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Department of Agriculture, Fisheries and Forestry

Final pest risk analysis report for *Drosophila suzukii*

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Cover images: Adult *Drosophila suzukii*, female (left) and male (right) (Hauser & Damus 2009)

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Acronyms and abbreviations

Acronym or abbreviation	Definition
ALOP	Appropriate level of protection
APHIS	Animal and Plant Health Inspection Service
ARS	Agricultural Research Service
DAFF	Australian Government Department of Agriculture, Fisheries and Forestry
FAO	Food and Agriculture Organization of the United Nations
IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
IRA	Import Risk Analysis
ISPM	International Standard for Phytosanitary Measures
NPPO	National Plant Protection Organisation
ODA	Oregon Department of Agriculture
OSU	Oregon State University
PRA	Pest Risk Analysis
SPS	sanitary and phytosanitary
USA	United States of America
USDA	United States Department of Agriculture

Abbreviation of units

Term or abbreviation	Definition
ºC	Degree Celsius
ha	Hectare
cm	Centimetre
g	Gram
kg	Kilogram
km	Kilometre
m	Metre
mm	Millimetre
s	Second

Summary

The Department of Agriculture, Fisheries and Forestry (DAFF) has undertaken a pest risk analysis to assess the quarantine risks posed by *Drosophila suzukii* which attacks a range of soft fruits, including caneberries, strawberries, cherries, blueberries, grapes and stone fruit.

The pest risk analysis meets Australia's obligations under the International Plant Protection Convention and the International Standards for Phytosanitary Measures (ISPM No. 1) to review emergency phytosanitary measures that were notified on 7 April 2010 through the World Trade Organization.

This pest risk analysis report identified several commodity groups, as potential pathways for the introduction of *Drosophila suzukii* with an unrestricted risk that exceeds Australia's acceptable level of protection (ALOP):

- Fresh fruit: caneberries, cherry, stone fruit, strawberry, blueberry, grapes, mulberries, figs, hardy kiwis, gooseberries, currants, dogwood, red bayberry, American pokeweed.

This pest risk analysis report recommends that additional measures be applied to fresh fruit of identified plant species being sourced from areas where *Drosophila suzukii* is known to occur.

A combination of risk management measures and operational systems are proposed to reduce the risks associated with the importation of identified commodities. Specifically, the proposed measures are:

- For fresh fruit potentially carrying life stages of *Drosophila suzukii*:
  - area freedom from *Drosophila suzukii*, or
  - a systems approach for fruit to ensure that fruit are not infested with *Drosophila suzukii*, or
  - application to fruit of a treatment known to be effective against all life stages of *Drosophila suzukii*,
    - Current approved treatments include methyl bromide fumigation for strawberry and cherry; or
    - sulfur dioxide/carbon dioxide fumigation followed by a six-day cold treatment for table grapes.
  - In addition, this report recommends methyl bromide fumigation for stone fruit (peach and nectarine only). and
- supporting operational systems to maintain and verify phytosanitary status.

1 Introduction

1.1 Australia’s biosecurity policy framework

Australia's biosecurity policies aim to protect Australia against the risks that may arise from exotic pests[1] 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 pest risk analysis (PRA) 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 PRAs are undertaken by the Department of Agriculture, Fisheries and Forestry (DAFF) using teams of technical and scientific experts in relevant fields, and involves consultation with stakeholders at various stages during the process. DAFF provides recommendations for animal and plant quarantine policy to Australia’s Director of Animal and Plant Quarantine (the Secretary of the Australian Government 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. DAFF 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 2011* located on the DAFF website http://www.daff.gov.au/ba.

1.2 This pest risk analysis

1.2.1 Background

A pest attacking a range of soft fruits was first recorded from North America in the Watsonville area of California in 2008 (Bolda 2009; Hauser *et al*. 2009). Samples of the pest obtained in September 2008 were identified as a species of *Drosophila* (vinegar flies). Species of *Drosophila* are attracted to fermenting, over-ripe and rotting fruit, and are well known nuisance pests in restaurants, grocery stores, fruit markets and homes (Jacobs 2010). Since *Drosophila* species were not known to attack fruit after harvest in

[1] A pest is any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2009)

the USA, and are attracted to over-ripe fruit, it was not considered to be a pest of concern for commercial fruit growers (Hauser *et al*. 2009).

However, reports of damage continued in spring of 2009 and several adults submitted for identification were determined to be *Drosophila suzukii*, a species which caused damage to fruit in Japan (Hauser *et al*. 2009). In September 2009, the initial reports of *Drosophila suzukii* attacking commercial fruit in Western USA were confirmed by an Oregon Department of Agriculture pest alert (ODA 2009).

Drosophila suzukii has subsequently been confirmed as present in Canada (British Columbia) (NAPPO 2010a) and the USA (California, Florida, Oregon and Washington) (NAPPO 2010b) in North America in 2010. Since then *Drosophila suzukii* has spread across North America and is present in most east coast states in the USA (see table 3.1) *Drosophila suzukii* was detected in Italy in September 2009 (EPPO 2010a) and has been reported as present in Spain and France (Calabria *et al*. 2012) and later spread to other countries including Belgium, Switzerland, Slovenia and Germany (EPPO 2012; Seljak 2011a; BFB 2012; Fischer *et al*. 2011). *Drosophila suzukii* is also native to several Asian countries including Japan, South Korea, China and India (Kanzawa 1939; Toda 1991; Hauser *et al*. 2009).

The presence of this new pest in the USA and the potential for its introduction into Australia, via imports of currently traded host fruit, resulted in Australia introducing emergency quarantine measures, prior to the re-commencement of trade. The emergency measures were announced on 7 April 2010 for cherries (*Prunus avium*), strawberries (*Fragaria* x *ananassa*), stone fruit (*Prunus* spp.) and table grapes (*Vitis* spp.) for human consumption from all countries.

In response to Australia's concerns over *Drosophila suzukii*, and the imminent emergency measures notification, the USA proposed interim conditions for the importation of strawberries, cherries and table grapes. In accordance with international obligations under the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement), Australia is obliged to consider emergency measures that could address the risk of a pest entering and establishing in Australia. For strawberries, cherries and table grapes, emergency measures included methyl bromide fumigation based on preliminary fumigation data for each commodity that showed 100% mortality of *Drosophila suzukii*. Until a complete submission on the efficacy of methyl bromide fumigation could be developed and considered suitable, emergency measures included an additional verification inspection, using fruit cuts and optical magnification, to confirm the efficacy of the treatment. Stakeholders were notified of the interim import conditions via public quarantine alerts, PQA0655 (strawberry) on 30 March and PQA0665 (cherry) on 18 May and PQA0679 (table grape) on 13 August on the Import Conditions (ICON) database. The interim conditions are in addition to existing policy (Table 1.1).

In addition to fresh fruit, *Drosophila suzukii* has been reported to attack the flowers of *Styrax japonicus* (Japanese snowbell) where adults successfully emerged from the flowers (Mitsui *et al*. 2010).

1.2.2 Scope

This PRA assesses the biosecurity risks of the importation of *Drosophila suzukii* in the following pathways:

- commercial grade fruit identified as hosts
- commercial grade flowers identified as hosts.

The risk for these pathways was assessed using information on the biology, ecology and impact of *Drosophila suzukii*.

Phytosanitary conditions exist for the import of a number of fresh fruit identified as hosts for *Drosophila suzukii*. Depending on the commodity and the risk posed by other pests of quarantine concern, these conditions include:

- off-shore pre-shipment or on-arrival inspection by DAFF of fruit from specified countries
- methyl bromide fumigation, and
- carbon dioxide/sulfur dioxide fumigation.

However, this pest risk analysis does not consider these specific phytosanitary measures during the pest risk assessments for the fruit pathways as existing measures will vary depending on the commodity and from where the fruit is sourced. Phytosanitary measures already in place are considered during the development of risk management measures, if required, following the pest risk assessment.

Imported commercial grade fruit will be produced to a standard suitable for retail sale. It is expected the commercial grade fruit sent to Australia will be graded and sorted to meet retail quality requirements and is likely to be sound and undamaged. The pathway analysis will take into consideration the commercial standard of the fruit at the border in accordance with relevant international standards (FAO 2004). However, the PRA does not consider the production methods employed to produce commercial grade fruit. The large number of countries where *Drosophila suzukii* is present makes it impractical to consider all possible management measures applied pre- and post harvest.

The PRA considers fresh fruit or flowers that are commercially produced in greenhouses or the field.

1.2.3 Existing policy

Australia has existing conditions in place to allow the importation of a range of fresh fruits and flowers that are suitable hosts for *Drosophila suzukii*. Fresh fruits for which Australia has imposed emergency measures to manage the risk of *Drosophila suzukii*, and their existing import conditions, are listed in Table 1.1. There are no existing import conditions for fresh flowers considered to be hosts of *Drosophila suzukii* (Table 1.2). Nursery stock can be imported and standard import conditions include methyl bromide fumigation followed by three months in post entry quarantine. In addition, it is standard practice to remove reproductive structures to improve vegetative growth of the imported nursery stock. Import conditions can be viewed on the DAFF ICON database available at http://www.daff.gov.au/aqis/import/icon-icd.

Table 1.1: Import conditions for fresh fruits hosts for *Drosophila suzukii*

Family	Host	ICON Conditions Fresh Fruit permitted?
Rosaceae	*Rubus* spp. (caneberries)	**No** (C6066)
	Fragaria spp. (strawberry)	**Yes** USA (C6000, C6030) **Yes** NZ (C6000, C6044, C6012)
	Prunus persica var. *nucipersica* (nectarines)	**Yes** NZ (C6000, C6012, C10579)
	Prunus persica (peaches)	**Yes** NZ (C6000, C6012, C10579)
	Prunus armeniaca (apricots)	**Yes** NZ (C6000, C6012, C10579)
	Prunus avium (cherry)	**Yes** NZ (C6000, C6012) **Yes** USA (C18469, C6000)
	Prunus domestica (plums)	**Yes** NZ (C6000, C6012, C10579)
	Other *Prunus* spp.	**No**
Ericaceae	*Vaccinium augustifolium* and *V. corymbosum* (blueberry)	**Yes** NZ (C6000, C6012, C10049)
	Vaccinium myrtillus (bilberry)	**No**
Grossulariaceae	*Ribes* spp. (red and black currants)	**Yes** NZ (C6000) **No** USA (C6000, C6018, C6107, C19788)
	RIbes uva-crispa (gooseberry)	**Yes** NZ (C6000) **No** USA (C6000, C6018, C6107, C19788)
Vitaceae	*Vitis* spp. (grapes)	**Yes** NZ (C6000, C6051, C6015; No access for WA, C9814) **Yes** Chile (C9082, C10523) **Yes** USA (C9267, C6000) **Yes** South Korea (C19446), subject to successful audit and verification activities
	Vitis labrusca (concord grapes)	**No**
Moraceae	*Ficus carica* (figs)	**No** USA (C6000, C6107,C6018, C19788) **Yes** NZ (C6000)
	Morus spp. (mulberry)	**No** (C6066)
Actinidiaceae	*Actinidia arguta* (hardy kiwi)	**Yes** NZ (C6000, C6012)
Cornaceae	*Cornus kousa* (dogwood)	**No**
Myricaceae	*Myrica rubra* (red bayberry)	**No**

Family	Host	ICON Conditions Fresh Fruit permitted?
Elaegnaceae	*Elaeagnus multiflora* (silver berry)	**No**
Phytolaccaceae	*Phytolacca Americana* (poke weed)	**No**

Table 1.2: Import conditions for fresh flower hosts for *Drosophila suzukii*

Family	Host	ICON Conditions Fresh Flowers permitted?
Styracaceae	*Styrax japonicus* (Japanese snowbell)	**Fresh Flowers – No** **Nursery stock – Yes** (C7301, C7302, C7300)
Theaceae	*Camellia japonica* (camelia)	**Fresh Flowers – No** **Nursery stock** – **No** Canada (C15015) **No** European countries (C15015) **No** NZ (C15015) **No** USA (C15015) **Yes** All other countries (nursery stock permitted; C15020)

1.2.4 Consultation

In addition to the quarantine alerts announcing emergency measures, DAFF consulted informally with key industry groups potentially affected by the consequence of the entry, establishment and spread of *Drosophila suzukii*. DAFF also provided written updates to ensure accurate information was released to stakeholders. Three industry updates were sent directly to peak industry representatives on 1 June 2010, 21 June 2010 and 30 July 2010 and these updates were subsequently distributed within these industries.

DAFF commenced a pest risk analysis (PRA) for *Drosophila suzukii*, consistent with Australia's international obligations, to assess the risks posed by the importation of fresh fruit commodities. Stakeholders were notified of the commencement of the pest initiated PRA by a Biosecurity Australia Advice on 31 March 2010. The PRA considers all potential fruit pathways, because although *Drosophila suzukii* is mostly found on members of the Rosaceae, it has been reported from plants in the Ericaceae, Vitaceae, Actinidaceae, Moraceae, Cornaceae and Myricaceae families (Dreves *et al*. 2009; NAPPO 2010a). These hosts include a range of cultivated and non-cultivated plants that are widely distributed in Australia (AVH 2010).

