '*Ca. L. psyllaeus*' to be transmitted through seed. Based on PCR testing, all parts of the fruit were found to contain the bacterium, including parts of the seed (MAFBNZ 2008). However, experiments on seed transmission of '*Ca. L. psyllaeus*' found no infection in 1030 tomato seedlings, 225 capsicum seedlings and 225 tamarillo seedlings raised from seed from infected fruit (Liefting 2008a). These results indicate that '*Ca. L. psyllaeus*' is not seed-transmitted.

Research on seed transmission of '*Ca. L. asiaticus*' in *Citrus* species is providing ambiguous results. Information presented by Graham *et al.* (2008) and Shatters (2008) at the International Research Conference on Huanglongbing, Orlando, Florida, suggests that while a proportion of seedlings that develop from seed from infected plants are positive for '*Ca. L. asiaticus*' by PCR testing and a proportion of these positive seedlings develop symptoms of citrus greening, the infection is transient and may be lost over time.

#### **4.4.5 Mechanical transmission**

There is no evidence that '*Ca. L. psyllae*' is spread mechanically through handling, pruning or other cultivation practices (Horticulture New Zealand 2008).

## 5 Risk assessments for pathways

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'*Candidatus L. psyllaeus*' and its vector *B. cockerelli* are not present in Australia, have the potential for establishment and spread and economic consequences in Australia and meet the criteria for a quarantine pest.

The risk assessments in this section focus on the major pathways identified for the potential introduction of '*Ca. L. psyllaeus*' associated with Solanaceae crops.

The probability of entry has been considered individually for each pathway as the pathway by which '*Ca. L. psyllaeus*' might enter Australia has a significant effect on these assessments. However, the probabilities of establishment and spread and the assessment of potential consequences have been assessed only once for the pathways considered here. This is because the probabilities of establishment and spread and the potential consequences consider post-border issues that are influenced by the susceptibility of hosts, the availability of hosts and the suitability of the environment in Australia for the pathogen.

### 5.1 Probability of entry

The risk assessment in this section focuses on the four pathways identified for the potential entry of '*Candidatus Liberibacter psyllaeus*':

- fruit (including seed)
- potato tubers
- nursery stock
- tomato-potato psyllids (*Bactericera cockerelli*).

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

#### 5.1.1 Pathway 1 – Fruit (including seed)

##### Probability of importation

The likelihood that '*Ca. L. psyllaeus*' will arrive in Australia with the trade in fresh fruit of known hosts, including their seeds: **HIGH**.

- '*Candidatus Liberibacter psyllaeus*' is known to infect capsicum, tomato, cape gooseberry, tamarillo and potato (MAFBNZ 2008).
- Both the plants and the fruits can be infected by '*Ca. L. psyllaeus*' and the bacterium has been detected in tomato fruits (MAFBNZ 2008).
- Fruit infected by '*Ca. L. psyllaeus*' are small, misshapen, with a strawberry-like appearance, and display uneven development of fruit locules (MAFBNZ 2008). Symptomatic fruit infected by '*Ca. L. psyllaeus*' is likely to be removed during grading operations.
- Asymptomatic fruit (tomato) has also been found to contain the bacterium (MAFBNZ 2008). Asymptomatic fruit is unlikely to be culled at harvest or during

post-harvest grading operations. This scenario would increase the chances of importing infected fruit into Australia.

- Furthermore, the bacterium would not be removed by standard post-harvest treatments, such as washing and brushing the fruit.
- New Zealand researchers have investigated the potential for '*Ca. L. psyllaeus*' to be transmitted through seed. Based on PCR testing, all parts of the fruit were found to contain the bacterium, including parts of the seed (MAFBNZ 2008).
- Good storage temperatures for tomatoes range from 7°C (90–95% humidity) for red ripe tomatoes to 13°C for mature green tomatoes (90–95% humidity) (PeakFresh 2008). These storage conditions are unlikely to have any significant impact on the level of '*Ca. L. psyllaeus*' in tomato or any other imported fruits.
- Tomatoes are highly perishable so short transport periods are necessary. Transport of fruit to Australia by either air or sea freight takes from a few hours to one week (Agribusiness Information Centre 2009). The short time from field to market also suggests that there would be little or no change in bacterial viability during post harvest transport and storage.

The demonstrated association of the pathogen with the pathway at its origin, presence of asymptomatic fruit and its ability to survive the duration of transport support a probability rating of 'high'.

### Probability of distribution

The likelihood that '*Ca. L. psyllaeus*' will be distributed within Australia in a viable state with imported fruit and transferred to a suitable host: **EXTREMELY LOW**.

- Fruits from '*Ca. L. psyllaeus*' host plants will be distributed for retail sale to multiple destinations within the PRA area, so a portion of the fruit is likely to reach areas of host abundance.
- Hosts of '*Ca. L. psyllaeus*' include capsicum, tomato, cape gooseberry, tamarillo and potato (MAFBNZ 2008). These species are widely distributed in commercial and domestic environments within Australia. The susceptibility of other members of the Solanaceae family to '*Ca. L. psyllaeus*' requires further investigation.
- Fruit infected by '*Ca. L. psyllaeus*' is small, misshapen, with a strawberry-like appearance, and display uneven development of fruit locules (Liefing *et al.* 2009). Symptomatic fruits are likely to be considered unmarketable by wholesalers and retailers. These fruits may be disposed of with general garbage or in compost bins before sale.
- Asymptomatic fruit in sound condition would be distributed and sold through markets and retail chains.
- Although the intended use of fresh fruit is human consumption, waste material would be generated (e.g. overripe and damaged fruit, uneaten portions). Whole or parts of the fruit may be disposed of at multiple locations throughout Australia in compost bins or amongst general household waste.
- The transfer of '*Ca. L. psyllaeus*' from fruit waste to a host would require a vector. The only known vector of '*Ca. L. psyllaeus*' is the tomato-potato psyllid (*Bactericera cockerelli*) (Hansen *et al.* 2008). Vector trials in New Zealand have

shown that this psyllid can transmit '*Ca. L. psyllae*' from infected tomato fruit with and without stalks or calyxes to healthy capsicum plants (Workman *et al.* 2008; Jones *et al.* 2008a, 2008b).

- There is no evidence that the tomato-potato psyllid is present in Australia.
- Only three psyllid species are known to vector '*Ca. Liberibacter*' species. In the field, the Asian citrus psyllid (*Diaphorina citri*) vectors '*Ca. L. asiaticus*' and '*Ca. L. americanum*' (Yamamoto *et al.* 2006), the African citrus psyllid (*Trioza erythrae*) vectors of '*Ca. L. africanus*' (Aubert 1987) and the tomato-potato psyllid (*B. cockerelli*) vectors '*Ca. L. psyllae*' (Hansen *et al.* 2008). This vector specificity suggests it is very unlikely that Australian native psyllids would be able to vector '*Ca. L. psyllae*'.
- Furthermore, there are no species in the genus *Bactericera* in Australia and the only known member of the Triozidae or Psyllidae families reported feeding on a solanaceous host in Australia is an undescribed species of *Acizzia* that feeds on eggplant (Kent 2008).
- Graft transmission has been demonstrated for '*Ca. L. psyllae*' in trials in New Zealand (MAFBNZ 2008) but fruit and fruit truss material is not suitable for grafting.
- Seed transmission trials found no '*Ca. L. psyllae*' infection in 1030 tomato seedlings, 225 capsicum seedlings and 225 tamarillo seedlings raised from seed from infected fruit (Liefting 2008a), indicating that '*Ca. L. psyllae*' is not seed-transmitted, at least at the frequency that would have been detected in these experiments. Therefore, it is unlikely that plants infected with '*Ca. L. psyllae*' would establish from seed from imported fruit of host species.

The absence of a suitable vector in the PRA area and the lack of seed and manual transmission, support a probability rating of 'extremely low'.

### 5.1.2 Pathway 2 – Potato tubers

#### Probability of importation

The likelihood that '*Ca. L. psyllae*' will arrive in Australia with trade in fresh potato tubers for consumption: **HIGH**.

- '*Candidatus Liberibacter psyllae*' is known to infect all parts of potato plants, including the tubers (MAFBNZ 2008).
- Potato tubers infected by '*Ca. L. psyllae*' have a brown discolouration of the vascular ring and necrotic flecking of internal tuber tissues (MAFBNZ 2008). Internal symptoms may be difficult to detect at harvest or during post-harvest grading operations.
- The characteristic symptom of '*Ca. L. psyllae*' infection is a striped pattern of discolouration that occurs only after the potato tuber is cooked. This symptom would not be apparent at the time of import.
- Infected hosts may also be asymptomatic (MAFBNZ 2008). Symptoms are thought to be induced by environment (temperature) and growing conditions (glasshouse or

field grown, soil moisture and nutrients). This scenario would increase the chances of importing infected tubers into Australia.

- Furthermore, the bacterium would not be removed by standard post-harvest treatments, such as washing and brushing.
- Potato tubers for the fresh market are generally stored at 4–6°C and those for processing at 7–10°C, with a relative humidity of 95% or above (DPIW 2007; Holley 2003). It is unknown what affect these storage conditions would have on the level of '*Ca. L. psyllaeus*' infection in potato tubers but they are not expected to eliminate the bacterium from the tubers.

The association of '*Ca. L. psyllaeus*' with potato tubers, ability for infected plants to remain asymptomatic and the likelihood of the bacterium remaining viable during transport and storage supports an assessment of 'high' for the importation of this species in potato tubers.

### Probability of distribution

The likelihood that '*Ca. L. psyllaeus*' will be distributed within Australia in a viable state with imported potato tubers and transferred to a suitable host: **MODERATE**.

- Potato tubers for consumption will be distributed for retail sale to multiple destinations within Australia.
- Potato tubers infected by '*Ca. L. psyllaeus*' have a brown discolouration of the vascular ring and necrotic flecking of internal tuber tissues (MAFBNZ 2008). Internal symptoms may not be detected during distribution and retail sale.
- The characteristic symptom of '*Ca. L. psyllaeus*' infection is a striped pattern of discolouration that occurs only after the potato tuber is cooked. This symptom would not be apparent at the point of sale of the fresh commodity.
- Infected tubers in apparently sound condition would be distributed and sold through markets and retail chains.
- Although the intended use of potato tubers is human consumption, waste material would be generated (e.g. sprouting and damaged tubers). Whole or parts of potato tubers could be planted or disposed of at multiple locations throughout Australia in compost bins or amongst general household waste.
- An important tuber characteristic of tuber infection is a loss of dormancy, resulting in premature sprouting and the production of very weak, spindly sprouts (UNL 2009). These tubers are unlikely to be planted or produce daughter plants, reducing the probability of the distribution of the bacterium.
- The only known vector of '*Ca. L. psyllaeus*' is the tomato-potato psyllid (*Bactericera cockerelli*) (Hansen *et al.* 2008). There is no evidence that this psyllid is present in Australia. There is also no evidence to suggest that this psyllid feeds on potato tubers or can acquire the bacterium from feeding on potato tubers.
- Only three psyllid species are known to vector '*Ca. Liberibacter*' species. In the field, the Asian citrus psyllid (*Diaphorina citri*) vectors '*Ca. L. asiaticus*' and '*Ca. L. americanum*' (Yamamoto *et al.* 2006), the African citrus psyllid (*Trioza erythrae*) vectors of '*Ca. L. africanus*' (Aubert 1987) and the tomato-potato psyllid (*B. cockerelli*) vectors '*Ca. L. psyllaeus*' (Hansen *et al.* 2008). This vector specificity



suggests it is very unlikely that Australian native psyllids would be able to vector 'Ca. L. psyllae'.

- Furthermore, there are no species in the genus *Bactericera* in Australia and the only known member of the Triozidae or Psyllidae families reported feeding on a solanaceous host in Australia is an undescribed species of *Acizzia* that feeds on eggplant (Kent 2008).
- For 'Ca. L. psyllae' to be distributed through infected tubers, they must be able to grow and produce infected plants. Shapovalov (1929) suggests that 'Ca. L. psyllae' infection can be transmitted with potato tubers. That is, infected tubers can produce rise to infected plants.
- It is therefore possible for the bacterium to be distributed within Australia with the planting or disposal of infected tubers into locations where they can grow, without the aid of its psyllid vector.

The association of 'Ca. L. psyllae' with potato tubers, the likelihood of distribution to multiple locations and the ability of infected tubers to produce infected plants, moderated by loss of dormancy and premature sprouting, support an assessment of 'moderate' for the distribution of this species in potato tubers.

### 5.1.3 Pathway 3 – Nursery stock

#### Probability of importation

The likelihood that 'Ca. L. psyllae' will arrive in Australia with the importation of nursery stock: **HIGH**.

- Nursery stock is significantly different from other commodities such as fruit, in that nursery stock can support all life stages of pests associated with it. Many of these are able to develop, reproduce and complete their life cycle without leaving the host.
- 'Candidatus L. psyllae' can be associated with all vegetative parts of host plants (MAFBNZ 2008), so nursery stock of host plants can be infected and provide a pathway for the importation of the bacterium into Australia.
- The bacterium is known to infect capsicum, tomato, cape gooseberry, tamarillo and potato (MAFBNZ 2008).
- Of these known hosts of 'Ca. L. psyllae', nursery stock of cape gooseberry, potato and tamarillo is permitted entry to Australia (Table 1.1).
- 'Candidatus L. psyllae' is a newly described pathogen (Hansen *et al.* 2008), and it is likely that further hosts will be identified in the future. These are likely to occur in the Solanaceae, Convolvulaceae or Lamiaceae, as the known vector of the bacterium, the tomato-potato psyllid, reproduces on a wide range of hosts in these families (Appendix A). Nursery stock of a number of these hosts is permitted entry to Australia (Appendix A).
- Plants infected by 'Ca. L. psyllae' show various symptoms including shortened petioles, chlorotic leaves and a sharp tapering of the leaf apex (spiky appearance) leading to leaf cupping (MAFBNZ 2008). Symptomatic nursery stock will be detected on arrival in Australia.

- It has also been noted that '*Ca. L. psyllaurosus*' infected plants may be asymptomatic (MAFBNZ 2008). Symptoms are thought to be induced by environment (temperature) and growing conditions (glasshouse or field grown, soil moisture and nutrients).
- It is likely that asymptomatic plants infected by '*Ca. L. psyllaurosus*' would pass routine visual inspections and be released from quarantine into Australia.
- Nursery stock is expected to be shipped at moderate temperatures and humidity levels to ensure its survival. These conditions are unlikely to adversely affect '*Ca. L. psyllaurosus*' during shipment.

The association of '*Ca. L. psyllaurosus*' with nursery stock, the ability for infected plants to remain asymptomatic and the likelihood that the bacterium would remain viable during transport and storage support an assessment of 'high' for the importation of this species in nursery stock.

### Probability of distribution

The likelihood that '*Ca. L. psyllaurosus*' will be distributed within Australia in a viable state with imported nursery stock and transferred to a suitable host: **HIGH**.