A draft PRA report was released on 21 October 2010 for a stakeholder consultation period of 60 days. Eight submissions were received including from state departments, horticultural industries and the United States Department of Agriculture. All submissions, and an extensive review of the latest information, were considered in developing the final PRA report for *Drosophila suzukii*.

2 Method for pest risk analysis

This section sets out the method used for the pest risk analysis (PRA) in this report. DAFF 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 2009). A pest is 'any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products' (FAO 2009).

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

Unrestricted risk is typically estimated taking into account the existing commercial production practices of the exporting country and that, on arrival in Australia, DAFF officers will verify that the consignment received is as described on the commercial documents and its integrity has been maintained. However, as this PRA considers host commodities from many different countries, only the commercial standard of the commodity was considered. Standard commercial practice will vary considerably between countries and it is therefore impractical to consider this in estimating the unrestricted risk in this PRA. When trade in a particular commodity is proposed by an exporting country, the commercial practices relevant to that country and commodity can then be considered and taken into account when assessing the efficacy of any proposed measure.

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 2009).

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 *Drosophila suzukii,* careful consideration was given to identify the potential pathways for the entry of this pest 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 2009).

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 2009). 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.

This report is a pest initiated PRA that considers the risk of one pest that could enter by multiple pathways. The results for pathway association for *Drosophila suzukii* are listed in Appendix B and are summarized in Chapter 4.

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 PRA.

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, the generation and disposal of waste and the presence and availability of suitable hosts in Australia. 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, DAFF 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 (e.g. grading and sorting) 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, DAFF 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 are given in Table 2.1.

Table 2.1: Nomenclature for qualitative likelihoods

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

The likelihood of entry *P* [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 likelihoods of entry *P* [entry] and establishment P[establishment]. The result is then combined with the likelihood of spread *P* [spread] to determine the overall likelihood of entry, establishment and spread *P* [EES]. A working example is provided below;

P [importation] x *P* [distribution] = *P* [**entry**] e.g. **low x moderate = low**

P [entry] x *P* [establishment] = *P* [**EE**] e.g. **low x high = low**

P [**EE**] x [spread] = ***P* [EES]** e.g. **low x very low = 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.

DAFF 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 DAFF'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 DAFF has an obligation to review the risk analysis and, if necessary, provide updated policy advice.

For commodities without existing trade and exact volumes are not known, DAFF assumes a significant 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 2009) 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) using Table 2.3.

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

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

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

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

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

2.2.4 Estimation of the unrestricted risk

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

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	**Very low risk**	Low risk	Moderate risk	High risk	Extreme risk
Moderate	Negligible risk	**Very low risk**	Low risk	Moderate risk	High risk	Extreme risk
Low	Negligible risk	Negligible risk	**Very low risk**	Low risk	Moderate risk	High risk
Very low	Negligible risk	Negligible risk	Negligible risk	**Very low risk**	Low risk	Moderate risk
Extremely low	Negligible risk	Negligible risk	Negligible risk	Negligible risk	**Very low risk**	Low risk
Negligible	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Negligible risk	**Very low risk**
	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 Pest information

3.1 Summary

Scientific name	*Drosophila suzukii* Matsumura, 1931 [Diptera: Drosophilidae]
Synonyms	*Drosophila indicus* Parshad & Paika, 1965 *Leucophenga suzukii* Matsumura, 1931 *Drosophila suzukii* subsp. *indicus* Pashan & Paika, 1964
Common name	Spotted wing drosophila, cherry drosophila
Known hosts	Includes *Fragaria* spp., *Prunus* spp., *Rubus* spp., *Vaccinium* spp., *Vitis* spp., and *Morus* spp. (see Appendix B for a full list)
Distribution	Asia, North America and Europe (see table 3.1)

3.2 Drosophila suzukii

The family Drosophilidae is composed of over 3750 species worldwide and over 2000 of these are species of *Drosophila* (Ashburner *et al*. 2005; Van Der Linde and Houle 2008; O'Grady and Markow 2009). Species of *Drosophila* are well known because of the extensive use of *Drosophila melanogaster* in genetic studies and as common vinegar flies associated with over-ripe and rotting fruit (Ashburner *et al*. 2005; Hauser *et al*. 2009; Jacobs 2010). Species of *Drosophila* are well known nuisance pests in restaurants, grocery stores, fruit markets and homes (Jacobs 2010). *Drosophila* spp. are also known to be nuisance pests during wine making and the fermentation of fruit (Ferrar 1987).

In Australia there are approximately 34 described species of *Drosophila* and 22 of these are from the Sophophora sub genus group (AFD 2010). *Drosophila suzukii* is one of 180 species of the melanogaster species group within the Sophophora sub genus group (Ashburner *et al*. 2005). *Drosophila suzukii* is part of a poorly described (taxonomically) *suzukii* sub group of Oriental species that is considered polyphyletic (composed of more than one ancestral lineage). Recent work supports the taxonomic position of the *suzukii* sub group that is closely related to the *melanogaster* and *takahashii* sub groups (Yang *et al*. 2012; Ometto *et al*. 2013).

In June, 1916, insect larvae were found to be infesting cherries (*Prunus avium*) pre harvest in Yamacho, Higashi Yamanashi County, Yamanashi Prefecture, Japan (Kanzawa 1935). Infested fruit was collected and the adult flies that emerged were confirmed as a species of *Drosophila* (Kanzawa 1935). The species was later described in 1931 by Dr Shounen Matsumura as *Drosophila suzukii* Matsumura, and he gave it the common name of cherry drosophila (Kanzawa 1935).

Recently the taxonomic status of the *Drosophila* genus has been the subject of scientific debate (Van Der Linde and Houle 2008; O'Grady and Markow 2009). It is considered likely the next revision of the *Drosophila* genus will elevate the Sophophora sub genus to genus level in its own right (Dalton 2010). The melanogaster species group, including *Drosophila suzukii*, is part of the Sophophora sub genus (Dalton 2010). A proposal to the International Committee of Zoological Nomenclature to maintain the *melanogaster* group within the *Drosophila* genus, because of the importance of *Drosophila* *melanogaster* to genetic research, has been rejected by the Committee (Dalton 2010). It is expected that the name *Drosophila suzukii* will eventually be revised to *Sophophora suzukii*.

3.3 Distribution of *Drosophila suzukii*

Drosophila suzukii is considered native to Asia (Kanzawa 1935; Dreves *et al*. 2009; Hauser *et al*. 2009) and recent genetic analysis supports this view (Ometto *et al*. 2013). It is widespread in China, Japan and Korea (Hauser *et al*. 2009; Kanzawa 1935; Lee 1964), but has a restricted distribution in India and Pakistan being limited to higher elevations of the northern regions (Hauser *et al*. 2009; Singh and Bhatt 1988; Singh and Negi 1989; Amin ud Din *et al*. 2005). More recently, *Drosophila suzukii* has been confirmed at altitudes above 500m in southern India during the monsoon (Guruprasad *et al*. 2010; Guruprasad *et al*. 2011). In Myanmar, adult flies have been collected at two locations in the central north of the country (Toda 1991). *Drosophila suzukii* has been recorded from Taiwan (Lin *et al*. 1977) and there is little information on the distribution of *Drosophila suzukii* within Far East Russia and Thailand.

In North America, *Drosophila suzukii* has been recorded from the USA and Canada. *Drosophila suzukii* was first recorded in Hawaii in 1980 and is typically recorded from elevations above 1 000m (Kaneshiro 1983; O'Grady 2002), but it has been recorded from lower elevations (Asquith and Messing 1992; Kido *et al*. 1996). It was first recorded from California in 2008 (Lee *et al*. 2011b) (species identity confirmed in 2009; Hauser 2011) and has since spread to Florida, Oregon, Washington and British Columbia in 2009 (Steck *et al*. 2009; ODA 2009; WSUE 2009; Hueppelsheuser 2009; Snyder 2010). The USA has not imposed quarantine restrictions (NAPPO 2010b) and the distribution of *Drosophila suzukii* was expected to expand to the mid western and eastern states during 2010 (Hauser *et al*. 2009). *Drosophila suzukii* has subsequently been confirmed as present in South Carolina, North Carolina, Louisiana, Utah and Michigan (Burrack 2010; OSU 2010c; Davis *et al*. 2010; Isaacs *et al*. 2010). There is also a media report by University of Florida entomologists that *Drosophila suzukii* is present in Kentucky and possibly other states as well (Tri-ology 2010; Price and Nagle 2011). In 2011, *Drosophila suzukii* spread across the eastern seaboard of the USA and many inland states as well (see table 3.1). *Drosophila suzukii* has now been confirmed in Mexico (NAPPO 2011).

Drosophila suzukii has been reported in Central and South America (Ashburner *et al*. 2005). It has recently been reported that *Drosophila suzukii* has been in Costa Rica since 1997, where it was considered abundant, and from Ecuador since 1998 (Calabria *et al*. 2012). There is no information on the extent of the distribution in these countries. Later information reports there are no collections of *Drosophila suzukii* from Central/South America and it is unlikely it is present in these countries (Hauser 2011).

Drosophila suzukii was first confirmed present in Europe from the Province of Trento in Italy in 2009 (EPPO 2010a). Since this detection it has been confirmed in Tuscany and in Calabria in the south of Italy (EPPO 2010c). More recent publications have confirmed it present from several locations along the Mediterranean region of Europe including Spain in 2008 and France in 2009 (Calabria *et al*. 2012; Cazaubon 2010; EPPO 2010b; EPPO 2010c). *Drosophila suzukii* has since spread to other countries including Belgium, Switzerland, Slovenia and Germany (EPPO 2012a; BFB 2012;

Seljak 2011a; Fischer *et al*. 2011). The media has also reported that *Drosophila suzukii* has been recorded attacking grapes in the Azores Islands, Portugal (Reign of Terroir 2010b) although these reports are yet to be verified. Table 3.1 summarises the distribution of *Drosophila suzukii*.

Table 3.1: Distribution of *Drosophila suzukii*

Region	Country	State/Areas
Asia	China (Toda 1991)	Numerous locations from the north to the south and south west of China (Damus 2009, Toda 1991). Recorded from the following provinces; Heilongjiang, Jilin, Liaoning, Beijing, Shanxi, Shandong, Jiangsu, Anhui, Shanghai, Zhejiang, Jiangxi, Hunan, Fujian, Guangdong, Hainan, Guangxi, Sichuan, Guangzhou, Yunnan (Kai *et al*. 1993).
	India (Singh and Negi 1989)	Kashmir (Hauser *et al*. 2009), northern India (Toda 1991).and Uttar Pradesh (Chamoli & Pauri region) for *Drosophila suzukii indicas* at approximately 5000 feet (Singh and Negi 1989) or at 6000 feet (1800m) above sea level (Singh and Bhatt 1988). *Drosophila suzukii* has recently been recorded from Mysore in southern India at altitude (680m and above) where it is collected infrequently (Guruprasad *et al*. 2010).
	Japan (Kanzawa 1935)	The four main Islands of Japan, plus the islands of Ryukyu, Bonin, Kume-jima and Iriomote-jima (Damus 2009; Toda 1991; Kondo and Kimura 2008).
	Myanmar (Toda 1991)	From the central north of the country including the highlands (Toda 1991)
	Pakistan (Amin ud Din *et al*. 2005)	Kashmir region (Amin ud Din *et al*. 2005)
	Russia (Toda *et al*. 1996)	Far east Russia (Toda *et al*. 1996)
	South Korea (Lee 1966)	Numerous locations across Korea (Damus 2009; Lee 1964) including Quelpart Island (Lee 1966).
	Thailand (Hauser *et al*. 2009; Toda 1991)	Present; no further information.
	Taiwan (Lin *et al*. 1977)	Recorded from Chung-tou and I-Lan in northern Taiwan (Lin *et al*. 1977).
Central America	Costa Rica (Ashburner *et al*. 2005)	Reported from collections in 1997 and considered common (Calabria *et al*. 2012). However, later reports can find no record of *Drosophila suzukii* in collections and these reports should be treated with caution (Hauser 2011).
South America	Ecuador (Ashburner *et al*. 2005)	Reported from collections in 1998 and considered rare (Calabria *et al*. 2012). However, later reports can find no record of *Drosophila suzukii* in collections and these reports should be treated with caution (Hauser 2011).
North America	Canada (BCMAL 2009)	Recorded first from two locations in western British Columbia, (Hueppelsheuser 2009) and in 2010 from Ontario, Alberta, Manitoba, Quebec and from Nova Scotia (Fisher *et al*. 2010; Shearer *et al*. 2010; Moreau 2011).
	United States (Hauser *et al*. 2009)	Hawaii Islands (Kaneshiro 1983), California (Bolda 2009), Oregon (Dreves *et al*. 2009), Washington (WSUE 2009), Florida (CAPS 2009), North and South Carolina (Burrack 2010), Louisiana (OSU 2010c) , Utah (Davis *et al*. 2010), Michigan

		(Isaacs *et al*. 2010), Alabama (ACES 2011), Arizona (Burrack *et al*. 2012),Arkansas (Johnson 2012), Pennsylvania (Demchak et al. 2011), Utah (Stanley-Vorel and Downey 2011), Idaho (UIN 2012), Virginia, West Virginia, Illinois, Ohio, Massachusetts, New Hampshire, Maine, Montana, Wisconsin, Michigan, Rhode Island, Connecticut, New Jersey, Maryland (CAPS 2012), New York (Loeb and Heidenreich 2012), Minnesota (MDA 2012), Mississippi (Sampson *et al*. 2012). Vermont (Grubinger 2012) and Kentucky (Price and Nagle 2011). Later publications support the distribution of *Drosophila suzukii* across most of eastern USA, including Georgia, Tennessee and all of north east USA (Stocks and Hodges 2011; Burrack *et al*. 2012).
	Mexico (NAPPO 2011)	Detected in the municipality of Los Reyes, State of Michoacan and is under eradication (NAPPO 2011),
Europe	France (Calabria *et al*. 2012)	Recorded from the Departments of Corsica, Herault, Gard, Alpes Maritimes, Var, Tarn et Garonne, Isere, Savole, Drome, Ardeche and Rhone (Calabria *et al*. 2012; Cazaubon 2010; Seigle Vatte 2010; DRAAF Rhone-Alpes 2010).
	Italy (EPPO 2010a)	Province of Trento, Pisa (Tuscany),regions of Calabria and Ligura (EPPO 2010a; EPPO 2010b; EPPO 2010c; Suss and Contanzi 2010)
	Spain (Calabria *et al*. 2012)	Near the town of Rasquera and in the city of Barcelona (Calabria *et al*. 2012) and region of Catalonia (Escudero *et al*. 2011)
	Portugal (Reign of Terroir 2010b)	Reported attacking grapes in the Island of San Miguel, Azores Islands. This record is based on a media report only. Subsequently, *Drosophila suzukii* has been confirmed present in Alentejo region of southern Portugal (EPPO 2012d).
	Slovenia (Seljak 2011a)	Detected in Slovenia in early October 2010, infesting fruit in a private garden in Nova Gorica (Seljak 2011a) and has since been detected at numerous locations across the country (Seljak 2011b; MAE 2012).
	Germany (BFB 2012)	Detected near Rastatt in Baden-Württemberg in autumn 2011 in insect collections for the Barcoding Fauna Bavarica (BFB) project using DNA techniques. Additional three sites in Southern Germany have been confirmed for *Drosophila suzukii* (BFB 2012).
	Switzerland (Fischer *et al*. 2011)	Recorded from multiple sites across Switzerland (Fischer *et al*. 2011).
	Croatia	Reported as present in the summer of 2011 (Sarto and Sorribas 2011) in the Istria region (EPPO 2012d).
	Belgium (EPPO 2012a)	A single *Drosophila suzukii* male was detected in Belgium during the last week of November 2011 (EPPO 2012a).
	Austria (EPPO 2012b)	*Drosophila suzukii* was found in several regions of Austria (EPPO 2012b).
	England (HDC 2012)	*Drosophila suzukii* detected in September 2012 in Kent (EPPO 2012d).
	Netherlands (EPPO 2012d)	*Drosophila suzukii* detected in the south of the country in October 2012 (EPPO 2012d).

3.4 Morphology and Biology of *Drosophila suzukii*

3.4.1 Morphology

Adults of *Drosophila suzukii* are a small fly approximately 2–3 mm long with a wing span of 6–8 mm (Kanzawa 1939; Kawase and Uchino 2005). Males are typically smaller than females. Males can be distinguished easily from most other species of *Drosophila* and females by the small dark spots on the end of their wings (Figure 3.1). Females have a distinct double serrated ovipositor (Figure 3.1) that is used to puncture intact skin of suitable fruit (Kanzawa 1939; Dreves *et al*. 2009; Hauser *et al*. 2009). This feature distinguishes females from other species of *Drosophila* in North America. Other species of *Drosophila* in Asia (e.g. *D. subpulchrella*) have a serrated ovipositor similar to *Drosophila suzukii* (Takamori *et al*. 2006; Kimura and Anfora 2011).

Figure 3.1: Adult male (left) and female (middle) of *Drosophila suzukii.* The serrated ovipositor can be seen in close up (right) (Dreves *et al*. 2009)

Eggs are white in colour and are on average 0.62 x 0.18 mm wide (Kanzawa 1939). The eggs have two tubes that extend from one end of the egg (Figure 3.2), that are used for respiration, and on average are 0.67 mm long. There are three larval instars that range in size (length x width) from 0.67 x 0.17 mm, 2.13 x 0.40 mm and 3.94 x 0.88 mm on average for first, second and third instars respectively (Kanzawa 1939). The larvae are white to cream in colour (Figure 3.2).

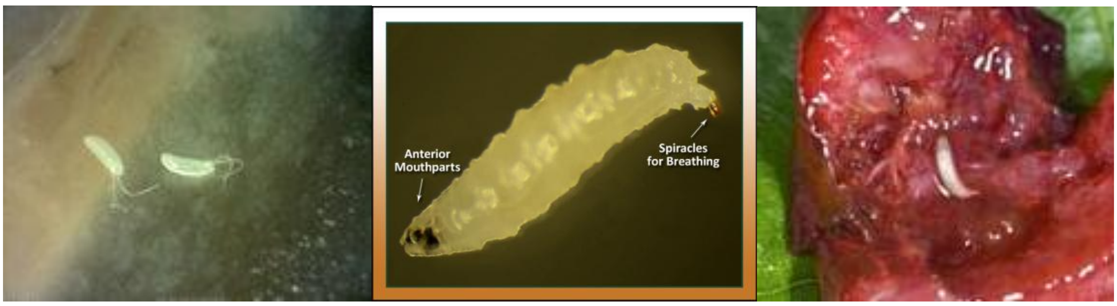

Figure 3.2: Eggs showing breathing tubes (left), larva (middle), and larva in a cherry, of *Drosophila suzukii* (BCMAL 2009; WSU 2009; Bolda *et al*. 2009)

The pupae of *Drosophila suzukii* are tan–brown in colour and measure 3 mm long by 1 mm wide (Kanzawa 1939; Figure 3.3). The breathing structures are an additional

0.3 mm long and have distinctive pairs of horn-shaped protrusions made by the jutting out of the anterior respiratory organs on both sides of the head. The respiratory organs further divide into seven to eight branches at the ends (Kanzawa 1935). The immature life stages of *Drosophila* are morphologically similar (Ferrar 1987) and make identification to species difficult. A taxonomic description of the immature life stages of *Drosophila suzukii*, including drawings, can be found in Okada (1968). However, immature life stages of *Drosophila suzukii* can be identified by molecular analysis (Hauser 2011).

There have been concerns raised by an Australian fruit industry that *Drosophila suzukii* has mutated during its range expansion into North America including a larger and more robust ovipositior that could allow the pest to attack a broader range of harder skinned fruits. There is no evidence this has occurred. However, there is a preliminary report of *Drosophila suzukii* with less well developed ovipositiors being trapped in the USA (DAFF 2010). It is considered that the less developed ovipositors may be due to *Drosophila suzukii* mating with native *Drosophila* resulting in hybrids. The possible hybrids have ovipositors that are more typical of the vast majority of *Drosophila* that only attack rotting fruit post harvest (DAFF 2010) that would make them more likely to have a restricted host range with potential to attack only damaged fruit or fruit with very thin skin.

Figure 3.3: Pupae of *Drosophila suzukii*; removed from the fruit (left) and within the fruit (right) (Dreves *et al*. 2009; BCMAL 2009). Note the distinct breathing structures exposed to the atmosphere.

3.4.2 Life cycle

After emergence, the adults typically become sexually mature in one to two days with a maximum of 13 days recorded (Kanzawa 1935; Kanzawa 1939). Adults live for 21–66 days and a female can oviposit 7–16 eggs per day with, on average, 384 eggs during her life in laboratory trials (Kanzawa 1939). More recent work has shown the average number of eggs laid per female over the first four weeks of oviposition ranges from 85–148 eggs and host influences the number of eggs laid (Brewer *et al*. 2011). A maximum of 160 eggs have been recorded to be laid in a day in cherry by a single female in trials by USA researchers (DAFF 2010). Eggs, larvae and pupae all vary in development time depending on the environmental conditions and generations over summer have the shortest development times. Eggs typically hatch in one day though they can hatch as quickly as 20 hours or take as long as four days (Kanzawa 1939). On average larvae take between 3 – 10 days to complete feeding and reach the pupal stage (Kanzawa 1939). The pupae require on average 4–14 days in the field to emerge as adults (Kanzawa 1939). The total development time from egg to adult ranges from 8–28 days in the field in Japan (Kanzawa 1935; Kanzawa 1939).

Under experimental conditions development time is directly dependant on temperature. Development time from egg to adult was from 21–25 days at 15 °C and 8–13 days at 25 °C (Kanzawa 1939). More recent laboratory trials in the USA report one generation can be completed in 12 days at 26 °C (Brewer *et al*. 2011) The short development time of *Drosophila suzukii* allows the fly to complete several generations in a season with up to 13 generations recorded in field conditions in Japan (Kanzawa 1939).

During autumn, as temperatures decrease, newly emerged *Drosophila suzukii* adults do not sexually mature and enter a winter diapause. When the temperature is below 5 °C, sexually mature adults can enter diapause and will not recommence activity until the following spring or when temperatures are suitable (Kanzawa 1939). Individual females can successfully oviposit hundreds of eggs prior to autumn, diapause through winter, and in the following spring, recommence oviposition. During this period females can live on average for over 200 days (maximum of 301 days) and oviposit, on average, 260 eggs during their lifespan (Kanzawa 1939).

In Japan and Italy, the eggs, larvae and pupae of *Drosophila suzukii* do not survive during winter, with adults considered to be the only over wintering stage (Kanzawa 1939; Rota-Stabelli *et al*. 2013). As the season warms, and temperatures increase above 10 °C, the adults that have over wintered become active from April to May in Japan (Kanzawa 1939; Sasaki and Sato 1995b). Initial infestation levels on cherries are low and fruit are generally attacked in the lower portion of the tree out of the wind (Kanzawa 1935), but infestation levels can quickly reach high levels. For example, the first ripe cherries picked in early June can have no symptoms of attack by *Drosophila suzukii* but infestations levels can quickly increase to 26–100% of the fruit by the first week of July due to the high reproductive potential of the fly (Sasaki and Sato 1995a). Although *Drosophila suzukii* typically oviposits eggs singly, when infestations are high many eggs can be laid into an individual fruit (Mitsui *et al*. 2006) and fruit throughout the tree can be attacked and infestation levels can be high (Kanzawa 1935). For example, 62 adults have emerged from a single cherry fruit (Kanzawa 1939). However, due to larval competition that results in small adults, the reproductive capacity of females that successfully emerge from highly infested fruit is likely to be very low (Kanzawa 1939; Takahashi and Kimura 2005).