- Nursery stock is imported into Australia for propagation in nurseries for sale and distribution to multiple destinations within Australia.
- Plants produced from the nursery stock will be planted directly into suitable habitats to grow.
- As nursery stock may not display symptoms of '*Ca. L. psyllaurosus*' infection, there is a risk that infected material would be used for propagation.
- '*Candidatus Liberibacter*' species are spread through propagation (Polek *et al.* 2007). Graft transmission has been proven for '*Ca. L. psyllaurosus*' in trials undertaken in New Zealand (MAFBNZ 2008).
- Production of nursery stock of cape gooseberry, tamarillo and other solanaceous plants would be by cuttings and grafts.
- The only known vector of '*Ca. L. psyllaurosus*' is the tomato-potato psyllid (Hansen *et al.* 2008). There is no evidence that this psyllid is present in Australia.
- Only three psyllid species are known to vector '*Ca. Liberibacter*' species. In the field, the Asian citrus psyllid (*Diaphorina citri*) vectors '*Ca. L. asiaticus*' and '*Ca. L. americanum*' (Yamamoto *et al.* 2006), the African citrus psyllid (*Trioza erythrae*) vectors of '*Ca. L. africanus*' (Aubert 1987) and the tomato-potato psyllid (*B. cockerelli*) vectors '*Ca. L. psyllaurosus*' (Hansen *et al.* 2008). This vector specificity suggests it is very unlikely that Australian native psyllids would be able to vector '*Ca. L. psyllaurosus*'.
- Furthermore, there are no species in the genus *Bactericera* in Australia and the only member of the Triozidae or Psyllidae families reported feeding on a solanaceous host in Australia is an undescribed species of *Acizzia* that feeds on eggplant (Kent 2008).
- As there are no known vectors of '*Ca. L. psyllaurosus*' in Australia, the only pathway for the distribution of the bacterium in nursery stock is the planting of infected plants into suitable habitats for their growth.

The association of 'Ca. L. psyllae' with nursery stock and the likely distribution of infected plants to multiple locations support an assessment of 'high' for the distribution of this species in nursery stock.

#### 5.1.4 Pathway 4 – Tomato-potato psyllid

##### Probability of importation

The likelihood that tomato-potato psyllids infected with 'Ca. L. psyllae' will arrive in Australia with trade in fresh fruit or nursery stock of host species of the Solanaceae family: **HIGH**.

- *Bactericera cockerelli* is the only known insect vector of 'Ca. L. psyllae' (Hansen *et al.* 2008). The psyllid acquires the bacterium by feeding on infected host plants.
- 'Candidatus L. psyllae' host plants include capsicum, tomato, cape gooseberry, tamarillo and potato (MAFBNZ 2008).
- *Bactericera cockerelli* is reportedly able to develop, reproduce and complete its life cycle on all known hosts of 'Ca. L. psyllae' (NZCOP 2008; Wallis 1955; Knowlton and Thomas 1934).
- Hosts of 'Ca. L. psyllae', such as tomato, potato and capsicum, are preferred by *B. cockerelli*. This makes it more likely that psyllids entering Australia from 'Ca. L. psyllae' affected areas would be infected with the bacterium.
- *Bactericera cockerelli* feeds on a wide range of plants, which includes species in 20 plant families, but the psyllid only breeds on species in the Solanaceae, Convolvulaceae and Lamiaceae (Wallis 1955). It would be possible for infected psyllids to enter Australia via trade in commodities, such as fresh fruit and nursery stock, of any of these species but is more likely to be associated with host species.
- A number of consignments of yellow bell and red bell peppers arriving in Hawaii from Los Angeles were infested with the tomato-potato psyllid (HDOA E-News 2004).
- Nursery stock represents a higher risk than fruit, as nursery stock of host species supports all life stages of the psyllid. Adult female *B. cockerelli* lay their eggs on the leaves of host plants and nymphs are commonly found on the underside of the leaf (Horticulture New Zealand 2009). Therefore, propagative material from 'Ca. L. psyllae' affected areas may harbour infected *B. cockerelli* eggs, nymphs and/or adults.
- 'Candidatus L. psyllae' can infect all life stages of the psyllid, including eggs (Hansen *et al.* 2008). *Bactericera cockerelli* eggs are quite small and may be difficult to detect during routine visual inspection. UCIPM (2008) states that the eggs are best seen with the use of a hand lens.
- In contrast, nymphs and adults of *B. cockerelli* are 2 mm and 3 mm in length respectively and are likely to be detected with the naked eye (Horticulture New Zealand 2009).
- Furthermore, feeding psyllids excrete visible waxy beads of excess sugar (Clark 2005).

- Existing pest management procedures applied in some countries may reduce the likelihood of '*Ca. L. psyllae*' infected psyllids entering Australia.
- In New Zealand, a voluntary code of practice is used for the management of the tomato/potato psyllid in greenhouse tomato and capsicum crops (NZCOP 2008). This code of practice includes both pre-harvest measures and post-harvest measures. The pre-harvest measures include management of alternative hosts, increased hygiene in and around the greenhouses, crop removal, cleaning greenhouses between crops, monitoring for the tomato/potato psyllid and insecticide applications. Post-harvest measures include keeping packaging areas clean, washing or brushing and packing export fruit in line with standard grading procedures, inspection and air blasting where necessary for truss tomatoes and fruit with calyces and segregating export fruit. However, not all host commodities are produced according to this code of practice and these measures are not mandatory. The New Zealand code of practice is in Appendix B.
- *Bactericera cockerelli* nymphs use their piercing mouth parts to extract plant juices from foliage. Therefore, in the case of nursery stock containing foliage, this species has the potential to remain active during transport and storage, and may be able to develop from nymphs to breeding adults.
- *Bactericera cockerelli* can survive as nymphs for up to 90 days but usually takes only 14–21 days before developing into adults. Eggs hatch within a few days of being laid. The entire duration of the lifecycle is 4–5 weeks, but this varies considerably depending on hosts and temperature (UNL 2009).
- Nursery stock is expected to be shipped at moderate temperatures and humidity levels, which are unlikely to adversely affect any '*Ca. L. psyllae*' infected psyllids populations that are present during shipment.
- The optimum temperature for the development and survival of *B. cockerelli* is 27°C. Temperatures below 16°C or above 32°C are reported to adversely affect the development and survival of this pest (Ferguson *et al.* 2003).
- However, fresh fruit is expected to be subject to cool temperatures during storage and transport. The storage temperatures for tomato fruit is 9–13°C (PeakFresh 2008).
- These storage temperatures are not lethal to *B. cockerelli*, but will slow down the egg laying and hatching processes. It is unknown, but considered unlikely, that these temperatures would reduce or eliminate '*Ca. L. psyllae*' within the psyllid.
- Tomatoes are also highly perishable so short transport periods are necessary. Transport of fruit to Australia by either air or sea freight takes from few hours to one week (Agribusiness Information Centre 2009). The short time from field to market also suggests that there would be little or no impact on the survival of '*Ca. L. psyllae*' within the eggs, nymphs or adults of *B. cockerelli* during post-harvest transport and storage.
- Nymphs and adults may enter through consignments of host fruit, such as capsicum and tomato. Capsicums and truss tomatoes may be particularly suitable for the importation of *B. cockerelli*, due to the presence of the calyx and the recesses between the calyx and the fruit where nymphs and adults may lodge.

The ability of 'Ca. L. psyllae' to infect its psyllid vector, the association of the psyllid with fruit and nursery stock of host plants and the likelihood of the bacterium remaining viable within the psyllid during transport and storage supports an assessment of 'high' for the importation of 'Ca. L. psyllae' in *B. cockerelli*.

### Probability of distribution

The likelihood that 'Ca. L. psyllae', having entered Australia in an infected psyllid will be transferred in a viable state to a host plant has been determined to be **HIGH**.

- *Bactericera cockerelli* infected with 'Ca. L. psyllae' imported into Australia on fruit and nursery stock of host plants would be distributed within Australia through wholesale and retail sale for consumption or growth in commercial production areas.
- The bacterium is associated with all life stages of *B. cockerelli*, including eggs (Hansen *et al.* 2008). Fruit or nursery stock could be infested with eggs, nymphs or adults of the psyllid. Eggs hatch in 5–9 days and nymphal development takes 19–24 days, depending on the temperature (Abdullah 2008).
- For infected psyllids to transfer to host plants they would need to complete their development into adults so that they can fly to the host plant. However, immature stages of the psyllid must have suitable food sources to allow them to survive until they mature. Due to the relatively long developmental time (up to 30 days from egg to adult), there is likely to be some mortality of eggs and nymphs.
- *Bactericera cockerelli* has a wide host range, feeding on plants in the Solanaceae, Convolvulaceae and Lamiaceae (Appendix A). Hosts of the psyllid are widely distributed in Australia. These hosts include the common weeds silverleaf nightshade (*Datura stramonium*), fierce thorn-apple (*Datura ferox*), sacred datura (*Datura innoxia*) and jimson-weed (*Datura metel* and *Datura stramonium*).
- 'Candidatus L. psyllae' has a narrower host range than *B. cockerelli*. Its known hosts are cape gooseberry, capsicum, chilli, potato, tamarillo and tomato (MAFBNZ 2008). These plants are grown widely in home gardens and commercial vegetable growing areas.
- Australia has a diverse flora of the Solanaceae (23 genera and about 200 species) but the susceptibility of these species to 'Ca. L. psyllae' is unknown.
- As 'Ca. L. psyllae' is a newly described pathogen, it is likely further hosts will be identified.
- For 'Ca. L. psyllae' to be transferred from fruit to a suitable host, infected psyllids would need to find a host of the bacterium, feed, and successfully transmit the bacterium to the host.
- Imported nursery stock is likely to be planted directly into suitable habitats to grow. If infected psyllids are imported on a 'Ca. L. psyllae' host, there is no requirement for the psyllid to be transported to a suitable host. Infected nymphs would be able to transmit 'Ca. L. psyllae' to the imported host plant and thus distribute the bacterium.
- If infected psyllids are imported with nursery stock of a non-'Ca. L. psyllae' host, the psyllid would need to move from the pathway to a suitable host.

- Psyllids can migrate long distances and flights of up to 83 km have been recorded (HTWG 2007). Similar long flights are likely to be undertaken by *B. cockerelli*.
- Nymphs are also capable of crawling short distances. However, nymphs typically settle on the undersides of leaves to feed (Horticulture New Zealand 2009), and would therefore be a lower risk for movement.
- In the case of plant material for commercial use, if infested nursery stock was introduced, the psyllid could potentially move to other suitable host plants surrounding them, and be passively redistributed by the further movement of these infested plants.
- For infected psyllids imported as eggs to transfer to a '*Ca. L. psyllae*' host plant, they would need to complete their development into adults so that they can fly to the host plant.
- Infected eggs hatch in 5–9 days and nymphal development takes 19–24 days, depending on the temperature (Abdullah 2008). However, immature stages of the psyllid must have suitable food sources to survive until they mature. Due to the relatively long developmental time (up to 30 days from egg to adult), there is likely to be some mortality of eggs and nymphs.
- Although the intended use of imported fresh fruit is human consumption, waste material would be generated (e.g. overripe and damaged fruit, uneaten portions).
- Whole or parts of the imported fruit may be disposed of at multiple locations throughout Australia in compost bins or amongst general household waste. Adults may be able survive on waste material for a short time before dispersing to suitable hosts.

The association of '*Ca. L. psyllae*' with its psyllid vector, the ability for infected psyllids to disperse both independently and through the movement of fruit and nursery stock, and the presence of multiple hosts within the PRA area, support an assessment of 'high' for the distribution of '*Ca. L. psyllae*' in *B. cockerelli*.

### 5.1.5 Overall probability of entry

The probability of entry is determined by combining the probability of importation with the probability of distribution using the matrix of rules for combining descriptive likelihoods (Table 2.2). The overall probability of entry for the four pathways being assessed in this PRA are set out in Table 5.1.

**Table 5.1: Overall probability of entry of '*Ca. L. psyllae*' for pathways**

Pathway	Probability of importation	Probability of distribution	Overall probability of entry
Fruit (including seed)	High	Extremely Low	Extremely low
Tubers	High	Moderate	Moderate
Nursery stock	High	High	High
Infected psyllids	High	High	High

## 5.2 Probability of establishment

The probability of establishment considers whether the bacterium could develop a persistent population in host plants. As the probability of entry was completed when the bacterium was transmitted to a host plant in a viable state, the probability of establishment needs only consider whether the bacterium will establish within the plant.

The likelihood that 'C. L. psyllauros' will establish within Australia, based on a comparison of factors in the source and destination areas considered pertinent to its survival and reproduction, is **HIGH**.

- 'Candidatus L. psyllauros' occurs in North Dakota, Texas, New York, Colorado, Kansas, New Mexico, Utah, Idaho, Arizona, Wyoming, Nebraska and California in the USA; Alberta in Canada; Sotillo in Mexico; and New Zealand (Carter 1939; MAFBNZ 2008).
- The climatic regions across this range are diverse and include desert, steppe, Mediterranean, marine west coast, humid continental and humid subtropical (Espenshade 1990).
- There are similar climatic regions in parts of Australia that would be suitable for the establishment of the bacterium.
- The entry of 'Ca. L. psyllauros' in imported nursery stock would allow the establishment of the bacterium in plants produced from this material.
- There are no agri-chemicals available for control of 'Ca. L. psyllauros' (Horticulture New Zealand 2008) and any chemicals used on host plants in Australia are not expected to prevent the bacterium establishing in a host plant.
- A number of hosts of 'Ca. L. psyllauros' are perennial. If a perennial host, such as tamarillo, was infected the bacterium would be able to establish a persistent population.
- If potato plants were infected, 'Ca. L. psyllauros' could establish in the plants and be passed on to daughter plants through tubers (Shapovalov 1929).
- If annual hosts such as capsicum, chilli and tomato were infected, the bacterium would only be established in the plants until they died at the end of the season.
- Should 'Ca. L. psyllauros' enter Australia in *B. cockerelli*, the psyllid could form a founding population. However, this would rely on sufficient numbers of adult psyllids being released into the Australian environment. A founding population of the psyllid would be able to transmit 'Ca. L. psyllauros' to other host plants and create a founding population of the bacterium.
- Australian climatic conditions in the commercial horticultural growing areas would support the development and survival of *B. cockerelli*.
- It is not certain how 'Ca. L. psyllauros' entered and established in New Zealand, but the presence of the tomato-potato psyllid in New Zealand only two years prior to the confirmation of 'Ca. L. psyllauros' in New Zealand suggests that it was introduced with the psyllid and was able to establish an undetected founding population (MAFBNZ 2008).

The ability of '*Ca. L. psyllae*' to multiply in infected hosts, especially in perennial species imported as nursery stock, supports a likelihood of 'high' for the establishment of '*Ca. L. psyllae*' in Australia.