3.4.3 Ecology

Female *Drosophila suzukii* preferentially oviposit on ripe fruit but will also oviposit on unripe and over-ripe fruit (Kanzawa 1939; Lee *et al*. 2011a, Brewer *et al*. 2012). On cherry fruit, the preferred oviposition period is two to three days before harvest (Kanzawa 1939). Larval development in ripe fruit is high and is lower in fruit of other stages of ripeness (Kanzawa 1939; Lee *et al*. 2011a). Larvae feeding in fruit that is very acidic fail to complete development (Kanzawa 1935). When females are given a host choice with *Prunus* spp., compared to cherry, oviposition occurs in peaches and plums at a rate of 27% and 9% respectively. Oviposition trials on wine and table grapes have shown oviposition does not occur on undamaged grapes with low sugar levels (Malguashca *et al*. 2010). Oviposition will occur on damaged fruit with low sugar levels but larvae develop poorly and fail to pupate (Malguashca *et al*. 2010). In contrast, under the same experimental conditions, undamaged fully ripe table grapes are attacked at higher levels (Malguashca *et al*. 2010) and table grapes are considered a host in Washington State, USA (TFREC 2010). Kanzawa (1939) recorded that different varieties of grapes sustained different levels of attack and considered skin thickness was the factor that limited oviposition. More recently, limited oviposition trials on some varieties of table grapes have shown low/no attack (USDA 2010) while other varieties have shown good levels of oviposition (e.g. on 'Thompson seedless', Bolda 2009; AWFG 2009; WSUE 2010). More recently, when *Drosophila suzukii* is given a choice between several hosts (e.g. raspberry, cherry, strawberry), 'Thompson seedless' were the least preferred host (Lee *et al*. 2011a). During the reproductive season for *Drosophila suzukii* in Yamanashi Prefecture in central Honshu, Japan, numbers of adults are greatest during early summer and autumn with a sharp decrease in numbers through the hottest period of summer (Kanzawa 1939; Mitsui *et al*. 2010). The decrease in adult numbers is unlikely to be due to a lack of host material; *Drosophila suzukii* can attack a range of hosts that fruit throughout the season in Japan (Sasaki and Sato 1995b). It is more likely that high temperatures lead to a decrease in adult numbers. For example, further north in Honshu, in Fukushima Prefecture, where mean maximum temperatures are several degrees cooler in summer (JMA 2010), the bimodal peak in *Drosophila suzukii* abundance during early summer and autumn has not always been observed (Sasaki and Sato 1995c). In 1993, the abundance of *Drosophila suzukii* on a range of hosts steadily increased through the reproductive season until a peak population was reached in autumn. However, in 1991 and 1992 in Fukushima Prefecture, when mean summer temperatures were 2–4 °C higher than 1993 (JMA 2010), numbers of *Drosophila suzukii* decreased during the hottest period of summer (Sasaki and Abe 1993). The work of Mitsui *et al*. (2010) has shown as the season becomes warmer *Drosophila suzukii* migrates from low to high altitude. The increase in the *Drosophila suzukii* population at altitude coincides with a decrease in the population at the lower (hotter) altitudes in midsummer (Mitsui *et al*. 2010). Since suitable fruit would be available at the lower altitudes during this period (Sasaki and Sato 1995b) the decrease in population is likely to be due to unfavourably high temperatures.

The development of *Drosophila suzukii* from egg to adult is affected by temperature with optimal conditions at 22–24 °C and no development occurs at temperatures above 31°C (Brewer *et al*. 2012). The negative effect of high temperature on adult mortality has been recorded experimentally where 75% of female *Drosophila suzukii* die at a constant temperature of 33.3 °C for 24 hours (Kimura 2004). Male flies are less tolerant of high temperature and 75 % mortality is reached at 32.6 °C (Kimura 2004). Higher temperatures have been shown to kill immature stages of *Drosophila suzukii* over several days when the maximum daily temperature is above 35 °C (Sasaki and Sato 1995b). Under laboratory conditions, adults will die if kept at 35 °C for three hours (Walton *et al*. 2010a) and pupae do not emerge if kept at temperatures of 32 °C or above (Sasaki and Sato 1995b).

In addition to the negative effects of high temperature, laboratory workers have observed the adults are extremely sensitive to low moisture/humidity (Van Steenwyk 2010). Adult flies will die under normal room conditions in 6–24 hours without a moisture source (DAFF 2010; Walsh *et al*. 2011; Kellermann *et al*. 2012). The sensitivity of *Drosophila suzukii* to low humidity is consistent with most other adult

Drosophila that require >70% humidity for successful reproduction (Ashburner *et al*. 2005).

Drosophila suzukii has established and spread in the hot climate of Florida (Black 2003; Snyder 2010). However, the initial population of *Drosophila suzukii* has been shown to be sensitive to temperature with peak trap captures occurring during winter when mean temperature is between 9 °C and 20 °C (Dean 2010). During the summer-autumn period, the activity of *Drosophila suzukii*, so far, is very low (Dean 2010; Dean *et al*. 2013). The typically higher summer rainfall and high humidity of Florida's climate (Black 2003; NOAA 2010) may assist *Drosophila suzukii* surviving periods of unsuitable high temperatures. In Japan, the relative humidity over summer is also typically high (JMA 2010) and this may assist *Drosophila suzukii* surviving high summer temperatures in sufficient numbers to reproduce successfully, as temperatures become favourable, and damage host fruit that ripens in autumn.

The combined effect of low humidity and high temperature is likely to be unfavourable to the survival and reproduction of *Drosophila suzukii*. For example, although *Drosophila suzukii* is prevalent in California, there are no reports of it damaging fruit in the lower central valley during the summer months. *Drosophila suzukii* has not been detected during phytosanitary inspections on table grapes exported to Australia from the central valley of California (USDA 2010). However, *Drosophila suzukii* has been recorded to attack damaged citrus during late winter and then very early cherries in mid to late spring in the central valley (Merced County 2010; Walsh *et al*. 2011; Caprile 2012) when the climate is more temperate (NCDC 2008; World Climate 2010). In summer, mean maximum temperatures exceed 35 °C and afternoon relative humidity is below 24 % for the lower central valley (based on data for Fresno:- NCDC 2008; World Climate 2010). From May to August, the number of days above 32 °C exceeds 8–25 per month in the central valley based on a 10 year average (USDA 2010). Further north in the central valley in San Joaquin County, the population of *Drosophila suzukii* follows a bimodal pattern with peak trap catches in late spring and another peak in autumn (Dalton *et al*. 2011; Brewer *et al*. 2012; Caprile 2012). Trap catches through summer continue but at lower levels (< 1 adult/trap/week; Dalton *et al*. 2011). The poor suitability of hot and dry climates is reflected by distribution models developed for North America based on the native distribution of *Drosophila suzukii* from Asia (Damus 2009).

In the related species, *Drosophila melanogaster*, increased adult desiccation resistance can be selected over many generations in laboratory trials (Bradley *et al*. 1999). The impact of increased desiccation resistance has not been tested on field populations of flies and whether this would lead to a change in their distribution or abundance. However, in India and Pakistan, *Drosophila suzukii* populations have only been recorded from higher elevations (see table 3.1) where the climate would be more temperate than lower hotter elevations. In southern India, *Drosophila suzukii* has been recorded from altitude (>500m) during the monsoon (Guruprasad *et al*. 2010; Guruprasad *et al*. 2011) when humidity is likely to be high. Later work has shown that the *Sophophora* taxonomic group (that *Drosophila suzukii* belongs to) has a low capacity for desiccation resistance and this capacity was lost early in their evolutionary development (Kellermann *et al*. 2012). The lack of adaption to desiccation may limit the ability of *Drosophila suzukii* to adapt to dry environments due to genetic constraints (Kellermann *et al*. 2012).

In Japan, adults were identified as the over wintering life stage, and at the end of the reproductive season in autumn as temperatures become progressively cooler, adults seek out over wintering sites under leaf litter and stones (Kanzawa 1939). The adult diapause over winter is not in response to day length and is reported to be in response to temperature (Toda 1979). Recent evidence from Florida indicates *Drosophila suzukii* can successfully reproduce during the middle of winter if temperatures are suitable (Dean 2010). For diapausing adults, over wintering survival can be affected by low temperatures where a constant temperature of –1.8 °C and –0.7 °C for 24 hours will kill 75 % of the females and males respectively (Kimura 2004).

In the USA, laboratory trials support the poor survival of *Drosophila suzukii* under cold conditions and that adults survive better than pupae (Dalton *et al*. 2011). The increased mortality of *Drosophila suzukii*, with decreasing temperatures for increasing periods, supports the concept that regions with extended winters will have increased mortality. The negative effect of severe winters on the population of *Drosophila suzukii* is supported by the increasing delay in *Drosophila suzukii* activity post winter from mild (California) to severe winter climates (Washington) (Dalton *et al*. 2011).

In Hokkaido, Japan, *Drosophila suzukii* is considered a domestic species associated with human habitation (Toda and Fukuda 1985). The species is believed to over winter in the colder north of Japan in sheltered human habitation sites, re-invading rural areas during summer. In Canada, *Drosophila suzukii* has been shown to be associated with grocery stores, fruit stands and outside a fruit packing house at the end of summer (BCMAL 2010); and in residential areas in late autumn after crops have been harvested (Fisher *et al*. 2010). Adults have also been trapped in packing houses in Washington and Florida, USA (WSUE 2010; Tri-ology 2011). In Oregon, field over wintering experiments have shown very low survival with only one adult in 1000 surviving until spring (DAFF 2010). More recently, adult over winter survival has shown be to higher depending on the experimental conditions (Walsh *et al*. 2011; Brewer *et al*. 2012). In over wintering trials in Japan, survival can vary from 0–23% and moisture may also play a role in the survival of adults during winter (Sasaki and Sato 1995b). In Oregon, USA, milder temperatures over winter (mean = 8.6 °C) allow some larvae (6%) and pupae to survive to adulthood (Walsh *et al*. 2011).

3.4.4 Host Damage

The oviposition scars and egg breathing tubes of *Drosophila suzukii* can be readily seen under magnification (x10–20) on smooth skinned fruit (see Figure 3.4) (Kanzawa 1939; DAFF 2010). *Drosophila suzukii* preferentially oviposits on mature fruit but can also oviposit on immature and spoiled fruit of suitable varieties at lower rates (Kanzawa 1939; Mitsui *et al*. 2006; Lee *et al*. 2001b).

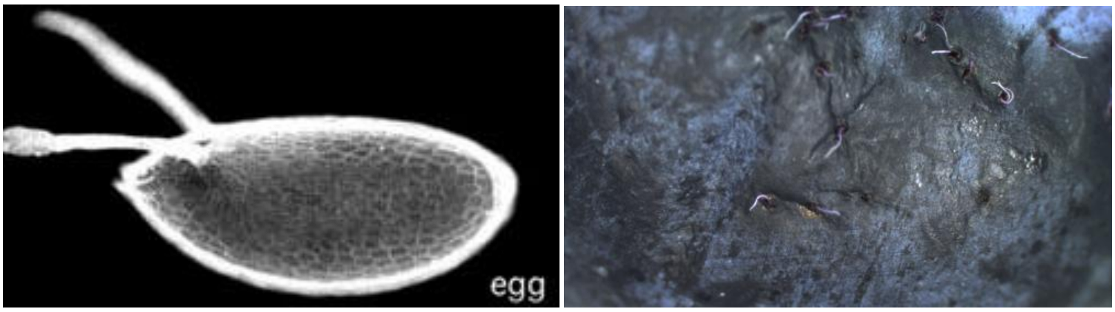

Figure 3.4: Eggs of *Drosophila suzukii*; removed from the fruit (left) and in blueberry fruit showing the white breathing tubes (right) (Hauser and Damus 2009; OSU 2010a).

The larval feeding of early instars causes the fruit to collapse around the oviposition scar, and if attack rates are high, the entire fruit can collapse (Figure 3.5). The oviposition scar exposes the fruit to secondary attack by pathogens and other insects (Figure 3.5) (Hauser and Damus 2009). The damage caused by *Drosophila suzukii* larvae renders the fruit unsuitable for sale (Bolda *et al*. 2010).

Figure 3.5: Initial larval damage of *Drosophila suzukii* showing collapse of fruit around oviposition point (left); larvae can be seen in a severely damaged blueberry (middle); secondary attack by pathogens (right) (Hauser and Damus 2009; OSU 2010a).

In its native range, *Drosophila suzukii* has been recorded to cause damage to a range of fruits including, cherry, grapes, blueberry and red bayberry (Kanzawa 1935; Kanzawa 1939; Sasaki and Sato 1995a; Tamada 2009; Uchino 2005; Kawase and Uchino 2005; Wu *et al*. 2007). It has also been recorded from mulberries, peaches, plums, strawberries and various caneberries (Kanzawa 1939; Sasaki and Sato 1995c). In North America, *Drosophila suzukii* has been recorded to cause damage to cherries, strawberries, blueberries and caneberries (Bolda 2009; Bolda *et al*. 2010; Coates 2009; Hauser *et al*. 2009). In addition, there have been media reports that commercial peaches have been attacked at high levels (CPAN 2009) and numerous other stone fruit, hardy kiwis and grapes have been recorded as hosts (Bolda 2009; Dreves *et al*. 2009; Hueppelsheuser 2009). In Europe, *Drosophila suzukii* has been recorded damaging strawberries, blueberries, raspberries, blackberries, cherries, stone fruit and other wild hosts (EPPO 2010a; Grassi *et al*. 2011).

Studies during the 1930's in Japan reported severe crop losses in some years and locations with crop losses of 100% for cherries and 80% for grapes (Kanzawa 1939). High levels of damage have also been recorded more recently from Japan with 26–100% of cherry fruit attacked in some locations (Sasaki and Sato 1995a). For grapes, more recent information confirms that certain varieties of wine and table grapes can be attacked by *Drosophila suzukii* (TPSAEC 2009; Van Steenwyk 2010; Pers. comm., Françoise Petter, EPPO, 22 December 2010; TFREC 2010; Lee *et al*. 2011a) and in high numbers in eastern USA in some instances (Demchak *et al*. 2011).

Kanzawa (1939) listed undamaged *Vitis vinifera* and *V. labrusca* (concord grapes) as hosts *of Drosophila suzukii.* However, at several points in Kanzawa (1939) the poor association of many varieties of grapes with *Drosophila suzukii* is listed. More recent reports also show differences between grape variety and host association with *Drosophila suzukii*. To more fully understand this association, the grape varieties considered by Kanzawa (1939) and other sources are listed in Table 3.2 with grape variety parentage based on information from the International Vitis Variety database. Oviposition is frequently recorded from varieties that have predominantly *V. vinifera* parentage. In contrast, varieties with *V. labrusca* as the sole parent have not been recorded to be an oviposition host for *Drosophila suzukii*. This information suggests a different risk of damage from *Drosophila suzukii* depending on *Vitis* spp. or parentage of a particular variety.

Table 3.2: Oviposition of *Drosophila suzukii* on grape variety

Variety	Oviposition	Parentage[2]	% *V. vinifera*
Black Hamburg	Yes (Kanzawa 1939)	*V. vinifera*	100
Herbert	Yes (Kanzawa 1939)	Schiava grossa (*V. vinifera*): x Carter (=Isabella (*V. labrusca* x *V. vinifera*))	75
Golden Queen	Yes (Kanzawa 1939)	Black Alicante (*V. vinifera*): x Ferdinand de Lesseps (=Chasselas de blanc (*V. vinifera*) x Isabella *V. labrusca* x *V. vinifera*)	75
Gros Coleman (=Gros colman)	Yes (Kanzawa 1939)	*V. vinifera*	100
Muscat of Alexandra	Yes (Kanzawa 1939)	*V. vinifera*	100
Muscat of Hamburg	Yes (Kanzawa 1939)	*V. vinifera*	100
Foster's seedling	Yes (Kanzawa 1939)	*V. vinifera*	100
Rose de Italy (=Italia rossa?)	Yes (Kanzawa 1939)	*V. vinifera*	100
Kyoshin	Yes (Kanzawa 1939)	Unknown	-
Thompson seedless	Yes (Lee *et al*. 2011a)	*V. vinifera* subsp *vinifera*	100
Black manuka[b] (=monukka)	Yes (WSUE 2010)	*V. vinifera*	100
Perlette[b]	Yes (WSUE 2010)	*V. vinifera*	100
Genora[b](=Glenora?)	Yes (WSUE 2010)	(For Glenora) Ontario (=Wichell (*V. vinifera* x *V. labrusca*) x Diamond = concord (*V. labrusca*) x Iona = Diana	69

[2] Source: Julius Kuhn Institute, Vitis International Variety Catalogue: http://www.vivc.de/

Variety	Oviposition	Parentage[2]	% *V. vinifera*
		= Catawba (*V. vinifera* x *L. labrusca*): x Russian seedless = Kishmish Chernyi (*V. vinifera*)	
Koshu[c]	No (Kanzawa 1939)	*V. vinifera*	100
Delaware[c]	No (Kanzawa 1939)	*V. vinifera*: x (*V. labrusca* x *V. aestvalis*)	50
Chasselas de Fontainbleau	No (Kanzawa 1939)	*V. vinifera*	100
Golden champion	No (Kanzawa 1939)	*V. vinifera*	100
Concord	No (Kanzawa 1939)	*V. labrusca*	0
Eaton	No (Kanzawa 1939)	*V. labrusca*	0
Kogyoku	No (Kanzawa 1939)	unknown	-
White Malaga	No (Kanzawa 1939)	*V. vinifera*	100
Cole lane (=colesvine?)	No (Kanzawa 1939)	*V. labrusca* x *V. vinifera*	50
Pergence (?)	No (Kanzawa 1939)	unknown	-
Brighton	No (Kanzawa 1939)	Diana Hamburg (= Diana (*V. vinifera* x *L. labrusca*)): x Schiava grossa (*V. vinifera*)	75
Brilliant	No (Kanzawa 1939)	Lindley (= carter = Isabella (*V. labrusca* x *V. vinifera*)) x white chasselas (*V. vinifera*): x Delaware (*V. vinifera* x (*V. labrusca* x *V. aestivalis*)).	63
Lenoir	No (Kanzawa 1939)	*V. aestivalis* x *V. vinifera* or *V. bourqiniana* Munson	50 or nil
Niagara	No (Kanzawa 1939)	Concord (*V. labrusca*) x Cassady (*V. labrusca*)	0
Hosters seedling (=Hosfords seedling?)	No (Kanzawa 1939)	*V. labrusca*	0
Kyoho	No (Kanzawa 1939)	Ishihara wase (= Campbell early mut. = Moore early (*V. labrusca*): x (Belvidere (*V. labrusca*) x Muscat Hamburg (*V. vinifera*)) x Centennial (*V. vinifera*).	37
Mars[a]	No (WSUE 2010)	Island Belle (= Pukhlyakovskii (*V. vinifera*) x Arkansas (=*V. labrusca*?)	50?
Suffolk red[a]	No (WSUE 2010)	Fredonia (*V. labrusca*) x Kishmishi Chernyi (*V. vinifiera*)	50
Reliance[a]	No (WSUE 2010)	Ontario (=Wichell (*V. vinifera* x *V. labrusca*) x Diamond = concord (*V. labrusca*) x Iona = Diana = Catawba (*V. vinifera* x *L. labrusca*): x Suffolk red (Fredonia (*V. labrusca*) x Kishmishi Chernyi (*V. vinifiera*)).	44
Early Campbell	No (Malguashca *et al*. 2010)	Moore early (*V. labrusca*): x (Belvidere (*V. labrusca*) x Muscat Hamburg (*V. vinifera*))	25

a. Variety resembles *V. labrusca* (Hemphill *et al*. 1992)
b. Considered to be thin skinned (WSUE 2010)
c. Variety with thick skin and oviposition is considered impossible (Kanzawa 1939)

In blueberries, *Drosophila suzukii* is considered the most important pest in Japan (Tamada 2009; Kawase and Uchino 2005). In the USA, damage to cherries of 80% have been recorded in one locality (ODA 2009) and there are reports of maximum damage of 40% in blueberries and 70% in caneberries (Bolda *et al*. 2010). Many of the reports for stone fruit damage are from speciality crop gardeners and pick your own fruit producers that do not produce fruit for export (USDA 2010) although some species of stone fruit are still considered preferred hosts in commercial crops (e.g. peaches, nectarines and apricots) (Shearer *et al*. 2010; Acheampong 2011a). The application of insecticides to control *Drosophila suzukii* is recommended in commercial stone fruit (Acheampong 2011a; BCMA 2011; Shearer 2010–update November 2011; Bush *et al*. 2012; Bush and Bell 2012; Olsen and Bell 2012). In Europe, *Drosophila suzukii* has been confirmed from peach and apricot in Corsica (EPPO 2011); attacking unripe and commercially ripe apricots in Italy (Grassi *et al*. 2011); apricots and peaches in France (Weydert 2011) and peaches in Spain (Escudero *et al*. 2011). In Canada (British Columbia), apricots, peaches, plums and nectarines have been confirmed as hosts (Acheampong 2011b, BCMA 2011).

In contrast to the reports of damage in temperate areas, there are no reports of commercial fruit damage in sub-tropical regions where *Drosophila suzukii* has established. For example, *Drosophila suzukii* has been recorded from Hawaii since 1980 (Kaneshiro 1983) and it is reported to be the most ubiquitous Drosophilid on the island of Kauai (Asquith and Messing 1992), but there is no report of damage to commercial fruit. In Florida, although *Drosophila suzukii* has been trapped near preferred hosts (e.g. strawberry), negligible levels of infestation have been recorded, and there are no reports of economic damage (Pers. comm., Dr David Dean, FDACS, 2 Sept. 2010; Dean *et al*. 2013). As discussed above, unfavourable high temperatures may play a role in limiting *Drosophila suzukii* populations in sub tropical regions.

Another factor that may be limiting *Drosophila suzukii* in Florida could be competition from another *Drosophila* species (Dean *et al*. 2013). *Drosophila melanogaster* is a tropical species (Pool and Aquadro 2006) that is well established in Florida and was consistently recorded at levels 100-fold higher than *Drosophila suzukii* from field collected strawberries. Under preliminary laboratory rearing trials *Drosophila melanogastor* outcompeted *Drosophila suzukii* (Dean *et al*. 2013).

3.4.5 Control

In Japan, a range of pre harvest control methods including trapping, pesticides, oviposition deterrents and fumigation have been trialled (Kanzawa 1939). The initial results showed trapping with a suitable attractant was effective at capturing large numbers of *Drosophila suzukii*. A trapping trial using very high numbers of traps conducted over large areas (24 hectares) at several locations over a four year period, showed a mixture of diluted molasses and wine, trapped large numbers of flies and resulted in an average infestation rate of fruit by *Drosophila suzukii* of 3.2 % (based on a summary of the data in Kanzawa 1939). Trapping is most effective if in place when host fruit are unripe and before they are oviposited by adults that have over-wintered (Kanzawa 1939). Over the same period, at several sites where trapping was not instigated, average infestation rate was 50.8% (based on a summary of the data in Kanzawa 1939). The conclusion of the study was trapping was cost effective and a suitable method of controlling *Drosophila suzukii* in cherries. Mass trapping trials have also been conducted in Italy and were considered to contribute to a reduction in damage by *Drosophila suzukii*, particularly in combination with an integrated management system (Grassi *et al*. 2013). Mass trapping on its own was not considered to be effective where pest pressure was high (Grassi *et al*. 2013).

Covering fruiting plants with a net has also been recommended in Japan to control damage by *Drosophila suzukii* (Kawase and Uchino 2005). A mesh size of <0.98mm has been shown to prevent all adult flies from passing through a protective net.

In North America initial control strategies have been based on the work of Kanzawa (1939) and methods for trapping *Drosophila suzukii* are summarized on the Oregon State University website. There are also recommendations for monitoring and pesticide application, using a range of contact and persistent insecticides that target adult flies with crop sanitation playing a key part of the control strategy (Dreves *et al*. 2009; OSU 2010d; Van Steenwyk 2010). The Oregon State University (OSU) is leading a collaborative research effort to understand the biology of *Drosophila suzukii* and develop control strategies. The latest information for this pest can be found at the OSU website; http://swd.hort.oregonstate.edu/.

Monitoring was initially recommended using fermented fruit baits such as apple cider vinegar (OSU 2010a). However, the latest advice is monitoring using apple cider vinegar traps are not effective at capturing adults from more than short distances (OSU 2012). Traps baited with yeast and sugar consistently trap more adults compared to apple cider vinegar (Brewer *et al*. 2012; Isaacs 2012). However, traps baited with sugar and yeast performed less well at cold temperatures, can be more unpleasant to work with and attract higher numbers of non target insects (Barrantes-Barrentes and Walsh 2012; Brewer *et al*. 2012). Work continues on developing better baits (such as combining vinegar and wine) and trap structures (such as colour, shape, and area of opening for access) to increase the detection efficacy and selectivity of traps and improve monitoring efforts (Landolt *et al*. 2012a & b; Brewer *et al*. 2012; Lee *et al*. 2012). The recent report that *Drosophila suzukii* has a high association with species of yeast may lead to the development of a more selective trap (Hamby *et al*. 2012). Further work on identifying individual components of fruit attractants may lead to more selective and powerful baits (Revadi *et al*. 2012). A pheromone lure has not been developed.

In Santa Cruz County, California, where *Drosophila suzukii* was first recognised as a pest, trapping numbers during 2010 remained very low, and below the levels recorded in 2008 and 2009 (Bolda 2009). It is believed the broad adoption of recommended management methods for *Drosophila suzukii* have contributed to the recorded decline in pest numbers (Bolda 2009).

Experimental work in the USA has tested several insecticides to confirm their efficacy. Organophosphates, pyrethroids and spinosyns have shown good contact or residual activity against *Drosophila suzukii* in laboratory and field studies on raspberry, strawberry, blueberry, grape and cherry (Beers *et al*. 2011; Bruck *et al*. 2011). Management recommendations include the application of at least two insecticides before harvest. It is recommended that insecticides with different modes of action are used in rotation to manage insecticide resistance because of the presence of multiple generations of *Drosophila suzukii* each growing season (Bruck *et al*. 2011). Later work incorporates the export market maximum residue limits in fresh produce into recommendations for effective insecticide use (Haviland and Beers 2012).

Drosophila suzukii has recently been confirmed to host a *Wolbachia* endosymbiont (*w*Suzi) that is closely related to a taxon that is associated with *Drosophila simulans* (Siozios *et al*. 2013). Manipulation of the *Wolbachia* endosymbiont association may promote the management of *Drosophila suzukii* by limiting successful reproduction through cytoplasmic incompatibility (Kaur *et al*. 2013).