### 5.3 Probability of spread

The likelihood that '*Ca. L. psyllae*' will spread within Australia, based on a comparison of those factors in the source and destination areas considered pertinent to the expansion of the geographic distribution of the pest, is: **HIGH**.

- The spread of '*Ca. L. psyllae*' within Australia would rely on the movement of infected potato tubers, nursery stock or *B. cockerelli*.
- There is the potential for the spread of the bacterium directly through infected potato tubers but premature sprouting and the production of spindly sprouts by infected tubers (UNL 2009) may limit this spread as these tubers are unlikely to be planted or produce daughter plants.
- '*Candidatus L. psyllae*' could be spread to new areas through the movement of infected planting material. As visual symptoms may not be present, and in the absence of specific testing regimes, infected nursery stock could easily be moved to new areas.
- Existing interstate quarantine control measures on the movement of nursery stock and potato tubers could reduce the rate of spread of '*Ca. L. psyllae*'.
- If '*Ca. L. psyllae*' entered in infected *B. cockerelli* and the psyllid established in Australia, the bacterium would be spread into new areas by the psyllid (Kumarasinghe 2008).
- *Bactericera cockerelli* has been reported from a variety of areas and environments. Its distribution includes Minnesota, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Texas and all states for Oregon and Washington. It was detected in Canada in Alberta and Saskatchewan. It is also reported from as far south as Mexico City and Rio Frio, Puebla (Cranshaw 1993). It has recently been detected in the Auckland region of New Zealand, both in greenhouse tomato and capsicum nurseries and commercial potato crops (MAFBNZ 2008). There are similarities in the natural and managed environment of these regions with many areas of Australia. This suggests that many areas in Australia where hosts of '*Ca. L. psyllae*' are grown would be suitable for the spread of the bacterium by *B. cockerelli*.
- '*Candidatus L. psyllae*' is wide spread in the potato, tomato, capsicum and eggplant growing areas of New Zealand (MAFBNZ 2008). This demonstrates the ability of the bacterium to spread if its vector and hosts are present.
- It is unlikely any of the endemic species of psyllid in Australia would be able to vector the bacterium. '*Candidatus L. psyllae*' is only known to be vectored by *B. cockerelli* and the only species of Australian Psyllidae or Triozidae known to feed on a solanaceous host is an undescribed species of *Acizzia* found on eggplant (Kent 2008).
- The widespread distribution of hosts of '*Ca. L. psyllae*' and *B. cockerelli* in many regions of Australia would assist the spread of '*Ca. L. psyllae*' if the pathogen and its vector were established in Australia.



- Psyllids can migrate long distances and flights of up to 83 km have been recorded (HTWG 2007). Adult *B. cockerelli* are strong fliers and can also be blown on the wind (Horticulture New Zealand 2008).
- The bacterium is not spread mechanically by rubbing or handling or on machinery or clothing during production of crops (Horticulture New Zealand 2008).

Movement of infected potato tubers, nursery stock of host species or *B. cockerelli* supports an assessment of 'high' for the spread of '*Ca. L. psyllaeus*'.

## 5.4 Overall probability of entry, establishment and spread

The probability of entry, establishment or spread is determined by combining the probability of entry, of establishment and of spread using the matrix of rules for combining descriptive likelihood (Table 2.2).

The overall likelihood that '*Ca. L. psyllaeus*' will enter Australia by the pathways discussed in this PRA, be distributed in a viable state to susceptible hosts, establish in that area and subsequently spread within Australia are set out in Table 5.2.

**Table: 5.2: Overall probability of entry, establishment and spread of '*Ca. L. psyllaeus*' for pathways**

Pathway	Probability of entry	Probability of establishment	Probability of spread	Overall probability of entry, establishment and spread
Fruit (including seed)	Extremely low	High	High	Extremely low
Tubers	Moderate			Moderate
Nursery stock	High			High
Infected psyllids	High			High

## 5.5 Consequences

The consequences of the entry, establishment and spread of '*Ca. L. psyllaeus*' in Australia have been estimated according to the methods described in Table 2.3. The assessment of potential consequences is provided below:

Impact scores for ' <i>Candidatus Liberibacter psyllaeus</i> '	
Criterion	Estimate and justification
<b>Direct</b>	
<b>Plant life or health</b>	<p><b>F</b> – Significant at national level</p> <p>The disease caused by '<i>Ca. L. psyllaeus</i>' has significant effect on plant health, life and yield. In tomato alone, it resulted in yield losses up to 85% and 50% in commercial crops in western North America during 2001 and 2004, respectively (Hansen <i>et al.</i> 2008).</p> <p>Crop losses of up to \$1 million were caused by '<i>Ca. L. psyllaeus</i>' and tomato-potato psyllid in greenhouse tomato and capsicum crops in New Zealand (MAFBNZ 2008). This is a relatively new pathogen to New Zealand and crop losses may increase in the</p>

	<p>future.</p> <p>The mean yield from potato crops affected by zebra chip symptoms was approximately 60% less than expected and harvested tubers had less dry matter (13%) than normal (19%) (Liefting <i>et al.</i> 2008a).</p> <p>Tubers from zebra chip affected plants produced potatoes unmarketable for potato chips (Munyeneza <i>et al.</i> 2008).</p> <p>Losses on some farms in the USA exceeded \$2 million annually during the last two seasons. About 38 percent of Texas acreage could be lost or sold at reduced prices attributable to increased presence of zebra chip (Rosson 2006).</p> <p>If not managed, this bacterium could threaten the economic viability of commercial producers in a range of areas across Australia.</p> <p>Other solanaceous plants in the environment, including amenity plants may be affected by symptoms of '<i>Ca. L. psyllaeus</i>' infection. Infection may reduce the amenity value or even result in plant death.</p>
<b>Any other aspects of environment</b>	<p><b>B-</b> Minor significance at local level</p> <p>There may be some impact on insect or animal species that feed on host plants due to the reduced availability or vigour of these host plants.</p>
<b>Indirect</b>	
<b>Eradication, control, etc.</b>	<p><b>F-</b> Significant at national level</p> <p>There are no agri-chemicals available for control of '<i>Ca. L. psyllaeus</i>'. Control of psyllid vector is the key to limiting the impact of pathogen. A strain of the psyllid in the USA has developed insecticide resistance (Horticulture New Zealand 2008).</p> <p>Eradication of the bacterium would require the removal of large numbers of native, amenity, weedy and commercial Solanaceae plants within the vicinity of outbreaks. Due to the large number of hosts plants affected, the costs of any eradication campaign are likely to be substantial.</p> <p>While potentially able to be managed in commercial production, the presence of the bacterium will significantly increase the production costs for producers.</p>
<b>Domestic trade</b>	<p><b>D-</b> Significant at district level</p> <p>The presence of '<i>Ca. L. psyllaeus</i>' in production areas may result in some domestic movement restriction for host commodities. However, due to the extremely low risk of entry of the pathogen posed by movement of fruit for consumption, restrictions are only likely for potato tubers and nursery stock.</p>
<b>International trade</b>	<p><b>D-</b> Significant at district level</p> <p>The presence of '<i>Ca. L. psyllaeus</i>' in production areas may limit access to some overseas markets and make market access negotiations more difficult. Some important markets for Solanaceae crops, such as New Zealand, already have the bacterium, but other areas do not. Due to the importance and value of some Solanaceae crops, disruption to trade is expected to be significant to growers and production areas.</p>
<b>Environmental and non-commercial</b>	<p><b>B –</b> Minor significance at local level</p> <p>While no direct control measures are available for the bacterium, large scale removal of alternate host plants may affect the environment. Broad-scale chemical treatments directed against known insect vectors may also have some impacts on native insects.</p>

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to a single criterion has an impact of '**F**', the overall consequences are estimated to be **High**.

## 5.6 Unrestricted risk

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the estimate of consequences using the risk estimation matrix shown in Table 2.5. The unrestricted risk estimates for '*Ca. L. psyllaeus*' for the four pathways are set out in Table 5.3.

## 5.7 Risk assessment conclusion

The results of the pathway risk assessments for '*Ca. L. psyllaeus*' are set out in Table 5.3.

The unrestricted risk for '*Ca. L. psyllaeus*' for the fruit pathway has been assessed as '**very low**', which meets Australia's ALOP. Therefore, specific risk management measures for fruit are not required.

The unrestricted risk for '*Ca. L. psyllaeus*' for the potato tuber, nursery stock and infected tomato-potato psyllid pathways has been assessed as '**high**', which is above Australia's ALOP. Therefore, specific risk management measures are required to ensure that the bacterium does not enter, establish and spread through these pathways.

**Table 5.3: Summary of pathway risk assessments for '*Candidatus L. psyllae*'**

Pathway	Entry			Establishment	Spread	P[EES]	Consequences							URE
	importation	distribution	Overall				direct		indirect				Overall	
							PLH	OE	EC	DT	IT	ENC		
Fruit (including seed)	H	EL	EL	H	H	EL	F	B	F	D	D	B	H	VL
Potato tubers	H	M	M			M								H
Nursery stock	H	H	H			H								H
Infected tomato-potato psyllids	H	H	H			H								H

**Likelihoods for entry, establishment and spread****N** = Negligible**EL** = Extremely low**VL** = Very low**L** = Low**M** = Moderate**H** = High**P[EES]** = Overall probability of entry, establishment and spread**Consequences**

Consequences from pest entry, establishment and spread are on an ascending scale from A to G (see method section 4).

**PLH** = Plant life or health**OE** = Other aspects of the environment**EC** = Eradication, control etc.**DT** = Domestic trade**IT** = International trade**ENC** = Environmental and non-commercial**URE** = Unrestricted risk estimate

## 6 Pest risk management

### 6.1 Pest risk management measures and phytosanitary procedures

Pest risk management evaluates and selects risk management options to reduce the risk of entry of '*Ca. L. psyllae*' for the pathways where the unrestricted risk exceeds Australia's ALOP. Risk management measures are required to reduce this risk to achieve Australia's ALOP.

The pathway risk assessments identified three pathways that had an unrestricted risk above Australia's ALOP. The specific pest risk management measures and operational system proposed for '*Ca. L. psyllae*' for these pathways are summarised in Table 6.1. The fruit pathway was assessed as being below Australia's ALOP, so no measures are justified.

**Table 6.1: Phytosanitary measures proposed for '*Ca. L. psyllae*'**

Pest	Pathway	Measures
' <i>Ca. L. psyllae</i> '	Potato tubers	Area freedom*; or Processing in quarantine approved premises
	Nursery stock	Area freedom*; or Post-entry quarantine and testing
	Tomato-potato psyllid	Area freedom* from psyllid; or Systems approach for fruit with pre- and post-harvest measures; or Fruit treatment known to be effective against all life stages of the psyllid (e.g. methyl bromide fumigation); and Methyl bromide fumigation of nursery stock
*: Area freedom may include pest free areas, pest free places of production or pest free production sites		

The entry of '*Ca. L. psyllae*' via the tomato-potato psyllid is considered in this context as a secondary pathway. The psyllid could be associated with fruit or nursery stock, but would not itself be intentionally imported into Australia. Therefore, in the description of risk management measures below, measures to prevent the entry of the tomato-potato psyllid are described for both the fruit and nursery stock pathways.

Biosecurity Australia considers that the risk management measures proposed in this pest risk analysis will achieve Australia's ALOP.

The procedures described in the following section are proposed as the basis for the import conditions for hosts of '*Ca. L. psyllae*' and the tomato-potato psyllid (*B. cockerelli*) from all sources into Australia. While the following measures are proposed

by Biosecurity Australia, any other measure that provides an equivalent level of protection would be considered.

Note that these measures are for '*Ca. L. psyllaurosus*' and *B. cockerelli* and are in addition to the existing import conditions for the commodities described in this PRA.

### 6.1.1 Potato tubers

The pathway risk assessment identified that potato tubers had an unrestricted risk above Australia's ALOP. Risk mitigation measures are required to reduce the risk to meet Australia's ALOP. In the pathway risk assessment, it was established that potato tubers could be infected with the bacterium and that these tubers may not be detected and enter Australia, leading to the establishment and spread of '*Ca. L. psyllaurosus*'. A number of options may be available to reduce these risks.

#### Area freedom from '*Ca. L. psyllaurosus*'

Area freedom is a measure that might be applied to manage the risk posed by '*Ca. L. psyllaurosus*'. The requirements for establishing pest free areas or pest free places of production are set out in ISPM No. 4: *Requirements for the establishment of pest free areas* (FAO 1996) and ISPM No. 10: *Requirements for the establishment of pest free places of production and pest free production sites* (FAO 1999).

If area freedom from '*Ca. L. psyllaurosus*' could be demonstrated for areas or countries, the probability of entry would be reduced from 'high' to at least 'extremely low'. The unrestricted risk would then be reduced to at least 'very low', which would achieve Australia's ALOP.

Any proposal for area freedom status will need to be assessed by Biosecurity Australia.

#### Processing in quarantine approved premises

Potato tubers could be imported to Australia specifically for processing into saleable commodities. Examples of end products include potato chips, potato gems and mashed potato products. If imported potato tubers are transported, processed, and any waste material disposed of under appropriate quarantine conditions, the probability that '*Ca. L. psyllaurosus*' would be distributed to host plants in Australia would be reduced from 'high' to at least 'extremely low'. The unrestricted risk would then be reduced to at least 'very low', which would achieve Australia's ALOP.

Proposals for potato tubers to be imported into Australia for processing in quarantine approved premises would need to be assessed by Biosecurity Australia.

### 6.1.2 Nursery stock

The pathway risk assessment identified that the nursery stock had an unrestricted risk above Australia's ALOP. Risk mitigation measures are required to reduce the risk to meet Australia's ALOP. In the pathway risk assessment, it was established that nursery stock could be infected with the bacterium and that this nursery stock may not be detected and enter Australia, leading to the establishment and spread of '*Ca. L. psyllaurosus*'. A number of options may be available to reduce these risks.

### Sourcing nursery stock from pest free areas

Area freedom is proposed as a measure that might be applied to manage the risk posed by '*Ca. L. psyllae*' in nursery stock imported into Australia. The requirements for establishing pest free areas or pest free places of production are set out in ISPM No. 4: *Establishment of pest free areas* (FAO 1996) and ISPM No. 10: *Requirements for the establishment of pest free places of production and pest free production sites* (FAO 1999).

If area freedom from '*Ca. L. psyllae*' could be demonstrated for areas or countries, the probability of entry in nursery stock would be reduced from 'high' to at least 'extremely low'. The unrestricted risk would then be reduced to at least 'very low', which would achieve Australia's ALOP.

Any proposal for area freedom status will need to be assessed by Biosecurity Australia.

### Post-entry quarantine and testing

Post-entry quarantine is proposed as a measure that might be applied to manage the risk posed by '*Ca. L. psyllae*' in nursery stock imported into Australia.