During the 2010 export season from the USA to all markets there were no detections of *Drosophila suzukii* in commercially produced export fruit for strawberry, cherry, stone fruit and table grapes (USDA 2010). Targeted control strategies are considered to manage *Drosophila suzukii* in strawberries, cherries from California and the Pacific North West states (PNW) and stone fruit from the PNW (USDA 2010). No specific in-field control strategies have been recommended for Californian table grapes as *Drosophila suzukii* has not been associated with this commodity (USDA 2010). Phytosanitary inspections by USA authorities have not detected *Drosophila suzukii* in commercial quantities of fruit for strawberry, cherry, table grapes and stone fruit (USDA 2010). However, some of the detection methods (fruit cutting, visual detection without magnification, etc) will not be effective at detecting some life stages of *Drosophila suzukii* on certain types of fruit.

More recently, *Drosophila suzukii* has been detected in commercially produced cherries at packing houses in the USA (WSUE 2012b). Country specific information on host association could be used bilaterally to support and develop suitable phytosanitary risk management measures.

4 Pathways

The initial information of *Drosophila suzukii* in North America has led to many reports of this pest attacking a large variety of fresh fruits. The known host range of *Drosophila suzukii* has been confused by the initial pest alerts and the numerous media reports of the pest attacking a large number of hosts. In this PRA report, two pathways are identified for *Drosophila suzukii* to enter Australia, fresh fruit and fresh flowers.

4.1 Pathway – Fresh Fruit

The original research on *Drosophila suzukii* in Japan showed the host range, on intact undamaged fruit, is much narrower than on damaged, dropped or artificially cut fruit (Kanzawa 1935; 1939). The confirmed host range of *Drosophila suzukii* on undamaged commercial fruit prior to harvest includes 41 taxa (species, varieties and hybrids) from 10 families (see Appendix B). Another eight species from the *Prunus* and *Rubus* genera are suspected to be hosts based on the high association of *Drosophila suzukii* with other species in those genera. An additional 54 taxa are recorded as hosts when the fruit is damaged, over ripe, from backyard and unmanaged environments, or where larvae do not complete development (Appendix B). Damaged and over ripe fruit from diverse families such as Rutaceae and Musaceae (citrus and bananas) have been recorded to be attacked (Price and Nagle 2009).

The status of apples and pears as hosts of *Drosophila suzukii* has been under particular scrutiny by domestic stakeholders. For example, stakeholders lodged appeals with the Import Risk Analysis Appeals Panel when DAFF did not list apple as a host for *Drosophila suzukii* in the import risk analysis (IRA) report for apples from China. On 24 June 2010, the Senate of the Parliament of Australia referred the issue of the IRA process for the proposed importation of Chinese apples into Australia, to the Senate Standing Committee on Rural and Regional Affairs and Transport. The issue of apple as a host for *Drosophila suzukii* was a major concern raised by stakeholders that appeared before the Senate inquiry public hearing (RRA&T 2010). These concerns were based on the original pest alerts from the USA that listed apple as a host (Dreves *et al*. 2009; ODA 2009; Steck *et al*. 2009) and the USA Animal and Plant Health Inspection Service (APHIS) pest alert (APHIS 2010). As discussed below, these references have now been shown to be erroneous.

Officers from DAFF travelled to the USA in May 2010 to verify the status of *Drosophila suzukii*, including its host range. During this trip, the officers met with key researchers studying *Drosophila suzukii*, including the authors of a number of pest alerts from Oregon. The researchers confirmed that there have been no reports of undamaged apples and pears being attacked by *Drosophila suzukii*. The researchers advised that apple and pear were mistakenly listed as hosts in the pest alerts on the basis of the English translation of an abstract of a paper written in Japanese, containing original research on *Drosophila suzukii*. In the main body of Kanzawa (1939), it is clarified that only damaged or cut apples and pears had been observed to host *Drosophila suzukii*. USA researchers have since revised their pest alerts and presentations and APHIS have reconfirmed that only damaged apples are recorded as a host (ODA 2010a; OSU 2010b; BA 2010a).

The DAFF officers have also been in contact with researchers in the USA who specialise in pome fruit horticulture. They have confirmed that there have been no reports of undamaged apples or pears being attacked, even where *Drosophila suzukii* was prevalent in apple growing areas (DAFF 2010; Pers. comm., Janet Caprile, Farm Advisor, Contra Costa County, 26 June 2010). The researchers concluded that the skin of apples or pears is too thick for *Drosophila suzukii* to penetrate and that it therefore cannot successfully attack undamaged commercial quality apple and pear fruit. Subsequently, the USA Agricultural Research Service (ARS) confirmed they have exposed apples to gravid females and failed to record oviposition (BA 2010b). *Drosophila suzukii* is native to Asia and was first reported from Japan in 1916 (Kanzawa 1935). There are no reports of this pest attacking undamaged apple fruit where *Drosophila suzukii* is abundant in major apple growing regions in Japan (Sasaki and Abe 1993; Sasaki and Sato 1995a, 1995b & 1995c; Apple University 2009) even though it has been recorded near apple orchards (Ookuma and Beppu 1987). There are no records of any infestation or damage on commercial apples or pears in any area where *Drosophila suzukii* occurs.

Canada's North American Plant Protection Organisation pest notification, and the Canadian Food Inspection Agency's (CFIA) draft Plant Health Risk Assessment for *Drosophila suzukii*, list pear as a host (NAPPO 2010a; CFIA 2010). Plant Biosecurity contacted the officer who prepared that risk assessment and they confirmed the host range was based on recent advice from a colleague in Japan. The CFIA officer then requested clarification from his colleague and they confirmed only damaged pear fruit was attacked (Pers. comm., Martin Damus, CFIA, 22 April 2010). The status of intact pear as a non host for *Drosophila suzukii* is supported by there being no records of pears damaged in the field by this pest and the original Japanese research that shows only cut fruit are hosts (Kanzawa 1939).

A publication from the USA that was first released online in 2010, listed pears as a host of *Drosophila suzukii* without clarification on the state of the fruit or level of association (Walsh *et al*. 2011). On contacting the authors they confirmed only over-ripe pears are attacked by *Drosophila suzukii* (Pers. comm. Dr Vaughn Walton, OSU, 13 October 2010).

Table 4.1: Fruit host groupings[1] considered as pathways for *Drosophila suzukii*

Family	Grouping	Fruit Commodity (examples)	Consider further	Group
Rosaceae	*Rubus* spp. (caneberry)	Raspberry	**Yes**	**1**
		Blackberry		
		Boysenberry		
		Loganberry		
	Prunus avium	Cherry	**Yes**	**2**
	Prunus spp. (Stone fruit etc)	Peach	**Yes**	**3**
		Nectarine		
		Apricot		
		Plums		
		Hybrids–plumcots, pluots etc		
		Other *Prunus* spp.		
	Fragaria spp.	Strawberry	**Yes**	**4**
Ericaceae	*Vaccinium augustifolium, Vaccinium corymbosum and Vaccinium myrtillus*	Blueberry and bilberry	**Yes**	**5**
Grossulariaceae	*Ribes* spp.	Red and black currants	**Yes**	**6**
	RIbes uva-crispa	Gooseberry		
Vitaceae	*Vitis vinifera*	Grapes	**Yes**	**7**
	Vitis labrusca			
Moraceae	*Ficus carica*	Figs	**Yes**	**8**
	Morus alba, Morus rubra, Morus australis and Morus nigra	Mulberry		
Actinidaceae	*Actinidia arguta*	Hardy kiwi	**Yes**	**9**
Myricaceae	*Myrica rubra*	Red bayberry	**Yes**	**10**
Elaeagnaceae	*Elaeagnus multiflora*	Silver berries		
Cornaceae	*Cornus kousa*	Dogwood		
Phytolaccaceae	*Phytolacca americana*	American pokeweed		

1. Groupings based on host association of *Drosophila suzukii* in Appendix B, taxonomic relatedness and/or production methods.

The undamaged fruit of 24 of the 41 taxa currently known to be hosts of *Drosophila suzukii* are from the Rosaceae family. An additional eight species in the family are suspected to be hosts as they have been reared from fallen and wild grown fruit where the status of the fruit is not known. Full details of the association are provided in Appendix B. There are over 300 genera in the Rosaceae (Tropicos 2010). There are 24 other host plant families that typically have only one or a few host taxa each (Appendix B). The exception being Ericaceae, Moraceae and Cornaceae that have six or seven recorded species associated with *Drosophila suzukii*. Host fruit that are further considered in Appendix B are summarised in Table 4.1. The risk of entry of *Drosophila suzukii* through infested fruit is the first pathway considered, for the ten fresh fruit commodity groups, during the pathway analyses.

The recorded host range of *Drosophila suzukii* has continued to increase and an additional 41taxa, including fruits from six new plant families, are considered to be associated with *Drosophila suzukii* since the draft PRA report was released in October 2010. The majority of these are from non-commercial fruit (backyard, wild hosts) where the state of the fruit is not known. These fruit are not commercially produced and there is currently no import conditions for these fruit. An exception is a single report of cranberry as a host from commercial fruit with no details about this association (Demchak *et al*. 2012). Import conditions exist for cranberries from New Zealand where *Drosophila suzukii* is not known to occur. However, there is a laboratory trial that reports cranberry at any stage of ripeness is not an oviposition host (Brewer *et al*. 2012). As import conditions do not exist for cranberries from countries where *Drosophila suzukii* occurs, and what information available is contradictory, a pest risk assessment will not be conducted at this time.

DAFF will continue to monitor the host range of *Drosophila suzukii*, and if new information becomes available, that affects host range or association, appropriate risk management measures will be recommended as necessary. For fruits where an association has already been identified (see appendix B), and an assessment has not been conducted in this PRA, the latest available information will be considered before imports of these potential hosts can occur.

4.2 Pathway – Fresh Flowers

It has recently been reported that *Drosophila suzukii* adults can successfully emerge from flowers of *Styrax japonicus* and *Camellia japonica* (Mitsui *et al*. 2010; Damus 2010a). Fresh cut flowers of *Styrax japonicus* and *Camellia japonica* are not permitted entry to Australia. Nursery stock of both species is permitted entry (Table 1.2). The importation of nursery stock with flowers, or fresh cut flowers, from countries where *Drosophila suzukii* is known to occur, could allow the importation of *Drosophila suzukii* into Australia.

The risk of entry of *Drosophila suzukii* through infested flowers is the second pathway considered during the pathway analyses.

5 Risk assessments for pathways

Drosophila suzukii is not present in Australia, has the potential for establishment and spread and economic consequences in Australia and therefore meets the criteria for a quarantine pest (Appendix A).

The risk assessments in this section focus on the fruit and flower pathways identified for the potential introduction of *Drosophila suzukii* in section 4 (see table 4.1). The analysis for the importation of fresh fruit is based on a generic assessment. Commodity specific information that may impact on the risk assessment is also presented. An individual likelihood rating is considered for each commodity grouping or species where it is considered appropriate.

The likelihood of distribution for the fruit pathways is considered under a generic assessment. The assessment approach is considered appropriate given that the survival of *Drosophila suzukii* is similar across its host range and because of the similar requirements for the handling and distribution of fresh fruit commodities.

A single assessment for the importation and distribution of fresh flowers (including nursery stock) has been conducted.

The probability of establishment and spread, and the consequences of *Drosophila suzukii's* establishment are not specifically linked to the pathway by which the pest might enter Australia. This is because the pathway of establishment considers factors only after the pest has transferred to a susceptible host in the PRA area. Therefore, the probability of establishment and spread, and the consequences of *Drosophila suzukii* have been assessed only once and the outcomes applied to all the pathways considered.

5.1 Pathway 1 – Fresh fruit

5.1.1 Probability of entry

Probability of importation

The likelihood that *Drosophila suzukii* will arrive in Australia with the trade in fresh fruit for consumption in a viable state from countries where the pest is present:

Caneberries (*Rubus* spp.)	**HIGH**
Cherry (*Prunus avium*)	**HIGH**
Stone fruit (*Prunus* spp.)	**HIGH**
Strawberry (*Fragaria* x *ananassa*)	**HIGH**
Blueberry (*Vaccinium* spp.)	**HIGH**
Table grapes (*Vitis vinifera*)	**MODERATE**
Concord grapes (*Vitis labrusca*)	**VERY LOW**
Hardy Kiwi (*Actinidia arguta*)	**LOW**
Mulberry (*Morus* spp.)	**HIGH**
Figs (*Ficus carica*)	**HIGH**

Currant and Gooseberry (*Ribes* spp.)	**LOW**
Other recorded fresh fruit hosts	
– Dogwood (*Cornus kousa*)	**MODERATE**
– Red Bayberry (*Myrica rubra*)	**MODERATE**
– Silverberries (*Elaeagnus multiflora*)	**MODERATE**
– Pokeweed (*Phytolacca americana*)	**MODERATE**

Introduction

- *Drosophila suzukii* is known to attack a range of fresh fruit (Appendix B). Three life stages (eggs, larvae and pupae) are internally associated with the fruit (Kanzawa 1939; Dreves *et al*. 2009; Lee *et al*. 2011a).
- *Drosophila suzukii* preferentially oviposits on fruit two to three days before harvest and one to several eggs (or more) can be oviposited per fruit (Kanzawa 1939). Under laboratory conditions, oviposition rates are positively linked to increasing fruit ripeness (Lee *et al*. 2011a). It is likely eggs and larvae would be associated with fruit at harvest.
- The eggs of *Drosophila suzukii* are small (<0.7 mm long by 0.2 mm wide) and they are oviposited below the surface of fruit (Kanzawa 1939; OSU 2010a). *Drosophila suzukii* eggs have two white respiratory tubes, approximately 0.7 mm long, that protrude through the oviposition scar to the outside of the fruit (Kanzawa 1939; Uchino 2005). The small size of the respiratory tubes makes them difficult to see with the naked eye.
- Although *Drosophila suzukii* preferentially attacks fruit prior to harvest, they also attack harvested fruits (Kanzawa 1939) and have been reported in association with packing houses in Canada and the USA (BCMAL 2009; WSUE 2010). Consequently, there is a risk of *Drosophila suzukii* adults being associated with fresh fruit in packing houses.
- The initial feeding damage of larvae in the fruit is small, typically seen as a small depression of the skin, that could easily be over looked (OSU 2010a) particularly for fruits with uneven surfaces (Lee *et al*. 2011a). This would allow infested fruit to enter the packing house and escape detection during the sorting and grading of fruit.
- Total development times from egg to adult can range from to 25 days at 15 °C and eight to 13 days at 25 °C (Kanzawa 1939). Fresh fruit are highly perishable so short transport periods are preferred. Although the current distribution of *Drosophila suzukii* is restricted to the northern hemisphere (table 3.1) transport by air could mean the time between harvest to arrival in Australia is as short as 48 hours. Eggs, larvae or pupae could still be completing development within the fruit.
- Eggs and larvae of *Drosophila suzukii* have been shown to be susceptible to cold (Kanzawa 1939). At temperatures in the range of –0.6 – $^{+}$2.2 °C, 5.5% of the eggs and larvae, survived for 72 hours but at 96 hours all eggs and larvae were dead (Kanzawa 1939). Although cold storage could increase mortality of *Drosophila suzukii* in fruit, the only study published was preliminary, included only limited

replication, did not replicate commercial conditions and was conducted at temperatures typically lower than those used in commercial shipping and storage of fruit (Bolda 2009; Woolworths 2010).

- Adult *Drosophila suzukii* can successfully diapause over winter, and in the following spring become sexually active. During this period females can live on average for over 200 days (maximum of 301 days) (Kanzawa 1939). The ability of adults to survive cold conditions for extended periods could allow them to survive fruit transport conditions which are most likely to be at temperatures between 0 – 13 °C (Woolworths 2010).
- *Drosophila suzukii* has recently invaded North America and Europe and the likely source of the introduction was attributed to the trade in fresh fruit (NAPPOa 2010; NAPPOb 2010; EPPO 2010c; EPPO 2011).
- In the USA, it is considered very likely the domestic movement of fruit will spread this pest to many other states within the country (Hauser *et al*. 2009; ODA 2010a).
- In the USA, even though trapping and management occurs in orchards that limits commercial damage, fruit infested by *Drosophila suzukii* can still be found (OSU 2010c; WSU 2012).

Caneberries (*Rubus* spp.)

- Monitoring programs in the Northwest of the USA and Canada show trap catches in *Rubus* spp. orchards are high and they are a preferred host for *Drosophila suzukii* (OSU 2010b; OSU 2010c; BCMAL 2010; Peerbolt 2010). Research shows that exposed ripe fruit are preferentially attacked with 5% of pink fruit, and 80% of ripe fruit, containing eggs (Walsh *et al*. 2011).
- In the USA in 2009, damage levels have been recorded to average 20% in the central coast region of California with around 10% of producers recording losses of 70% (Bolda *et al*. 2010).
- In Oregon, in commercial blackberry, which received between 3–5 insecticide applications, 80% of fields sampled recorded infested fruit in 2011 and 50% of fields sampled had infested fruit in 2012 (Todd 2013). In a field sprayed with insecticides, infestations rates of *Drosophila suzukii* per berry varied from 0.02 to 0.3; and in an unsprayed field, infestation rates ranged from 2–14 per berry (Todd 2013).
- In eastern USA, raspberries are attacked at a higher rate than blackberries in field crops and under cover in high tunnels (Burrack *et al*. 2013). For crops produced with a weekly insecticide application, the mean number of *Drosophila suzukii* per berry for 2011 and 2012 was 0.25 and 1.2 for blackberry and 0.9 and 2.84 for raspberry, respectively.
- In Italy, 60–100% of raspberry fruit sampled at the right commercial ripening stage (pink/red colour) in some untreated plantations during September–October, were infested by eggs (Grassi *et al*. 2011). For blackberry and raspberry orchards applying insecticides, infestations levels across the season could still be in the range of 20–100% (Grassi and Pallaoro 2012).

- Damage to commercial crops has been recorded in France (Weydert 2011) and Slovenia (Seljack 2011).
- The uneven surface and hairs of *Rubus* spp. fruit will make the visual detection of eggs and respiratory tubes more difficult compared to smooth skinned fruit (DAFF 2010; Lee *et al*. 2011a).

The demonstrated association of the pest with the pathway at its origin, presence of internal life stages that can be very difficult to detect by the naked eye, and its ability to survive the duration of transport support a probability rating of 'high' for the importation of *Drosophila suzukii* on fresh fruit of caneberries.

Cherry (*Prunus avium*)

- Monitoring programs in the Northwest of the USA show trap catches in cherry orchards are high and they are a preferred host for *Drosophila suzukii* (OSU 2010b; OSU 2010c; Peerbolt 2010).
- *Drosophila* larvae have been intercepted in commercial cherries exported from California to Florida and it is suspected they were *Drosophila suzukii* (Tri-ology 2009).
- *Drosophila suzukii* larvae in cherries, reportedly from homegrown fruit from Oregon, have been intercepted at California's border stations. Larvae have also been intercepted in cherries at the Californian border, from other states in the USA (Colorado & Washington) and from Canada (British Columbia & Alberta), that are consistent with *Drosophila suzukii* DNA. However, the actual origin of these intercepted cherries has not been confirmed (Hoffman 2009).
- Fruit infested with larvae have been detected at packing houses in Washington State, USA (WSU 2012) and there is a report of over 10 % of early fruit has been damaged in eastern Washington State (WSUE 2012a).
- One to several eggs, or higher, can be oviposited per fruit and in Japan infestation levels of cherry fruit in orchards can regularly be over 50% and even reach 100% during the harvest period (Kanzawa 1939; Sasaki and Sato 1995a). In the USA, yield losses of 33% to 80% have been recorded in some localities and over a wide area of cherry production areas in California (Bolda *et al*. 2010; ODA 2010a; Walsh *et al*. 2011).
- *Drosophila suzukii* larvae in cherries, reportedly from homegrown fruit from Oregon, have been intercepted at California's border stations (Hoffman 2009).
- In Italy, infestation occurs in May at low levels (3%) and steadily increases through harvest to reach infestations of 46% in July. Infestation levels were still high even if adult abundance was low (Grassi and Pallaoro 2012).
- In Italy, up to 90% of late harvest cherries were infested with *Drosophila suzukii* from orchards where insecticides had been applied at the reddening of the fruits to manage *Rhagoletis cerasi* (Grassi *et al*. 2011).
- In France, yield losses have been recorded to be from negligible to 90–100% (Weydert 2011). In Spain, up to 100% damage has been reported in commercial crops (Escudero *et al*. 2011).

The demonstrated association of the pest with the pathway at its origin, presence of internal life stages that can be very difficult to detect by the naked eye, and its ability to survive the duration of transport support a probability rating of ‘high’ for the importation of *Drosophila suzukii* on fresh cherry fruit.

Stone fruit (*Prunus* spp.)

- One to several eggs (or higher) can be oviposited per fruit though oviposition rates on stone fruit are only 9–27% compared to cherry in laboratory trials (Kanzawa 1939). Damaged fruit in orchards have been recorded for nectarines, peaches, plums and plumcots (Coates 2009; Coates 2010; Dreves *et al* 2009; Sasaki and Sato 1995c; BCMAL 2010). Infestation levels can be high enough in peaches to result in levels of damage ranging from 20–80% although some of these reports are from unmanaged orchards (CPAN 2009; Dreves *et al*. 2009; ODA 2010a; USDA 2010).

- In the PNW of the USA, peaches are considered a preferred host with infestation reported and nectarines, plums and plumcots are considered secondary hosts for *Drosophila suzukii* (OSU 2010b). Later information recommends commercial peaches should be sprayed with insecticides to manage *Drosophila suzukii* (Shearer 2011; Bush et al. 2012).

- In eastern USA, *Drosophila suzukii* larvae have been detected in peaches from orchards that were unsprayed or in peaches lightly sprayed with insecticides (Polk *et al*. 2012).

- Under controlled multiple choice experiments that included preferred hosts such as caneberries and cherry, when *Drosophila suzukii* was presented peaches (commercially grown in the central valley of California) for oviposition, it was a poor host for oviposition (Bellamy *et al*. 2013). From the limited level of infestation, no larval emergence occurred. However, the study noted that no emergence occurred from 40% of fruit infested, including those the study identified as having a high host potential index (e.g. preferred host) (Bellamy *et al*. (2013).

- In contrast, larval performance was highest when development occurred in growth media based on peach fruit (Bellamy *et al*. 2013). It is not clear if oviposition levels and adult emergence would be different under no-choice experiments. Further information to clarify host association may allow country specific import conditions to be developed.

- In Canada, it is strongly recommended to spray peaches, nectarines, plums and prunes to prevent fruit infestation (BCMAL 2010). Later information confirmed commercial peaches, nectarines and plums are hosts in Canada (BCMA 2011; BCMA 2012).

- In the USA, apricots were considered a less preferred host and attack has only been recorded when fruit is very late season, over-ripe or damaged (Coates 2009). There is a media report quoting a local agricultural official that apricots are being attacked by *Drosophila suzukii* in Corsica, France (Corsematin 2010) although it was later reported that there was no larval infestation with only adults recorded in the orchard (USDA 2010). However, later information reports apricots are a host in Corsica (EPPO 2011).

- More recently, commercial apricots have been confirmed as a host in North America (Shearer *et al*. 2010; BCMA 2011; BCMA 2012) and insecticide application is recommended (Bush and Bell 2012). In Italy, even unripe fruit is attacked (Grassi *et al*. 2011). Up to 20–50% of the fruit sampled from apricot orchards in one district were infested with *Drosophila suzukii* (Grassi *et al*. 2011).
- In France, commercial peach and apricots have been damaged in several locations (Weydert 2011) and in Spain there have been reports of 10–40% damage on peaches and plums (Escudero *et al*. 2011).
- The densely hairy surface of peaches will make the detection with the naked eye of eggs and respiratory tubes more difficult compared to smooth skinned fruit (DAFF 2010).

The demonstrated association of the pest with the pathway at its origin, presence of internal life stages that can be very difficult to detect by the naked eye, and its ability to survive the duration of transport support a probability rating of ‘high’ for the importation of *Drosophila suzukii* on fresh stone fruit.

Strawberry (*Fragaria* x *ananassa*)

- Monitoring programs in the northwest of the USA show trap catches in strawberry fields are high and they are a preferred host for *Drosophila suzukii* (OSU 2010b; OSU 2010c; Peerbolt 2010). In eastern USA, high larval infestations in North Carolina have been reported (Burrack 2010).
- In California little economic damage has been recorded in strawberries and this is considered to be due to the short interval between fruit ripening and harvest (Bolda *et al*. 2010). Some commercial damage has been recorded in Oregon (OSU 2010c) and *Drosophila suzukii* was first recorded from Washington on strawberries (Walsh *et al*. 2011).
- *Drosophila suzukii* has invaded Europe and has already been recorded to damage commercial strawberries (EPPO 2010a). Later information confirms infestations can reach very high levels for late season fruit where 60–100% damage has been recorded (Suss and Contanzi 2010; Grassi *et al*. 2011; Grassi and Pallaoro 2012). Early in the season, when *Drosophila suzukii* populations are lower and insecticide application more frequent, infestation levels range from 2–10% (Grassi *et al*. 2011; Grassi and Pallaoro 2012).
- In France, significant economic losses have been recorded in several regions (Weydert 2011) and 20% damage has been reported in Spain (Escudero 2011).
- The hairy and uneven surface of strawberries will make the detection with the naked eye of eggs and respiratory tubes more difficult compared to smooth skinned fruit (DAFF 2010).

The demonstrated association of the pest with the pathway at its origin, presence of internal life stages that can be very difficult to detect by the naked eye, and its ability to survive the duration of transport support a probability rating of ‘high’ for the importation of *Drosophila suzukii* on fresh strawberry fruit.