All commercial food crops, which include cape gooseberry, eggplant, pepino, potato, tamarillo and tomatillo, are classed as high risk nursery stock for Australia. All high risk nursery stock imported into Australia is subject to a period of post-entry quarantine on arrival in Australia. During this post-entry quarantine period, plants are required to produce new growth and may require testing for specific pathogens. Tissue cultures of high risk nursery stock also require growth in post-entry quarantine and any specific testing required for the species.

Biosecurity Australia proposes that nursery stock of all species of the Solanaceae be treated as high risk nursery stock until more is known about the host range of '*Ca. L. psyllae*'.

A minimum three month period of growth in post-entry quarantine is proposed for nursery stock of all species of the Solanaceae, except for potato (*Solanum tuberosum*). During this quarantine period, it is proposed that plants be grown at  $25 \pm 1^\circ \text{C}$ , as this temperature range has been shown to allow the development of the bacterium (Hansen *et al.* 2008). In addition to the observation of new growth for symptoms of '*Ca. L. psyllae*' infection (see Section 4.2.1), Biosecurity Australia proposes that all plants should be actively tested using available PCR primers specific to '*Ca. L. psyllae*' at the end of the quarantine period or when symptoms develop. Potato has a specific indexing protocol in post-entry quarantine and Biosecurity Australia proposes that an additional PCR test for '*Ca. L. psyllae*' be added to this protocol.

If nursery stock of solanaceous species was grown in post-entry quarantine, observed for symptoms of psyllid yellows and tested for infection using PCR primers specific to '*Ca. L. psyllae*', the probability of entry in nursery stock would be reduced from 'high' to at least 'extremely low'. The unrestricted risk would then be reduced to at least 'very low', which would achieve Australia's ALOP.

### 6.1.3 Infected tomato-potato psyllids

The pathway risk assessment identified that infected tomato-potato psyllids had an unrestricted risk above Australia's ALOP. Risk mitigation measures are required to reduce the risk to meet Australia's ALOP. In the pathway risk assessment, it was established that tomato-potato psyllids infected with the bacterium on fruits and nursery stock may not be detected and enter Australia, leading to the establishment and spread of 'Ca. L. psyllauros'.

#### Area freedom from tomato-potato psyllid

Area freedom is a measure that might be applied to manage the risk posed by 'Ca. L. psyllauros' associated with tomato-potato psyllids. The requirements for establishing pest free areas or pest free places of production are set out in ISPM No. 4:

*Establishment of pest free areas* (FAO 1996) and ISPM No. 10: *Requirements for the establishment of pest free places of production and pest free production sites* (FAO 1999).

If area freedom from the tomato-potato psyllid could be demonstrated for areas or countries, the probability of entry would be reduced from 'moderate' to at least 'extremely low'. The unrestricted risk would then be reduced to at least 'very low', which would achieve Australia's ALOP.

Any proposal for area freedom status will need to be assessed by Biosecurity Australia.

#### Systems approach for fruit including pre- and post-harvest measures

A systems approach combining crop monitoring and psyllid control with post-harvest measures could be used to reduce the risk of infected tomato-potato psyllids being imported to Australia with consignments of fruit of Solanaceae crops.

Currently, imports of fruit of Solanaceae crops are mainly from New Zealand and include capsicum, tomato and tamarillo. Therefore, the consideration of a systems approach is made with specific reference to information on the measures being taken in New Zealand to control the psyllid. However, Biosecurity Australia would consider any system that provides an equivalent level of control of the tomato-potato psyllid.

As stated in the pathway risk assessments, an industry code of practice has been developed for the greenhouse capsicum and tomato industries in New Zealand. In the code of practice, crop monitoring regimes and action thresholds are recommended to control the psyllid in greenhouses (NZCOP 2008). See Appendix B for a copy of the code of practice. Compliance with the code of practice will ensure low psyllid populations in greenhouses.

In the code of practice, post-harvest processing of greenhouse grown capsicum and tomato fruit is undertaken and the standard measures include washing or brushing of the fruit. Brushing of fruit is used specifically to remove dirt, debris and other extraneous material (often referred to as trash) and to ensure that the fruit is of a high quality and in a saleable condition. Biosecurity Australia considers that brushing of fruit would be effective in removing all life stages of the psyllid on the surface of fruit, providing the brushing can reach all parts of the fruit.



Biosecurity Australia considers that brushing of fruit would be suitable for loose tomato and tamarillo fruit. These brushing processes are considered to be unsuitable for some commodities, such as truss tomatoes and capsicum fruit, where spaces between the fruit and the calyx around the stem end provide a cryptic habitat where psyllids may reside.

Biosecurity Australia considers that the use of a systems approach for the production of loose tomatoes, based on compliance with the New Zealand code of practice for greenhouse tomato and capsicum crops and commercial brushing practices, would reduce the probability of entry of infected tomato-potato psyllids from 'moderate' to at least 'extremely low'. The unrestricted risk would then be reduced to at least 'very low', which would achieve Australia's ALOP.

Systems similar to the New Zealand code of practice for the tomato-potato psyllid in greenhouse tomato and capsicum crops may also reduce the probability of entry on other commodities such as tamarillo. Biosecurity Australia will consider the effectiveness of any system proposed by exporting countries for their commodities.

### **Treatment of fruit and nursery stock**

A treatment that is known to be effective against all life stages of *B. cockerelli* (e.g. fumigation with methyl bromide) is a measure that might be applied to manage the risk posed by tomato-potato psyllids infected by '*Ca. L. psyllae*' in imports of fruit and nursery stock of members of the Solanaceae. Treatment of fruit and nursery stock would reduce the probability of entry of infected tomato-potato psyllids to at least 'extremely low'. The unrestricted risk would then be reduced to at least 'very low', which would achieve Australia's ALOP

It is proposed that where methyl bromide fumigation of fruit of solanaceous crops is adopted, it must be completed in accordance with the relevant AQIS standards at one of the following rates:

- 48 g/m<sup>3</sup> for 2 hours at 10-15°C
- 40 g/m<sup>3</sup> for 2 hours at 16-20°C
- 32 g/m<sup>3</sup> for 2 hours at 21°C +

Currently all imports of nursery stock of members of the Solanaceae, excluding tissue cultures, must be fumigated with methyl bromide before undertaking post-entry quarantine. Biosecurity Australia proposes that AQIS continues this practice.

Treatments for fruit, other than methyl bromide fumigation, will be considered by Biosecurity Australia if proposed by the exporting country.

Treatments for fruit will need to be applied offshore to ensure that any live adult psyllids in consignments of fruit do not enter Australia

## **6.2 Operational systems for the maintenance and verification of phytosanitary status**

A system of operational procedures is necessary to maintain and verify the phytosanitary status of fresh fruit during production and export to Australia. This is to

ensure that the recommended risk management measures have been met and are maintained.

Biosecurity Australia proposes a system for this purpose that is consistent with ones currently in place for the importation of fresh fruits from other sources. Details of this system, or of an equivalent one, will be determined by agreement with the National Plant Protection Organisation (NPPO) of the exporting country.

### **Recognition of the competent authority**

The NPPO of the exporting country will be recognised as the competent authority.

The objectives of the competent authority are to ensure that:

- proposed service and certification standards are met by all relevant agencies participating in this program
- proposed administrative processes are established that provide assurance that the proposed requirements of the program are being met.

### **Registration of export greenhouses and fields**

All fresh fruit of solanaceous species exported to Australia must be sourced from registered greenhouses or fields. Copies of the registration records must be available for audit by AQIS if requested. The NPPO will be required to register each export greenhouse or field prior to commencement of exports from that area.

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

The objectives of this proposed procedure are to ensure that:

- fruit is sourced from registered export greenhouses or fields that have used pest and disease control programs
- export greenhouses and fields from which fruit is sourced can be identified so investigation and corrective action can be targeted rather than applying to all contributing export greenhouses or fields in the event that live quarantine pests are intercepted during phytosanitary inspections.

### **Registration of packing houses and auditing of procedures**

All packing houses intending to export fruit to Australia will be required to be registered with the NPPO.

Packinghouses will be required to be able to identify the source of fruit processed in the facility using the registration number of the export greenhouses or fields so cartons and pallets (that is, one source per pallet) can be labelled with this number.

The objectives of this proposed procedure are to ensure that:

- fruit is only sourced from NPPO registered packing houses where fruit is cleaned to export standard to ensure it is not contaminated by quarantine pests or regulated articles<sup>3</sup>
- registration numbers of export greenhouses or fields can be used for trace-back and auditing purposes.

### **Packaging and labelling**

The objectives of this proposed procedure are to ensure that:

- secure packaging is used to ensure that fruit of solanaceous species is not re-contaminated after washing, grading and packing
- unprocessed packing material (which may vector pests not identified as being on the pathway) is not imported with the fruit
- all wood material used in packaging the commodity complies with AQIS conditions (see AQIS publication 'Cargo Containers: Quarantine aspects and procedures' at <http://www.daffa.gov.au/aqis/import/cargo/aspects-procedures>)
- all cartons or pallets (one source per pallet) must be labelled with the registration numbers of the export greenhouses or fields. The 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 greenhouses or fields.

### **Specific conditions for storage and movement**

Arrangements for secure storage and movement of produce are to be developed by the NPPO in consultation with AQIS.

The objectives of this proposed procedure are to ensure that:

- product for export to Australia is maintained in secure conditions that will prevent mixing with fruit for domestic consumption or export to other destinations
- the quarantine integrity of the commodity is maintained during storage and movement.

### **Phytosanitary inspection by the NPPO**

The NPPO will inspect all consignments in accordance with official procedures for all visually detectable quarantine pests and regulated articles. Sample rates must achieve a confidence level of 95% that not more than 0.5% of the units in the consignment are infested/infected. This equates to a level of zero units infested/infected by quarantine

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<sup>3</sup> The IPPC defines a regulated article as 'any plant, plant product, storage place, packaging, conveyance, container, soil and any other organism, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved'.

pests in a random sample size of 600 units from the homogenous inspection lot<sup>4</sup> in the consignment<sup>5</sup>, where one unit is one fruit.

Detection of live quarantine pests or regulated articles will result in failure of the consignment. If a consignment fails inspection by the NPPO, the exporter will be given the option of treatment and re-inspection of the consignment or removal of the consignment from the export pathway.

Records of the interceptions made during these inspections (live or dead quarantine pests, and regulated articles) are to be maintained by the NPPO and made available to Biosecurity Australia or AQIS as requested. The detection of live or dead quarantine pests for which area freedom is claimed will result in the suspension of area freedom arrangements, pending review. This information will assist in future reviews of this import pathway and consideration of the appropriateness of the phytosanitary measures that have been applied.

The objectives of this proposed procedure are to ensure that:

- all consignments are inspected by the NPPO
- only consignments where no quarantine pests or other regulated articles are found during inspection are exported to Australia.

### **Phytosanitary certification by the NPPO**

The NPPO will issue a phytosanitary certificate for each consignment after completion of the pre-export phytosanitary inspection. Each phytosanitary certificate is to contain the following additional declaration:

*The fruit in this consignment has been produced in accordance with the conditions governing entry of fruit of the Solanaceae family to Australia and inspected and found free of quarantine pests*

consistent with International Standards for Phytosanitary Measures No. 7 *Export Certification System* (FAO 1997).

The objectives of this proposed procedure are to ensure that:

- formal documentation is provided to AQIS verifying that the relevant measures have been undertaken offshore.

### **Pre-clearance or on-arrival phytosanitary inspection by AQIS**

Consignments will be inspected by AQIS using the standard AQIS inspection protocol. The detection of live quarantine pests, dead quarantine pests for which area freedom is claimed, or other regulated articles will result in the failure of the inspection lot<sup>6</sup>. No land bridging of goods will be permitted unless goods have cleared quarantine.

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<sup>4</sup> An inspection lot is the number of boxes presented for a single phytosanitary inspection.

<sup>5</sup> A consignment is the number of boxes of fresh fruits in a shipment to Australia covered by one phytosanitary certificate.

<sup>6</sup> An inspection lot is the number of boxes presented for a single phytosanitary inspection.

In consultation with the NPPO, AQIS may complete the inspection as a pre-clearance inspection in the exporting country. For pre-clearance inspections, AQIS will confirm that a Notice of Intent (NOI) to export is completed and related to the product presented for inspection, undertake inspection of the inspection lot, and authorise the NOI. For pre-cleared consignments, AQIS will undertake a documentation compliance examination for consignment verification purposes at the port of entry in Australia prior to the release from quarantine.

The objectives of this proposed procedure are to ensure that:

- all lots are inspected by AQIS for quarantine pests and other regulated articles
- the detection of live quarantine pests, dead quarantine pests for which area freedom is claimed, or other regulated articles will result in the rejection of the inspection lot.

### **Remedial action(s) for non-compliance**

The objectives of this proposed procedure are to ensure that:

- any quarantine risk is addressed by remedial action, as appropriate
- non-compliance with import requirements is addressed, as appropriate.

Should non-compliance with the import conditions be detected, the trade may be suspended or the import conditions amended until remedial action is completed and Biosecurity Australia and/or AQIS is satisfied that trade can recommence under the conditions set out in this pest risk analysis.



## 7 Conclusion

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The findings of this draft PRA report are based on a comprehensive analysis of relevant scientific and other appropriate literature.

Biosecurity Australia considers that the risk management measures proposed in this draft PRA report will achieve Australia's appropriate level of protection against the pests identified in this risk analysis. Various risk management measures may be suitable to manage the risk of '*Ca. L. psyllae*' in the pathways associated with the import of solanaceous fruit into Australia. Biosecurity Australia will consider any other measures suggested by stakeholders that provide an equivalent level of phytosanitary protection.





# Appendices



## Appendix A: Known hosts of the tomato–potato psyllid (*Bactericera cockerelli*)

Host	Common name	Host association	Present in Australia	ICON conditions for Nursery stock
<b>Convolvulaceae</b>				
<i>Convolvulus arvensis</i> L.	Field bindweed	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	Yes (AVH 2008)	No (C10285)
<i>Ipomoea batatas</i> (L.) Lam.	Sweet potato, Kumara	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	Yes (AVH 2008)	Yes (C7383, C7384, C7300)
<i>Ipomoea purpurea</i>	Morning glory	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	Yes (AVH 2008)	NA
<b>Lamiaceae</b>				
<i>Mentha spicata</i> L.	Spearmint	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	Yes (AVH 2008)	Yes (C7328, C7329, C7300)
<i>Micromeria chamissonis</i> (Benth.) Greene		Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	No	NA
<b>Solanaceae</b>				
<i>Atropa belladonna</i> L.	Deadly nightshade, Bella Donna	Unknown	Yes (Randall 2007)	Yes (C7301, C7302, C7300)
<i>Capsicum annuum</i> L.	Capsicum, Pepper	Breeding host. This species supports large populations of the psyllid (NZCOP 2008)	Yes (Randall 2007)	No
<i>Capsicum frutescens</i> L.	Chilli	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	Yes (Randall 2007)	No
<i>Datura fastuosa</i> L.		Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	Yes (Randall 2007)	No (C7172)
<i>Datura innoxia</i> Mill.		Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	Yes (Haegi 1976)	No (C7172)

Host	Common name	Host association	Present in Australia	ICON conditions for Nursery stock
<i>Datura meteloides</i> Dunal		Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	Yes (Haegi 1976)	No (C7172)
<i>Datura stramonium</i> L.	Jimsonweed, Thornapple	Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	Yes (Haegi 1976)	No (C7172)
<i>Hyoscyamus albus</i> L.		Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	Yes (Randall 2007)	Yes (C7301, C7302, C7300)
<i>Hyoscyamus niger</i> L.	Henbane	Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	Yes (Randall 2007)	Yes (C7301, C7302, C7300)
<i>Lycium andersonii</i> A. Gray		Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	Yes (Fukuda <i>et al.</i> 2001)	NA
<i>Lycium exsertum</i> A. Gray		Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	Yes (Fukuda <i>et al.</i> 2001)	NA
<i>Lycium fremontii</i> A. Gray		Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	Yes (Fukuda <i>et al.</i> 2001)	NA
<i>Lycium halimifolium</i> Mill.	Matrimony vine	Breeding host (Wallis 1955)	Yes (Fukuda <i>et al.</i> 2001)	NA
<i>Lycium macrodon</i> A. Gray		Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	Yes (Fukuda <i>et al.</i> 2001)	NA
<i>Lycium pallidum</i> Miers		Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	Yes (Fukuda <i>et al.</i> 2001)	NA
<i>Lycium parishii</i> A. Gray		Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	Yes (Fukuda <i>et al.</i> 2001)	NA
<i>Lycium quadrifidum</i> Moc. & Sessé ex Dunal		Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	Yes (Fukuda <i>et al.</i> 2001)	NA
<i>Lycium torreyi</i> A. Gray		Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	Yes (Fukuda <i>et al.</i> 2001)	NA

Host	Common name	Host association	Present in Australia	ICON conditions for Nursery stock
<i>Lycopersicon esculentum</i> Mill [synonyms: <i>Solanum lycopersicum</i> L., <i>Lycopersicon lycopersicum</i> (L.) H. Karst.]	Tomato	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	Yes (APNI 2008)	No
<i>Lycopersicon pimpinellifolium</i> (L.) Mill	Currant tomato	Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	Yes (AVH 2008)	No
<i>Nicandra physalodes</i> (L.) Gaertn.	Apple of Peru	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	Yes (Hawton 1976)	Yes (C7301, C7302, C7300)
<i>Nicotiana affinis</i> Moore	Flowering tobacco	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	No	No (C6066)
<i>Nicotiana glutinosa</i> L.		Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	Yes (APNI 2008)	No (C6066)
<i>Nicotiana tabacum</i> L.	Tobacco	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	Yes (Panchamukhi 2000)	No (C6066)
<i>Nicotiana texana</i> Maxim.		Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	No	No (C6066)
<i>Nierembergia hippomanica</i> Miers	Cup flower	Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	Yes (Richardson <i>et al.</i> 2006)	Yes (C7301, C7302, C7300)
<i>Physalis angulata</i> L.	Cut leaf ground-cherry	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	Yes (Bean 2006)	Yes (C7427, C7300, C18152)
<i>Physalis comata</i> Rydb.	Wild ground-cherry	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	No (Bean 2006)	NA
<i>Physalis franchetti</i> Mast.	Chinese lantern	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	Yes (APNI 2008)	Yes (C7427, C7300, C18152)
<i>Physalis heterophylla</i> Nees	Clammy ground-cherry	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	No (Bean 2006)	No

Host	Common name	Host association	Present in Australia	ICON conditions for Nursery stock
<i>Physalis ixocarpa</i> Brot. ex Hornem. [synonym: <i>Physalis philadelphica</i> Lam.]	Tomatillo	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	<b>Yes</b> (Bean 2006)	<b>Yes</b> (C7427, C7300, C18152)
<i>Physalis lanceolata</i> Michx.		Breeding host (Wallis 1955)	<b>No</b> (Bean 2006)	<b>No</b>
<i>Physalis lobata</i> Torr.	Purple ground-berry	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	<b>No</b>	<b>Yes</b> (C7427, C7300, C18152)
<i>Physalis longifolia</i> Nutt.	Longleaf ground-cherry	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	<b>Yes</b> (Bean 2006)	<b>NA</b>
<i>Physalis mollis</i> Nutt.	Longleaf ground-cherry	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	<b>No</b> (Bean 2006)	<b>NA</b>
<i>Physalis peruviana</i> L.	Cape gooseberry	Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	<b>Yes</b> (Samuel <i>et al.</i> 1930)	<b>Yes</b> (C7427, C7300, C18152)
<i>Physalis pruinosa</i> L.	Husk tomato	Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	<b>Yes</b> (Randall 2007)	<b>Yes</b> (C7427, C7300, C18152)
<i>Physalis rotundata</i> Rydb.	Longleaf ground-cherry	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	<b>No</b> (Bean 2006)	<b>NA</b>
<i>Solanum aviculare</i> G. Forst.	Bullibulli	Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	<b>Yes</b> (Subroto and Dolan 1994)	<b>Yes</b> (C7436, ) C18152
<i>Solanum baylisii</i> Geras.		Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	<b>Yes</b> (Randall 2007)	<b>Yes</b> (C7436, C18152)
<i>Solanum betaceum</i> Cav. [synonym: <i>Cyphomandra betacea</i> (Cav.) Sendtn.]	Tamarillo	Breeding host (NZCOP 2008)	<b>Yes</b> (Randall 2007)	<b>Yes</b> (C7436, C18152)
<i>Solanum capsicastrum</i> Link ex Schauer	Jerusalem cherry	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	<b>Yes</b> (Radford <i>et al.</i> 1994)	<b>Yes</b> (C7436, C18152)

Host	Common name	Host association	Present in Australia	ICON conditions for Nursery stock
<i>Solanum carolinense</i> L.	Ball nightshade, Bull nettle, Horse nettle, Devil's tomato	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	<b>Yes</b> (Parsons and Cuthbertson 1992)	<b>Yes</b> (C7436, C18152)
<i>Solanum citrullifolium</i> A. Braun		Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	<b>Yes</b> (Randall 2007)	<b>Yes</b> (C7436, C18152)
<i>Solanum elaeagnifolium</i> Cav.	White horse-nettle, Silver-leaf nightshade	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	<b>Yes</b> (Kidston <i>et al.</i> 2007)	<b>Yes</b> (C7436, C18152)
<i>Solanum gracile</i> Sendtn.	Velvety nightshade	Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	<b>No</b>	<b>No</b>
<i>Solanum jamesii</i> Torr.	Wild potato	Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	<b>No</b>	<b>Yes</b> (C7436, C18152)
<i>Solanum melongena</i> L.	Eggplants, Aubergine	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	<b>Yes</b> (AVH 2008)	<b>Yes</b> (C7436, C18152)
<i>Solanum mexicanum</i> Moc. & Sessé ex Dunal		Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	<b>No</b>	<b>Yes</b> (C7436, C18152)
<i>Solanum nigrum</i>	Wonderberry, Black nightshade, Blackberry nightshade, Garden huckleberry	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	<b>Yes</b> (AVH 2008)	<b>Yes</b> (C7436, C18152)
<i>Solanum pyracanthum</i> Jacq.	Porcupine tomato	Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	<b>No</b>	<b>Yes</b> (C7436, C18152)
<i>Solanum racemigerum</i> Zodda		Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	<b>No</b>	<b>Yes</b> (C7436, C18152)
<i>Solanum rostratum</i> Dunal	Buffalo-bur	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	<b>Yes</b> (AVH 2008)	<b>No</b>

Host	Common name	Host association	Present in Australia	ICON conditions for Nursery stock
<i>Solanum sanitwongsei</i> Craib		Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	<b>No</b>	<b>Yes</b> (C7436, C18152)
<i>Solanum sisymbriifolium</i> Lam.	Viscid nightshade, Sticky nightshade	Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	<b>Yes</b> (AVH 2008)	<b>Yes</b> (C7436, C18152)
<i>Solanum triflorum</i> Nutt.	Wild tomato	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	<b>Yes</b> (AVH 2008)	<b>Yes</b> (C7436, C18152)
<i>Solanum tuberosum</i> L.	Potato	Oviposit, complete its nymphal development and emerge as normal adult (Wallis 1955)	<b>Yes</b> (AVH 2008)	<b>Yes</b> (C7322, C7323, C7300)
<i>Solanum villosum</i> Mill.	Hair nightshade	Oviposit, complete its nymphal development and emerge as normal adult (Knowlton and Thomas 1934)	<b>Yes</b> (AVH 2008)	<b>Yes</b> (C7436, C18152)

**NA** These species are prohibited entry into Australia by legislation pending an assessment.



## **Appendix B: New Zealand Code of Practice for the Management of the Tomato/Potato Psyllid in Greenhouse Tomato and Capsicum Crops**

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4 November 2008

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## 1. Introduction

The tomato/potato psyllid, *Bactericera cockerelli* is a relatively new pest to New Zealand (confirmed present by Biosecurity NZ May 2006) and is the vector for Candidatus *Liberibacter* a plant disease of tomato, capsicum and other solanaceous crops including potato. This document is the industry's Code of Practice for its greenhouse tomato and capsicum growers. For further information contact:

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### 1.1 Objective

The objective of this Code of Practice is to provide guidance to growers and others in the industry for the effective, safe and responsible control of the tomato/potato psyllid in order to minimise the impact of *Liberibacter* on production and export market access.

### 1.2 Scope

The Code of Practice is aimed at all producers of greenhouse tomato and capsicum crops. Use of this Code will result in a number of benefits for this industry group and consumers alike. Implementation of the Code will ensure:

- a. Damage to individual crops will be minimised
- b. Control of the pest will be effective and sustainable
- c. Management of other pests of significance in these crops will not be unduly affected
- d. Current IPM practices in place remain functional and the continued supply of high quality low residue fruit to the NZ public and our export customers is not compromised
- e. Resumption and continuation of export of these crops will be facilitated

### 1.3 Relevant legislation and industry standards

All relevant legislation and industry standards should be followed or adhered to in the control of the tomato/potato psyllid. For further information refer to the following:

- New Zealand (Maximum Residue Limits of Agricultural Compounds) Food Standards 2008 (<http://www.nzfsa.govt.nz/policy-law/legislation/food-standards/nz-mrl-fs-2008-consolidation.pdf> )
- New Zealand GAP or GLOBALGAP
- GROWSAFE®
- Other Approved Supplier or Produce Trading Partners programmes

### 1.4 Information on the tomato/potato psyllid

The tomato/potato psyllid is a small phloem-feeding, winged insect about 3mm in length and resembles a miniature cicada. This pest can sometimes vector 'psyllid yellows' disease to a number of host plants. Recently, a new species of bacterium causing this disease in solanaceous plants has been described as belonging to the genus *Candidatus Liberibacter*. A description of the insect is found in Appendix 1 along with additional sources of information and photos of life stages, characteristic excreta and typical host plant damage. Horticulture New Zealand has published sets of identification cards and a poster, and MAF Biosecurity New Zealand has a pamphlet with further information and images. Refer to Appendix 1 for the relevant web links.

## **2. Responsibilities, training and planning**

### **2.1 Monitoring Duties and Responsibilities**

Greenhouse growers or managers should:

- Identify a suitably trained person (or persons) to scout the crop on at least a weekly basis (shorter interval during periods of high pest pressure).
- Establish a crop monitoring plan based on the requirements of section 3.3. Make maps of the greenhouse unit in which row numbers and bays can be easily identified.
- Set up a pest monitoring records system, and record pest numbers, life stages, location, and actions taken.
- Undertake monitoring at least weekly, increasing in frequency to daily monitoring during periods of high pest pressure.
- Ensure that monitoring is consistent between plants and between monitoring personnel.
- Make all greenhouse staff aware of Psyllid and Liberibacter symptoms and encourage reporting to the crop scout of any unusual or unhealthy symptoms in the greenhouse.
- Make identification cards and posters available to all staff.

### **2.2 Training requirements**

- Crop monitoring personnel must be familiar with monitoring techniques and of Psyllid/Liberibacter symptoms or identification.
- All greenhouse staff should be familiar with the potato/tomato psyllid and the symptoms of the disease that it can sometimes cause.
- Quality images and easy to understand descriptions of the disease vectored by the psyllid facilitates more informed feedback from staff because symptoms of feeding damage may resemble other disorders.
- Ensure sufficient copies of the psyllid field identification cards are available.

### **2.3 Pre-planting requirements**

- Only source seedlings from a supplier implementing psyllid control measures during the nursery phase:
  - Psyllid control on young plants can be achieved by spraying or drenching with an IPM compatible insecticide. Abamectin or spinosad sprays are options. For drenching, Calypso (Thiacloprid) in the irrigation water at a rate of 20ml per 1000 plants has been effective. Avoid substantial run off in the days following application. Repeat if required.
- Inspect the area surrounding the greenhouse for host plants, both weeds and ornamentals (see Appendix 2). Remove and destroy host plants where possible.

### **2.4 Planting**

- Only plant seedlings that are free of pests. If psyllids are found on seedlings, destroy infected seedlings before they are introduced into the greenhouse.
- Check all other seedlings in the batch to ensure they are not infested.
- Psyllid control on young plants can be achieved by spraying or drenching with an IPM compatible insecticide. Abamectin or spinosad sprays are options. For drenching, Calypso (Thiacloprid) in the irrigation water at a rate of 20ml per 1000 plants has been effective. Avoid substantial run off in the days following application. Repeat if required.

## **2.5 Crop removal and actions between cropping cycles**

- Before the end of a crop, pests should be contained within the building and eliminated before the old plants are removed. This prevents pests from being spread into the environment around the outside of the greenhouse. Apply a high volume pesticide spray of, for example, abamectin together with triple rate surfactant or mineral spraying oil. Keep the greenhouse closed for 24 hours before plant removal.
- Remove the plants in a secure manner such as in covered bins to land fill or covered composting.
- Clean and disinfect the greenhouse ensuring all plant material including weeds and volunteer plants are removed and destroyed.
- Check all flying insect pests have been eradicated by hanging yellow sticky traps (at least 10/ha) and inspect daily. Fog or spray insecticide if pests are present. Close the greenhouse ventilators and doors and allow a period for warming to accelerate pest eradication.
- Where possible, set up a double door system at the greenhouse entrance using insect mesh. This is to prevent flying insects from easy access to the crop. Hang one yellow sticky trap at least every 10m<sup>2</sup> in this area.

## **3. Key aspects of crop protection**

To successfully control the tomato/potato psyllid over an extended period, various methods must be employed or control will not be reliable.

### **3.1 Control Methods**

#### *3.1.1 Cultural practices*

Cultural aspects of crop protection involve considering all of the basic growing best practice concepts to ensure optimum growing conditions for maintaining a healthy crop which has maximum resistance to pests and diseases. Attend to as many of these as possible; e.g. temperature, irrigation, pH and fertility, plant spacing.

#### *3.1.2 Hygiene*

Preventing pests from entering the crop should always be a key consideration in crop management. This commences before the end of a crop to ensure low carry over of all pests and diseases (refer sections 2.3-2.5, above). All crop debris should be removed from the greenhouse and immediate environment. Weed and volunteer plant removal is required to ensure no green bridge remains for hosting pests. Adequate sanitation is essential before the new crop arrives. During the cropping period ensure good hygiene practices are observed at all times. Infestations must be dealt with promptly and appropriately, and diseased plants should be removed promptly and disposed of in a secure manner.

#### *3.1.3 Biological agents*

Research on a number of new natural enemies of the psyllid is underway. Some beneficial insects and mites are found in the crop without being introduced. If agrichemicals are carefully managed, predatory mites, lacewings, ladybirds, parasitic wasps and other beneficial arthropods and entomopathogenic fungi will contribute to controlling pests (their impact on Tomato/potato psyllid is not extensively researched at this stage). Refer to Appendix 4 on side effects of chemicals on natural enemies and identify the least damaging options if it is determined that spraying is required.

#### *3.1.4 Physical methods*

Exclusion of pests by screening vents and doors is not practical for many properties at present. However certain spray options with a physical mode of action should be considered whenever possible. Soaps; e.g. dish washing liquids, and compounds that are sticky or have

deterrent properties; e.g. certain spreader and sticker adjuvants, can be employed to prevent pests from visiting plants and/or laying eggs. Several essential oils; e.g. cedar wood and neem, deter psyllids from selecting plants for egg laying. Care should be taken when trialling oils as many are phytotoxic. Yellow sticky traps placed near vents and entranceways can be used to reduce psyllid populations migrating into the greenhouse.

### 3.1.5 Chemicals

Chemicals registered for use in tomato and capsicum crops are listed in section 3.5. Care is required in selecting chemicals so that a minimum of damage is done to beneficial organisms and resistance to the pesticide is prevented. Most chemicals should only be used 2 – 3 times per season. Adhere strictly to specific product advice at all times to ensure pesticide resistance is minimised. Consult crop protection specialists for advice on selection, application guidelines and rotation of products with different modes. Always ensure compliance with New Zealand Maximum Residue Limits.

## 3.2 Management of alternative host plants

Check plants in the area surrounding the greenhouse are not hosting tomato/potato psyllids. Remove known host plants where possible. The host range of the tomato/potato psyllid is said to include the plants listed in Appendix 2.

Check regularly to ensure a buffer zone remains free of host weeds. If the pest psyllid lays eggs on desirable ornamentals that cannot be removed or replaced, control these populations by selecting sprays from the list in section 3.5. Continue the practice of rotating pesticides by their mode of action groups.

## 3.3 Crop monitoring

It is necessary to monitor psyllid populations in order to make informed decisions for their control. Monitoring psyllid populations on the plants in the greenhouse is the most reliable and effective way to monitor psyllid populations at the moment. Yellow sticky traps may give some indication of psyllid activity but currently there is insufficient information to relate trap catches with psyllid populations in greenhouse crops. Yellow sticky traps however can give background information on psyllid activity. Yellow sticky traps if hung near vents can be used to reduce psyllid populations migrating into the greenhouse.

### 3.3.1 Monitoring for tomato/potato psyllids

#### (a) Scheduled crop scouting

The method outlined below is based on a 4m x 8m structural module common in many multispan Venlo style glasshouses, but can readily be adapted to suit other structures. The 4m sections between poles along the row are a designated sampling unit. Each sampling unit will contain approximately 15 tomato stems or >40 capsicum stems.

Monitoring is based on searching for psyllid sugars as a way for homing in on psyllid infestations:

- Monitor at least weekly – more frequent monitoring is recommended during times of high pest pressure.
- Each week, sample 1 row per 8 metre bay and alternate the rows (1 through to 5) between weeks so that all rows are monitored over a 5 week period.
- Monitor the plant between poles which is showing the most psyllid sugars.
- If no sugars are seen, monitor a plant at random within a 4m bay.

- Concentrate on monitoring the top section of capsicum plants and middle section of tomato plants.
- Score the psyllid infestation:
  - 0 no psyllids present
  - 1 adults only
  - 2 adults and eggs
  - 3 adults, eggs and nymphs (on 1 -5 leaves)
  - 4 adults, eggs and nymphs (on > 5 leaves)
  - 5 psyllid infestation on adjacent plants
- Using the 4 metre section method approximately 1 in 60 - 65 plant stems should be examined in each monitoring period.
- Not all plants infected with *Liberibacter* show disease symptoms, however these may be detected during scheduled crop monitoring.
  - Record and then remove all plants showing yellowing symptoms associated with the *Liberibacter* disease in each sampling section.
  - Any plants showing *Liberibacter* symptoms anywhere in the greenhouse should also be removed.
- If the symptoms are not expressed strongly, plant samples may be sent for testing for *Liberibacter*.
- Make control action decisions as described in section 3.2.2.

#### **(b) Monitoring yellow sticky traps**

Yellow sticky traps are not a formal part of the monitoring programme, as there is currently not enough information to relate trap catches with action thresholds. However they can be useful for giving a quick assessment of comparative psyllid activity in greenhouses for given periods.

It is suggested that sticky traps are monitored and replaced weekly inside and outside the greenhouse in north, south, east and west positions (See Sections 2.5 & 3.5). Caution is required in interpreting results from sticky yellow traps from outside the greenhouse as other psyllid species may also be present and these may be difficult to distinguish from the tomato/potato psyllid adults.

#### **(c) Monitoring by staff while working the crop**

In addition to specific crop scouting activities, described in 3.3.1. (a), all greenhouse staff should be trained to look for and recognise psyllids and their symptoms while working the crop. It is suggested that a reward system be instigated as an incentive for extra vigilance.

All staff working in the crops must be able to recognise all the life cycle stages of the tomato/potato psyllid and to report suspected psyllid infestations to crop monitors. This is extremely important at the initial stages of the psyllid infestation when numbers of psyllids in greenhouses may be very low.

This informal monitoring by crop working staff is a very important component of crop monitoring and should be incorporated into the monitoring programme.

#### **(d) Monitoring other pest and diseases**

Psyllid monitoring can be incorporated into the other pest and disease monitoring. It is suggested that each plant that is selected to be monitored for psyllids is also used for monitoring whitefly and other pests and biological control agents.

### 3.3.2 Guidelines for Action Thresholds for Psyllid control

The guidelines for action thresholds are described below and are only indicative – they are based on grower experience and have not yet been scientifically validated.

Monitoring will give growers two values: the proportion sample infested with psyllids and a value from 1 - 5 indicating the severity of the infestations. Both values need to be taken into account when defining the required action. In general growers should take the action that applies to the highest of the value or percentage. For example, if the percentage value is <1% but the level of infestation is >1.8, then a full insecticide application should be made.

**Table 1: Suggested action thresholds**

Percentage of sample infested with psyllids	Value indicating level of psyllid infestation	Action
0	0	No action
<1%	<1.5	Remove infected leaves
1-2%	1.5-1.8	Spot spray insecticides
>2%	>1.8	Full insecticide application

These guidelines are only indicative and will require adjustment by individual growers to meet their particular requirements.

### 3.3.3 Control actions

#### Removal of infected leaves

At very low infestation levels, psyllids may be controlled by removing infested leaves.

These leaves should be placed directly into plastic bags, sealed and disposed of in a safe manner.

#### Spot spraying

When spot spraying is to be undertaken further monitoring of plants and rows around the identified infested area should be undertaken to more accurately define the section of greenhouse that needs to be treated by spot spraying.

#### Monitoring hot spots

Experienced growers can often determine areas in their greenhouse where the initial psyllid infestations occur. Extra monitoring in these areas will give additional information. It has been reported that psyllids preferentially attack plants that have previously been infested with psyllids. Marking and monitoring these plants may also give additional information.

### 3.3.4 Records - Monthly Tomato/potato/psyllid/Liberibacter summary sheet

Monthly data sheets can be used to summarise psyllid monitoring, control actions and Liberibacter infestations (see Appendix 3 for the layout of the monthly recording sheet). A separate sheet should be used for each greenhouse on the property.

This summary sheet records:

#### Weed Hosts:

Surveying the property for weeds that are host plants for the tomato/potato psyllid and recording actions to remove these alternate host plants (See Appendix 2 for list of weed host plants).



**Neighbouring crops:**

The location of neighbouring crops that host the tomato/potato psyllid and control strategies.

**Yellow sticky traps:**

Total tomato/potato psyllids caught on sticky traps inside and outside the greenhouse.

**Plant monitoring for psyllids**

Weekly counts of the number of plants monitored, percent of plant infested with psyllids, the mean psyllid score and the control actions taken in response to the monitoring for each week.

**Plant monitoring for *Liberibacter***

Weekly counts of the number of plants showing *Liberibacter* symptoms and the response including the number of plants removed.

**Insecticide application**

Record all insecticides applied each week for both the control of psyllids and other pests. This data will include product used, active ingredient, concentration, water rate and method of application.

**3.4 Consideration of other pests, pollinators and natural enemies.**

Many methods of controlling plant pests are not selective to the pest and can kill beneficial insects. Consideration must be given to the role pollinators need to play in a crop and the importance of maintaining populations of natural enemies such as parasitic wasps and predators. If bumblebees or biological control agents are being caught on yellow sticky traps in substantial numbers, either reduce trap density or change the trap position relative to the height of the crop.

Sprays with a contact mode of action should also be used with care as these can also reduce the role beneficial organisms" play in the control of psyllids and other important pests (See Appendix 4).

**3.5 Plant protection products**

The tomato/potato psyllid is a relatively new pest in tomato and capsicum crops in New Zealand, and is not currently covered by any New Zealand agrichemical registrations.

Fortunately many agrichemicals registered for controlling pests such as greenhouse whitefly and mites also have activity against the tomato/potato psyllid. While optimum application rates have not been set, concentrations listed on labels for similar insect pests should be regarded as appropriate rates when a product is used to target psyllids.

At all times adhere to pest management best-practice including:

- Seek up-to-date advice on pest management options.
- Implement cultural and biological control options where available.
- Utilise non-chemical methods to suppress pests as part of the management.
- Use sound scouting procedures and action thresholds.
- Apply insecticides only when necessary.
- Use appropriate, adequately maintained spray equipment.

- Spot spray infested areas whenever feasible. Commence spraying from a low infestation area and progress towards the „hot spot“ or towards a greenhouse wall to avoid dispersing the pest.
- Preserve natural enemies of plant pests by using selective products when possible. Refer to Appendix 4 for side effects of chemicals on beneficial organisms.
- Report poor control of an insecticide to a crop protection advisor.
- Do not use the same spray on successive generations of the pest.
- Rotate active ingredients with different Mode of Action Classifications.
- Ensure that the relevant MRL is not exceeded at time of harvest (Table 2).

Many insecticides act on the nervous system of the pest but do not necessarily target the same site within the nervous system. Thus there are different groups affecting the nervous system, some inhibiting metabolic processes, others are feeding blockers or inhibitors of cuticle synthesis. For more detailed information refer to IRAC website: [www.irac-online.org](http://www.irac-online.org).

Active ingredients reported to give control of this pest both locally and in other countries include the following chemicals:

**Table 2: Spray Options Information Summary**

Group	Active Ingredient	Chemical Trade Name	Mode of Action	NZ Registration (MRL) *	Pre-harvest Interval
1A	Methomyl	Lannate L	Contact and Ingestion	Tom (0.3 mg/kg) Cap (0.3 mg/kg)	Tom – 2 days Caps – 2 days
1A	Oxamyl	Vydate L	Contact Ingestion Plant systemic	Not Registered (0.1 mg/kg)	Unknown
1A	Pirimicarb	Pirimax 500 Pirimor 50 Pirimisect Prohive™	Contact Fumigant Trans laminar	Tom (1.0 mg/kg) Cap (1.0 mg/kg)	Tom – 3 days Caps - unknown
1B	Diazinon	Dew 500 Diazinon 800/W Diazonyl 60 EC	Contact Ingestion Respiratory	Tom (0.5 mg/kg) Cap (0.5 mg/kg)	Tom – 3 days Caps – 14 days
1B	Dichlorvos	Dichlorvos	Contact Ingestion Fumigant	Tom (2.0 mg/kg) Cap (2.0 mg/kg)	Tom – 3 days Caps – 3 days
1B	Malathion	Maldison	Contact Ingestion	Tom (8.0 mg/kg) Cap (8.0 mg/kg)	Tom – 3 days Caps – 3 days
1B	Methamidophos	Metafort 60 SL Monitor Tamaron	Contact Ingestion Plant systemic	Tom (0.1 mg/kg) Cap (0.2 mg/kg)	Tom – 3 days Caps - unknown
1B	Pirimiphos methyl	Actellic SG	Contact Ingestion Fumigant	Tom (1.0 mg/kg) Cap (1.0 mg/kg)	Tom – 3 days Caps – 3 days
3A	Alpha-cypermethrin	Bestseller 100EC Cypher Dominex 100 Fastac	Contact Ingestion	Tom (0.1 mg/kg)	Tom – 3 days
3A	Deltamethrin	Ballistic Decis Forte Deltaphar 25 EC Cislin Insectigone	Contact Ingestion	Tom – outdoor (0.05 mg/kg)	Tom – 3 days
3A	Lambda-cyhalothrin	Karate-Zeon	Contact Ingestion	Tom – outdoor (0.1 mg/kg)	Tom – 3 days Caps - unknown

Group	Active Ingredient	Chemical Trade Name	Mode of Action	NZ Registration (MRL) *	Pre-harvest Interval
3A	Taufluvalinate	Mavrik	Contact Ingestion	Tom – outdoor (0.2 mg/kg)	Tom – 3 days Caps - unknown
4A	Imidacloprid	Confidor	Contact Ingestion Plant systemic	Not registered (0.1 mg/kg)	Tom – unknown Caps - unknown
4A	Thiacloprid	Calypso	Contact Ingestion Plant systemic	Not registered (0.1 mg/kg)	Tom – unknown Caps - unknown
4A	Thiamethoxam	Actara, Cruiser	Contact Ingestion Plant systemic	Not registered (0.1 mg/kg)	Tom – unknown Caps - unknown
5	Spinetoram		Contact Ingestion	Not registered (0.1mg/kg)	Tom – unknown Caps - unknown
5	Spinosad	Success Naturalyte	Contact Ingestion	Tom - Outdoor (0.01mg/kg) Cap – not registered (0.1 mg/kg)	Tom – 3 days Caps - unknown
6A	Abamectin	Abamax Apostle Avid Verdex	Contact Ingestion	Tom (0.1 mg/kg)	Tom – 3 days Caps - unknown
9A	Pymetrozine	Chess WG	Feeding inhibitor	Tom (0.5 mg/kg)	Tom – 3 days
15	Novaluron	Rimon	Chitin Inhibitor	Not registered (0.1 mg/kg)	Tom – unknown Caps - unknown
17A	Buprofezin	Mortar Ovation 50WDG Pilan	Insect growth regulator	Tom (0.5 mg/kg) Cap (0.5 mg/kg)	Tom – 3 days Caps – 3 days
21A	Fenpyroximate	Fenamite	Contact	Not registered	Tom – unknown Caps - unknown
23	Spiromesifen	Oberon	Inhibits development and fecundity. Ovicidal	Tom (0.5 mg/kg) Cap (1.0 mg/kg)	Tom – 1 day Caps – 1 day
23	Spirotetramat	Movento	Inhibition of lipid production	Not registered (0.1 mg/kg)	Tom – unknown Caps - unknown
28	Chlorantraniliprole	Coragen	Nerve & muscle action	Not registered (0.1 mg/kg)	Tom – unknown Caps - unknown

\* Maximum Permitted Residue Level in Food– “NZ Food Standards 2008”

Some of these active ingredients are also effective when applied as a drench. The side effects on beneficial organisms can be reduced when systemic active ingredients are applied in this manner. Consult your insecticide supplier for details.

Extracts from the neem tree contain many chemicals with insecticidal properties. The most commonly researched extract is azadirachtin which is reported to have useful activity against the tomato/potato psyllid. The mode of action on psyllids is unknown but researchers have reported disruption of feeding and growth along with prevention of settling and egg laying. Neem extracts and other botanical products could play a useful role in repelling or deterring the pest from using the plant as a host.

Further spray options that are compatible with biological control agents and pollinators are soaps, oils and naturally occurring fungi, the latter being pathogenic to many insects. Soaps and oils can sometimes be used with selected agrichemicals to give dual modes of action when spraying. Plant damage can result from such mixtures so small scale trials should be carried out first.

Two of the most commonly used insect pathogens are *Beauveria bassiana* and *Verticillium lecanii*. Under favourable conditions these fungi can give good control of psyllid nymphs but environmental conditions may limit the useful life of these organisms.

The tomato/potato psyllid has numerous natural enemies in New Zealand in the form of predators, parasites and pathogenic fungi. Long term control of this pest will be best accomplished by utilising as many deterrent options as possible and supported by chemical use when required.

### **3.6 Advice on effective application of insecticides**

Whenever insecticides are applied attention to equipment set up is crucial to achieving good control. For targeting both sides of the leaf surface a boom spray with fan nozzles (03F80) 30cm apart, 45 deg upward from horizontal at a pressure setting of 2.5 – 3.0 bar and ground speed of one metre per second is efficient. For targeting underside of leaves only, a cone nozzle angled under the leaf may be more appropriate. Use spray sensitive paper placed in target ones to confirm adequate insecticide coverage.

### **3.7 Insecticide application records**

Record all details of spray applications in a spray diary. This includes the operator's name, dilution rates of active ingredients and additives, total volume, spray speed, pressure, temperature and climate data (Refer Appendix 5). Obtain comments from the crop scout after spraying, on efficacy of each spray and be guided by past results when deciding on conditions for a repeat spray if required.

### **3.8 Best practice where vectors are involved**

- Work with neighbours to achieve low tomato/potato psyllid numbers in the greenhouse vicinity.
- Control pest psyllids in the crop to low levels using IPM best practice.
- Aggressive management of infected plants reduces the risk of disease spread within the crop. Rouge out infected plants, place in plastic bags and bury or burn them promptly.

#### **4. Phytosanitary security - post harvest handling of tomatoes and capsicums for export**

Where crops are being packed for export, measures should be implemented to ensure freedom from psyllids and to prevent contamination of packed product. MAF approved organizations should document their post inspection security procedures in their operator system. The operator system to include product identification and traceability of lots, sampling and inspection levels, storage and treatment of uninspected and failed lots.

Tomatoes and capsicums destined for export to Australia should undergo product inspection in line with the criteria set for the standard AQIS pre-clearance requirements. This product needs to have passed over the grading line and to have been packed in accordance with good packhouse practice as is required to meet both customer and phytosanitary needs. Good packhouse practice should include:

- The packing area should be kept free from dust, leaves and plant material in line with good hygiene practice.
- Pre packing inspections should take place to identify potential quality and biosecurity risks with the ungraded fruit.
- Product received from growers who do not comply with the psyllid code of practice needs to be stored separately from product destined for export.
- Export product will be subject to washing or brushing and packing in line with standard grading procedures.
- In the case of calyx on fruit and truss tomatoes, the product needs to be visually inspected and air blown where necessary.
- Product packaging should preferably be built on line and should be stored in a dust and pest free environment.
- Packed export fruit must be kept apart from ungraded fruit with a minimum quarantine area of 1 metre between lots.

## 5. Summary of recommendations for minimising psyllid and other insect levels in crops

- Ensure all staff and visitors are instructed in compulsory growing-site hygiene practices.
- Plant good quality pest-free seedlings.
- Use pest resistant cultivars where possible.
- Ensure growing best practice in plant care, irrigation, plant nutrition and environmental control.
- Use biological control options for pest and disease management whenever possible.
- Choose spray options that have a non toxic physical mode of action where available.
- Ensure as many staff as possible can recognise key pests and diseases so that prompt remedial actions can be taken to minimise impact on yield and quality.
- Maintain robust crop scouting procedures with strict routines and evaluation of records.
- Take pest control actions in accordance with pest monitoring records and recommended thresholds
- Choose agrichemicals with care targeting least side effects on beneficial insects including bumblebees and adequate rotation of classes of mode of action to prevent insecticide resistance. Ensure with holding periods can be realised before the next harvest day. Keep records of all treatments.
- Check the selection of spray equipment is appropriate, settings, calibration and active ingredient dilution rate. Ensure good target coverage is achieved during each spray session. Moisture sensitive paper can be used to confirm coverage.

## Appendix 1: Life cycle and pest ID

The potato/tomato psyllid, *Bactericera cockerelli* (Homoptera: Psyllidae) is a hemipteran insect measuring 2-3 millimetres (mm) with piercing-sucking mouthparts that enables this pest to feed on the phloem of its host plants. It undergoes incomplete metamorphosis: egg, nymph and adult.

Eggs are oval, small and attached to the leaves by a short stalk which would require magnification for identification but quite noticeable when on the leaf edges. Eggs are yellow when first laid and turn orange prior to eclosion or emergence to the first nymphal stage. Eggs are hatched between 4 to 5 days after being laid.

The nymph passes five scale-like nymphal stages requiring between 12-21 days. The nymph looks much like a scale insect or a large whitefly scale and grows to 2 mm. It is flat and has a fringe of spines around the edges. Within this stage, it changes from light yellow to tan then to greenish brown. However, wing buds appear at the 3<sup>rd</sup> nymphal stage and become very apparent at the 4<sup>th</sup> and 5<sup>th</sup> stages. The wing buds of the psyllid nymph distinguish it from the whitefly nymph.

Adult psyllids are winged and resemble tiny cicadas. They are yellowish or greenish as they emerge and turn dark green or brown as they mature with white stripes on the thorax and head after 5 days. The psyllids are seen in aggregates feeding and mating on the leaves of host plants and mate more than once. After mating, female psyllids lay eggs on any part of the leaves. A single female is capable of laying up to 510 eggs in its lifetime.

Psyllid total development occurs between 15.5°C and 32.2°C with optimum development occurring at 26.6°C. In a greenhouse environment averaging at 18°C, psyllid takes 33 days to complete its life cycle.

Sources of additional information:

<http://www.biosecurity.govt.nz/pests-diseases/plants/potato-tomato-psyllid/photos.htm>

<http://www.biosecurity.govt.nz/pests-diseases/plants/potato-tomato-psyllid.htm>

[http://www.tomatoesnz.co.nz/research\\_reports\\_public.htm](http://www.tomatoesnz.co.nz/research_reports_public.htm)

[http://www.freshvegetables.co.nz/research/reports\\_public.html](http://www.freshvegetables.co.nz/research/reports_public.html)

## Appendix 2. Host plants for the tomato/potato psyllid

Adult potato/tomato psyllids can be found on many plants, especially in summer when they are migrating. Although they may be able to feed on a wide range of plants they can only reproduce only on some members of the Solanaceae and Convolvulaceae families.

In addition to the host plants listed in the table, the psyllid probably breeds on Chilli. Overseas it has been found breeding on field bindweed (*Convolvulus arvensis*) and morning glory (*Ipomoea purpurea*) (Convolvulaceae) and tobacco and black nightshade (*Solanum nigrum*) (Solanaceae). However, overseas information must be confirmed locally. For example we have found that black nightshade (sometimes called deadly nightshade) is not a breeding host plant in New Zealand. Adults may lay eggs on the plant, but all nymphs die.

Table: Plants on which potato/tomato psyllid can breed in New Zealand. Plants that support large populations of the psyllid are indicated with an asterisk.

<b>Family Name</b>	<b>Crop/weed</b>	<b>Common name</b>	<b>Scientific name</b>
Convolvulaceae	Crop	Kumara	<i>Ipomoea batatas</i>
Solanaceae	Crop	Capsicum*	<i>Capsicum annuum</i>
	Crop	Egg plant*	<i>Solanum melongena</i>
	Weed	Poroporo	<i>Solanum aviculare</i> and probably <i>S. laciniatum</i>
	Crop	Potato*	<i>Solanum tuberosum</i>
	Crop	Tamarillo	<i>Solanum betaceum</i>
	Crop	Tomatoes*	<i>Solanum lycopersicum</i>
	Weed	Thorn apple	<i>Datura stramonium</i>
	Weed	Apple of Peru	<i>Nicandra physalodes</i>



### Appendix 3. Monthly tomato/potato psyllid / Liberibacter Record Summary sheet

Date	
Greenhouse/unit	
Size	
Crop	
Cultivar	
Number of plants	
Planted	
Pull out	
Export/no export	

Weed host survey	Found	Action
Apple of Peru		
Thorn apple		
Bindweed		
Nightshade*		
Other host		

Presence of alternative crop host in locality			
Crop	Stage	Location	Strategy
Potatoes			
Tomatoes			
Capsicums			
Tamarillo			
other			

Yellow sticky traps			
Outside	Total 1-4 psyllids	Inside	Total 1-4
Week 1		Week 1	
Week 2		Week 2	
Week 3		Week 3	
Week 4		Week 4	

Plant monitoring for psyllids								
	Number sampled	% plants infested	Total score	Mean score per Plant sampled	Response		Spray action	
					No action	Leaf cull	Spot	House
Week 1								
Week 2								
Week 3								
Week 4								

Plant monitoring for Liberibacter			
	Number plants showing symptoms	Response	
		Plants removed	Other
Week 1			
Week 2			
Week 3			
Week 4			

Full house insecticide applications							
	Applied for psyllids	Applied for other pests	Product	Active ingredient	Concentration	Water rate	Application method
Week 1							
Week 2							
Week 3							
Week 4							



**Appendix 4. Toxicity of selected Chemicals to Natural Enemies**

Insecticide active ingredient	Bumble Bees (2)		Predatory Mites (1)						Parasitoids (1)			
			<i>Amblyseius cucumeris</i>		<i>Phytoseiulus persimilis</i>		<i>Hypoaspis miles</i>		<i>Aphidius</i> spp.		<i>Encarsia formosa</i>	
	Tox	Per	Tox	Per	Tox	Per	Tox	Per	Tox	Per	Tox	Per
Abamectin	B	72 h	2	5d	4	1w	2	5d	4	1w	3	5d
Acetamiprid	B	24 h	3	5d	3	1w	4	1w	3	-	4	2w
Alphacypermethrin	C	-	4	>8W	4	>8w	3	-	4	-	4	>8w
Buprofezin	A	-	1	-	2	-	1	-	1	1w	1	-
Chlorantraniliprole	-	-	-	-	-	-	-	-	-	-	-	-
Deltamethrin	B	72h	4	>8w	4	>8w	4	>8w	4	>8w	4	>8w
Diazinon	C	-	4	3w	4	1w	2	-	4	-	4	4-6w
Dichlorvos	B	36h	4	3d	4	1w	4	-	4	-	4	1w
Dinotefuran	-	-	-	-	-	-	-	-	-	-	-	-
Fenpyroximate	B	36h	4	-	4	>8w	3	>8w	3	-	1	-
Flonicamid	A	-	1	-	1	-	1	-	1	-	1	-
Imidacloprid	C	-	4	-	3	-	4	-	4	-	4	-
Lamba-cyathothrin	C	-	4	>8w	4	>8w	4	>8w	4	>8w	4	>8w
Malathion	C	-	4	>8w	2	1w	1	-	4	>8w	4	>8w
Maldison	-	-	-	-	-	-	-	-	-	-	-	-
Methamidophos	C	-	4	-	4	6w	4	-	4	>4w	4	>4w
Methomyl	B	72h	4	-	4	1w	4	-	4	-	4	-
Oxamyl	C	-	4	8w	4	>8w	3	-	4	>8w	4	>8w
Novalorun	B	72h	2	-	1	-	2	-	-	-	-	-
Permethrin	C	-	4	>8w	4	>8w	4	>8W	4	>8w	4	>8W
Pirimicarb	B	24h	3	3d	2	3d	1	-	1	-	2	3d
Pirimiphos-methyl	C	-	3	3d	2	3d	1	-	1	-	2	3d
Pymetrozine	A	-	1	-	2	-	2	-	2	-	1	-
Pyriproxifen	A	-	1	-	2	-	1	-	1	-	1	-
Spinetoram	-	-	-	-	-	-	-	-	-	-	-	-
Spinosad	B	24h	1	-	1	-	1	-	3	-	3	1w
Spiromesifen	A	-	2	-	3	-	1	-	-	-	-	-
Spirotetramat	-	-	-	-	-	-	-	-	-	-	-	-
Taufluvinate	B	72h	4	-	4	-	4	-	4	-	4	-
Thiacloprid	B	24h	-	-	3	2w	3	-	3	-	3	-
Thiamethoxam	C	-	-	-	4	>2w	2	-	4	-	-	-

**Note 1:** The side effects of insecticides are classified into four categories according to IOBC/WPRS classification:

Class	Toxicity	Percentage death or reduction of parasitism capacity
1	Non-toxic	<25 death
2	Slightly toxic	25-50% death
3	Moderately toxic	50-75 death
4	Toxic	> 75% death

Pesticides residual effects: For beneficial organisms, the residual period or persistence (Per) is given in days (d), weeks (w), or Hours (h). A hyphen (-) signifies that the information is not available. "More than" (>) signifies that the indicated residual period is a strict minimum.

**Note 2:** The side effects on bumblebees (*Bombus spp.*) are described in 3 classes:

Class	Advice
A	Can be used in combination with bumblebees
B	Remove the bumblebees hive before product application and until after the indicated persistence period
C	Do not use in combination with bumblebees

Bumblebee hives must be removed from the greenhouse before the application and not returned until after the indicated persistence period for class B. Hives can be removed for a maximum period of 72 hours before tomato pollination is affected.

Sources of additional information:

[www.iobc.ch/2005/IOBC\\_Pesticide\\_Database\\_Toolbox.pdf](http://www.iobc.ch/2005/IOBC_Pesticide_Database_Toolbox.pdf)

[www.koppert.nl/e0110.html](http://www.koppert.nl/e0110.html)

[www.biobest.be](http://www.biobest.be)

[www.goodbugs.org.au](http://www.goodbugs.org.au)

## Appendix 5: Spray Record

[illegible]



## Appendix C: Australia's Biosecurity Policy Framework

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### Australia's biosecurity policies

The objective of Australia's biosecurity policies and risk management measures is the prevention or control of the entry, establishment and spread of pests and diseases that could cause significant harm to people, animals, plants and other aspects of the environment.

Australia has diverse native flora and fauna and a large agricultural sector, and is relatively free from the more significant pests and diseases present in other countries. Therefore, successive Australian Governments have maintained a conservative, but not a zero-risk, approach to the management of quarantine risks. This approach is consistent with the World Trade Organization's (WTO's) *Agreement on the Application of Sanitary and Phytosanitary Measures* (SPS Agreement).

The SPS Agreement defines the concept of an 'appropriate level of protection' (ALOP) as the level of protection deemed appropriate by a WTO Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory. Among a number of obligations, a WTO Member should take into account the objective of minimising negative trade effects in setting its ALOP.

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

Consistent with the SPS Agreement, in conducting risk analyses Australia takes into account as relevant economic factors:

- the potential damage in terms of loss of production or sales in the event of the entry, establishment and spread of a pest or disease in the territory of Australia
- the costs of control or eradication of a pest or disease
- and the relative cost-effectiveness of alternative approaches to limiting risks.

### Roles and responsibilities within Australia's quarantine system

Australia protects its human<sup>7</sup>, animal and plant life or health through a comprehensive quarantine system that covers the quarantine continuum, from pre-border to border and post-border activities.

Pre-border, Australia participates in international standard-setting bodies, undertakes risk analyses, develops offshore quarantine arrangements where appropriate, and engages with our neighbours to counter the spread of exotic pests and diseases.

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<sup>7</sup> The Australian Government Department of Health and Ageing is responsible for human health aspects of quarantine.

At the border, Australia screens vessels (including aircraft), people and goods entering the country to detect potential threats to Australian human, animal and plant health.

The Australian Government also undertakes targeted measures at the immediate post-border level within Australia. This includes national co-ordination of emergency responses to pest and disease incursions. The movement of goods of quarantine concern within Australia's border is the responsibility of relevant state and territory authorities, which undertake inter- and intra-state quarantine operations that reflect regional differences in pest and disease status, as a part of their wider plant and animal health responsibilities.

## **Roles and responsibilities within the Department**

The Australian Government Department of Agriculture, Fisheries and Forestry is responsible for the Australian Government's animal and plant biosecurity policy development and the establishment of risk management measures. The Secretary of the Department is appointed as the Director of Animal and Plant Quarantine under the *Quarantine Act 1908* (the Act).

There are three groups within the Department primarily responsible for biosecurity and quarantine policy development and implementation:

- Biosecurity Australia conducts risk analyses, including IRAs, and develops recommendations for biosecurity policy as well as providing quarantine advice to the Director of Animal and Plant Quarantine and AQIS
- AQIS develops operational procedures, makes a range of quarantine decisions under the Act (including import permit decisions under delegation from the Director of Animal and Plant Quarantine) and delivers quarantine services and
- Product Integrity, Animal and Plant Health Division (PIAPH) coordinates pest and disease preparedness, emergency responses and liaison on inter- and intra-state quarantine arrangements for the Australian Government, in conjunction with Australia's state and territory governments.

## **Roles and responsibilities of other government agencies**

State and territory governments play a vital role in the quarantine continuum. Biosecurity Australia and PIAPH work in partnership with state and territory governments to address regional differences in pest and disease status and risk within Australia, and develop appropriate sanitary and phytosanitary measures to account for those differences. Australia's partnership approach to quarantine is supported by a formal Memorandum of Understanding that provides for consultation between the Australian Government and the state and territory governments. Depending on the nature of the good being imported or proposed for importation, Biosecurity Australia may consult other Australian Government authorities or agencies in developing its recommendations and providing advice.

As well as a Director of Animal and Plant Quarantine, the Act provides for a Director of Human Quarantine. The Australian Government Department of Health and Ageing is responsible for human health aspects of quarantine and Australia's Chief Medical Officer within that Department holds the position of Director of Human Quarantine.



Biosecurity Australia may, where appropriate, consult with that Department on relevant matters that may have implications for human health.

The Act also requires the Director of Animal and Plant Quarantine, before making certain decisions, to request advice from the Environment Minister and to take the advice into account when making those decisions. The Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA) is responsible under the *Environment Protection and Biodiversity Conservation Act 1999* for assessing the environmental impact associated with proposals to import live species. Anyone proposing to import such material should contact DEWHA directly for further information.

When undertaking risk analyses, Biosecurity Australia consults with DEWHA about environmental issues and may use or refer to DEWHA's assessment.

## Australian quarantine legislation

The Australian quarantine system is supported by Commonwealth, state and territory quarantine laws. Under the Australian Constitution, the Commonwealth Government does not have exclusive power to make laws in relation to quarantine, and as a result, Commonwealth and state quarantine laws can co-exist.

Commonwealth quarantine laws are contained in the *Quarantine Act 1908* and subordinate legislation including the Quarantine Regulations 2000, the *Quarantine Proclamation 1998*, the *Quarantine (Cocos Islands) Proclamation 2004* and the *Quarantine (Christmas Island) Proclamation 2004*.

The quarantine proclamations identify goods which cannot be imported, into Australia, the Cocos Islands and or Christmas Island unless the Director of Animal and Plant Quarantine or delegate grants an import permit or unless they comply with other conditions specified in the proclamations. Section 70 of the *Quarantine Proclamation 1998*, section 34 of the *Quarantine (Cocos Islands) Proclamation 2004* and section 34 of the *Quarantine (Christmas Island) Proclamation 2004* specify the things a Director of Animal and Plant Quarantine must take into account when deciding whether to grant a permit.

In particular, a Director of Animal and Plant Quarantine (or delegate):

- must consider the level of quarantine risk if the permit were granted, and
- must consider whether, if the permit were granted, the imposition of conditions would be necessary to limit the level of quarantine risk to one that is acceptably low, and
- for a permit to import a seed of a plant that was produced by genetic manipulation – must take into account any risk assessment prepared, and any decision made, in relation to the seed under the Gene Technology Act and
- may take into account anything else that he or she knows is relevant.

The level of quarantine risk is defined in section 5D of the *Quarantine Act 1908*. The definition is as follows:

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

- (a) the probability of:

- (i) a disease or pest being introduced, established or spread in Australia, the Cocos Islands or Christmas Island; and
  - (ii) the disease or pest causing harm to human beings, animals, plants, other aspects of the environment, or economic activities; and
- (b) the probable extent of the harm.

The Quarantine Regulations 2000 were amended in 2007 to regulate key steps of the import risk analysis process. The Regulations:

- define both a standard and an expanded IRA
- identify certain steps which must be included in each type of IRA
- specify time limits for certain steps and overall timeframes for the completion of IRAs (up to 24 months for a standard IRA and up to 30 months for an expanded IRA)
- specify publication requirements
- make provision for termination of an IRA and
- allow for a partially completed risk analysis to be completed as an IRA under the Regulations.

The Regulations are available at [www.comlaw.gov.au](http://www.comlaw.gov.au).

## International agreements and standards

The process set out in the *Import Risk Analysis Handbook 2007* is consistent with Australia's international obligations under the SPS Agreement. It also takes into account relevant international standards on risk assessment developed under the International Plant Protection Convention (IPPC) and by the World Organisation for Animal Health (OIE).

Australia bases its national risk management measures on international standards, where they exist and when they achieve Australia's ALOP. Otherwise, Australia exercises its right under the SPS Agreement to apply science-based sanitary and phytosanitary measures that are not more trade restrictive than required to achieve Australia's ALOP.

## Notification obligations

Under the transparency provisions of the SPS Agreement, WTO Members are required, among other things, to notify other members of proposed sanitary or phytosanitary regulations, or changes to existing regulations, that are not substantially the same as the content of an international standard and that may have a significant effect on trade of other WTO Members.

## Risk analysis

Within Australia's quarantine framework, the Australian Government uses risk analyses to assist it in considering the level of quarantine risk that may be associated with the importation or proposed importation of animals, plants or other goods.

In conducting a risk analysis, Biosecurity Australia:

- identifies the pests and diseases of quarantine concern that may be carried by the good
- assesses the likelihood that an identified pest or disease or pest would enter, establish or spread and
- assesses the probable extent of the harm that would result.

If the assessed level of quarantine risk exceeds Australia's ALOP, Biosecurity Australia will consider whether there are any risk management measures that will reduce quarantine risk to achieve the ALOP. If there are no risk management measures that reduce the risk to that level, trade will not be allowed.

Risk analyses may be carried out by Biosecurity Australia's specialists, but may also involve relevant experts from state and territory agencies, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), universities and industry to access the technical expertise needed for a particular analysis.

Risk analyses are conducted across a spectrum of scientific complexity and available scientific information. An IRA is a type of risk analysis with key steps regulated under the Quarantine Regulations 2000. Biosecurity Australia's assessment of risk may also take the form of a non-regulated analysis of existing policy or technical advice to AQIS. Further information on the types of risk analysis is provided in the *Import Risk Analysis Handbook 2007*.



## Glossary

Term	Definition
<b>Additional declaration</b>	A statement that is required by an importing country to be entered on a phytosanitary certificate and which provides specific additional information pertinent to the phytosanitary condition of a consignment in relation to regulated pests (FAO 2008).
<b>Appropriate level of protection</b>	The level of protection deemed appropriate by the Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory (WTO 1995).
<b>Area</b>	An officially defined country, part of a country or all or parts of several countries (FAO 2008).
<b>Biosecurity Australia</b>	A prescribed agency within the Australian Government Department of Agriculture, Fisheries and Forestry. Biosecurity Australia provides science-based quarantine assessments and policy advice that protects Australia's favourable pest and disease status and enhances Australia's access to international animal and plant related markets.
<b>Consignment</b>	A quantity of plants, plant products and/or other articles being moved from one country to another and covered, when required, by a single phytosanitary certificate (a consignment may be composed of one or more commodities or lots) (FAO 2008).
<b>Control (of a pest)</b>	Suppression, containment or eradication of a pest population (FAO 2008).
<b>Endangered area</b>	An area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss (FAO 2008).
<b>Entry (of a pest)</b>	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO 2008).
<b>Establishment</b>	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2008).
<b>Establishment potential</b>	Likelihood of the establishment of a pest.
<b>Fresh</b>	Living; not dried, deep-frozen or otherwise conserved (FAO 2008).
<b>Fruits and vegetables</b>	A commodity class for fresh parts of plants intended for consumption or processing and not for planting (FAO 2008).
<b>Host</b>	A species of plant capable, under natural conditions, of sustaining a specific pest.
<b>Import Permit</b>	Official document authorising importation of a commodity in accordance with specified phytosanitary import requirements (FAO 2008).
<b>Infestation (of a commodity)</b>	Presence in a commodity of a living pest of the plant or plant product concerned. Infestation includes infection (FAO 2008).
<b>Inspection</b>	Official visual examination of plants, plant products or other regulated articles to determine if pests are present and/or to determine compliance with phytosanitary regulations (FAO 2008).
<b>Intended use</b>	Declared purpose for which plants, plant products, or other regulated articles are imported, produced, or used (FAO 2008).
<b>Interception (of a pest)</b>	The detection of a pest during inspection or testing of an imported consignment (FAO 2008).
<b>Introduction</b>	The entry of a pest resulting in its establishment (FAO 2008).
<b>Lot</b>	A number of units of a single commodity, identifiable by its homogeneity of

Term	Definition
	composition, origin etc., forming part of a consignment (FAO 2008).
<b>National Plant Protection Organisation</b>	Official service established by a government to discharge the functions specified by the IPPC (FAO 2008). DAFF is Australia's National Plant Protection Organisation.
<b>Official control</b>	The active enforcement of mandatory phytosanitary regulations and the application of mandatory phytosanitary procedures with the objective of eradication or containment of quarantine pests or for the management of regulated non-quarantine pests (FAO 2008).
<b>Pathway</b>	Any means that allows the entry or spread of a pest (FAO 2008).
<b>Pest</b>	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2008).
<b>Pest categorisation</b>	The process for determining whether a pest has or has not the characteristics of a quarantine pest or those of a regulated non-quarantine pest (FAO 2008).
<b>Pest free area</b>	An area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained (FAO 2008).
<b>Pest risk analysis</b>	The process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated and the strength of any phytosanitary measures to be taken against it (FAO 2008).
<b>Pest risk assessment (for quarantine pests)</b>	Evaluation of the probability of the introduction and spread of a pest and the magnitude of the associated potential economic consequences (FAO 2008).
<b>Pest risk management (for quarantine pests)</b>	Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2008).
<b>Phytosanitary certificate</b>	Certificate patterned after the model certificates of the IPPC (FAO 2008).
<b>Phytosanitary measure</b>	Any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO 2008).
<b>Phytosanitary regulation</b>	Official rule to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests, including establishment of procedures for phytosanitary certification (FAO 2008).
<b>Polymerase chain reaction</b>	A technique that utilises a heat stable DNA polymerase to amplify a piece of DNA by <i>in vitro</i> enzymatic replication, initiating a chain reaction in which the DNA template is exponentially amplified, generating millions or more copies of the target DNA.
<b>Polyphagous</b>	Feeding on a relatively large number of host plants from different plant families.
<b>Protected area</b>	A regulated area that an NPPO has determined to be the minimum area necessary for the effective protection of an endangered area (FAO 2008).
<b>Quarantine pest</b>	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO 2008).
<b>Regulated article</b>	Any plant, plant product, storage place, packaging, conveyance, container, soil and any other organism, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved (FAO 2008).
<b>Restricted risk</b>	'Restricted' risk estimates apply to situations where risk management measures are used
<b>Spread</b>	Expansion of the geographical distribution of a pest within an area (FAO 2008).

Term	Definition
<b>SPS Agreement</b>	WTO Agreement on the Application of Sanitary and Phytosanitary Measures (WTO 1995).
<b>Stakeholders</b>	Government agencies, individuals, community or industry groups or organisations, whether in Australia or overseas, including the proponent/applicant for a specific proposal
<b>Systems approach(es)</b>	The integration of different risk management measures, at least two of which act independently, and which cumulatively achieve the appropriate level of phytosanitary protection (FAO 2008).
<b>Unrestricted risk</b>	'Unrestricted' risk estimates apply in the absence of risk management measures.





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