Blueberry (*Vaccinium* spp.)

- Monitoring programs in the northwest of the USA and Canada show trap catches in blueberry orchards are high and they are a preferred host for *Drosophila suzukii* (OSU 2010b; OSU 2010c; BCMAL 2010; Peerbolt 2010).
- In Japan, *Drosophila suzukii* is considered the main pest of blueberries (Tamada 2009). Infestations of blueberry fruit ranged from 2–4% for mature fruit and up to 14 % for fallen fruit (Uchino 2005).
- In the USA, maximum yield losses of 40% have been recorded in some localities (Bolda *et al*. 2010). In field trials in Washington, infestation rates are initially low in unripe fruit in early summer and can reach 84% infestation on fully mature fruit by the end of summer (Tanigoshi *et al*. 2010). In a six acre no spray commercial blueberry field in Willamette Valley, Oregon, located near wild hosts, infestation rates in 2012 were over 50% from marketable fruit (Ohrn and Dreves 2013).
- Since the detection of *Drosophila suzukii* in 2010 in Michigan USA, the population and damage has continued to grow and it is considered a significant challenge to blueberry growers (Isaacs 2013).
- In Italy, high bush blueberries are considered to be highly susceptible to attack with infestation levels of 90–100% (Grassi *et al*. 2011). In orchards where insecticides are applied infestations stay below 5% and once insecticides application stops, infestation levels increase to 80% over four weeks (Grassi and Pallaoro 2012).
- The eggs and very young larvae of *Drosophila suzukii* can escape detection at harvest and then develop and cause damage to fruit post harvest (Grassi *et al*. 2011).

The demonstrated association of the pest with the pathway at its origin, presence of internal life stages that can be very difficult to detect by the naked eye, and its ability to survive the duration of transport support a probability rating of 'high' for the importation of *Drosophila suzukii* on fresh blueberry fruit.

Currants and gooseberry (*Ribes* spp. *and Ribes uva-crispa*)

- Currants growing in non commercial situations have been recorded as hosts in Canada (BCMA 2011). In north western USA, it is currently recommended to apply insecticides to currants to manage the risk of *Drosophila suzukii* (DeFrancesco and Bell 2012).
- In Europe, cultivated currants are listed as hosts (Cini *et al*. 2012). However, Cini *et al*. (2012) recognise the status of currants as a host cited in their paper (including currants) should be still considered tentative, since some information on host range is not well documented. No damage has been recorded on red currants in Trentino, Italy (Grassi *et al*. 2011).
- Gooseberry has been recorded as a reproductive host in laboratory trials (Brewer *et al*. 2012). In north western USA, *Drosophila suzukii* is reported to be a prominent pest of gooseberry (WSCPR 2011) and it is currently recommended to apply insecticides to manage the risk of this pest (DeFrancesco and Bell 2012).
- However, for currants and gooseberry, there are still no confirmed reports of *Drosophila suzukii* infesting commercially produced fruit.

The presence of internal life stages that can be very difficult to detect by the naked eye and its ability to survive the duration of transport could support a probability rating of high. However, the uncertain and likely lower association with currants and gooseberry, compared to other hosts, and the lack of reports of commercial damage support a probability rating of 'low' for the importation of *Drosophila suzukii* on currants and gooseberry fruit.

Table grapes (*Vitis vinifera*) and Concord grapes (*Vitis labrusca*)

Table grapes

- During the 1930's in Japan, *Drosophila suzukii* was trapped in table grape vineyards at high levels and there are reports of damage as high as 80% (Kanzawa 1939). More recently there have been reports of outbreaks of *Drosophila suzukii* on grapes in Hokkaido (CFIA 2010) and it has been reared from glasshouse grown grapes (TPSAEC 2009). However, *Drosophila suzukii* may not be an important pest on grapes in Japan today as there are no confirmed reports of economic damage, no insecticides are registered for use on grapes against this pest and recent trials failed to record oviposition on the grape variety (unknown) tested (Pers. comm., Martin Damus, CFIA, 16 December 2010).
- The lack of reported attack in Japan in recent years may be due to changes in commercial practice, including the type of cultivars commonly grown and harvested. For example, table grapes represent 87% of grapes produced in Japan and the varieties 'Kyoho' and 'Delaware' are the most commonly grown table grape varieties representing 58% of total production in 1997 (Morinaga 2001). 'Delaware' is a variety reported to be resistant to oviposition because of its tough skin (Kanzawa 1939) and 'Kyoho' ripen in August when *Drosophila suzukii* numbers are typically low in Japan (Kanzawa 1939; see section 3.4.3 Ecology and Table 3.2 on grape parentage).
- In the USA, *Drosophila suzukii* has been recorded from grapes though infestation rates remain low during the early part of the 2010 season (OSU 2010c). In eastern USA, grapes (variety not specified; Demchak *et al*. 2012) and wine grapes (Cowles 2012) have been recorded as a host and high levels of infestation have been recorded in some instances (Demchak *et al*. 2011).
- In British Columbia, Canada, table grapes are considered a host and wine grapes are suspected of being a host and insecticide application is recommended to manage *Drosophila suzukii* in commercial fruit (Acheampong 2011a).
- In oviposition trials, larvae have been reared at high rates from table grapes ('Red flame') that are fully ripe with sugar levels above 18% and low acidity (Malguashca *et al*. 2010). In wine grapes that are not fully ripe, with lower sugar levels and higher acidity, few larvae have successfully pupated in the trials so far (Malguashca *et al*. 2010) although later work reported no larvae completed development in the wine grapes tested (Brewer *et al*. 2012).
- 'Thompson seedless', has also been shown to be readily oviposited through the undamaged skin by *Drosophila suzukii* under laboratory conditions (Bolda 2009; AWFG 2009) and successful development to adult has been confirmed at lower levels compared to other hosts (Lee *et al*. 2011a). Larvae have been confirmed from

wine and table grape varieties in the field where oviposition has occurred through the skin of the fruit (OSU 2010c).

- As fruit ripens during the later part of the season, attack levels may increase rapidly as *Drosophila suzukii* preferentially oviposits on fully ripe fruit two to three days before harvest (Kanzawa 1939).
- It has also been reported the attack levels can vary greatly depending on the variety of grape (Kanzawa 1939; Malguashca *et al*. 2010; USDA 2010; Pers. comm., Françoise Petter, EPPO, 22 December 2010) and this has been attributed to the skin thickness of particular varieties (Kanzawa 1939; Pers. comm., Martin Damus CFIA, 16 December 2010).
- In Washington State, grapes grown in the east of the state are now considered a non-preferential host (Barrantes-Barrantes and Walsh 2012).
- In Europe, grapes have been reported to be a host, particularly soft skin varieties (Cini *et al*. 2012). Damage increases during the season and of the fruit sampled in September, 71% was infested (Grassi and Pallaoro 2012). It was later confirmed the infestations were recorded on wine grapes (Pers. comm., Dr Alberto Grassi, 5 September 2012).
- There have been additional reports of damage to wine grapes in Spain (Escudero *et al*. 2011; (Pers. Comm., Dr Adriana Escudero, 6 September 2012).
- However, the variation in oviposition rates across most grape varieties has not been determined under consistent experimental conditions or field sampling and there is still a level of uncertainty associated with the rate of attack on a particular *V. vinifera* variety.
- For example, recent work from the USA reports 'Pinot noir', 'Riesling' and 'Merlot' wine grapes are not a development host for *Drosophila suzukii* under laboratory conditions (Brewer *et al*. 2012). However, in another trial, *Drosophila suzukii* developed to adult (in very low numbers) in 'Chardonnay' and 'Merlot' varieties under laboratory conditions (Lee *et al*. 2011) and pest extension material shows damage in 'Chardonnay' and 'Pinot noir' wine grapes (Walton *et al*. 2010). In eastern USA, field damage to 'Pinor noir' grapes has been reported (Pfeiffer 2013).
- Information provided by the USA showed commercially produced table grape varieties commonly exported to Australia can be oviposited by *Drosophila suzukii* and complete development in the laboratory (USDA 2012). However, oviposition rates were lower than for other hosts (e.g. cherry).
- As more information becomes available on *Drosophila suzukii* host association in table grapes, it is likely that in the future the importation risk could be different for particular varieties.

The association of the pest with some table grape varieties, including the current uncertainty about varietal association, presence of internal life stages that can be very difficult to detect by the naked eye, and its ability to survive the duration of transport could support a probability rating of 'high'. However, there are still no reports of commercial damage or high association with common table grape varieties under commercial production and this information supports a lower rating compared to other hosts with a high association with *Drosophila suzukii* under commercial conditions. Therefore the information supports a probability rating of 'moderate' for the importation of *Drosophila suzukii* on fresh table grapes.

Concord grapes

- Kanzawa (1939) listed *V. labruscae* (= *V. labrusca*) as a host for *Drosophila suzukii* on undamaged fruit (see table 39 in Kanzawa 1939). Kanzawa (1939) reported on the field infestation of grapes in Japan and listed a range of varieties that supported or did not support oviposition by *Drosophila suzukii* (see table 43; Kanzawa 1939). However, when the parentage of these varieties is considered, the majority of the varieties attacked are of *V. vinifera* parentage (see table 3.2).
- All varieties that are 100% *V. labrusca*; 'Concord', 'Eaton', 'Niagara' and 'Hoster's seedling', do not support oviposition in the fruit by *Drosophila suzukii* (see table 3.2).
- In a further five varieties with *V. labrusca* parentage no oviposition was reported by Kanzawa (1939) (see table 3.2). Only three varieties ('Herbert', 'Golden queen' and 'Glenora') with *V. labrusca* parentage supported oviposition in the field and these are pre-dominantly of *V. vinifera* parentage (see table 3.2).
- For example, both 'Kyoho' and 'Delaware' have *V. labrusca* parentage (see table 3.2) that may contribute to these varieties being a poor oviposition host. 'Delaware' is a variety reported to be 'impossible' for *Drosophila suzukii* to oviposit in because of its tough skin (Kanzawa 1939) and 'Kyoho' is considered to be a thick skinned variety of grape (Wan *et al*. 2008).
- In addition to the original work of Kanzawa (1939), there are now more recent reports where the species of grape is considered in assessing host range. In the USA there is a report that *Drosophila suzukii* ruined tender skinned varieties of seedless table grapes; 'Black Manuka', 'Perlette', 'Genora' (WSUE 2010). Where the parentage of these varieties is known, they are entirely derived from *V. vinifera* (see Table 3.2).
- However, compared to the *V. vinifera* varieties above in the same table grape planting, varieties with tougher 'slip-skins' ('Mars', 'Suffolk Red', 'Reliance') remained free of damage (WSUE 2010). These varieties have a large portion of their parentage from *V. labrusca* (see Table 3.2) and are considered to be a 'labrusca' type grape (Hemphill *et al*. 1992). 'Slip skins' are considered tough in comparison to varieties like 'Thompson seedless' (Hemphill *et al*. 1992) that are considered to have a thin skin (Wan *et al*. 2008).
- In a field experiment in Washington State, USA, 'Concord' grapes were exposed to *Drosophila suzukii*. Eggs were recorded on the outside of the fruit but no larval development was recorded (Tanigoshi and Gerdeman 2013). The oviposition of eggs on the outside of fruit was previously reported by Kanzawa (1939) when the tough skin of the host (e.g. 'Koshu' and 'Delaware') prevents insertion of the egg. Eggs on the outside of the host are then susceptible to desiccation (Kanzawa 1939).

- In Europe, fox grape (*Vitis labrusca*) cv. 'Isabella' has been reported as a host (Seljak 2011a). However, later information confirmed this occurred only in rotting grapes (MAE 2012).
- In laboratory trials, oviposition did not occur on undamaged concord grapes (*V. labrusca*) (Malguashca *et al*. 2010). On damaged grapes, oviposition occurred although larval development was poor (Malguashca *et al*. 2010).
- There is one report of wild grown fruit of *V. labrusca* being attacked (Maier 2012). The fruit sampled were ripe or rotten and there is no record of whether they were damaged (Pers. Comm., Chris Maier, 12 October 2012).
- Recent work on oviposition choice by *Drosophila suzukii* has shown oviposition rate is negatively correlated with the penetration force required to allow oviposition to occur through a host (Burrack *et al*. 2013). Oviposition did not occur in artificial media with a penetration force above a certain threshold. These data suggest *Drosophila suzukii* will reject firm fleshed hosts (Burrack *et al*. 2013).
- As more information becomes available on *Drosophila suzukii* host association in concord grapes, and varieties based on this species, it is likely that in the future the importation risk could be different for particular *V. labrusca* varieties.

The poor association of the pest with the pathway at its origin, lack of oviposition in control situations, with no reports of concord grapes being attacked under commercial production could support a rating of 'extremely low'. However, the current uncertainty about association with grape varieties of *V. labrusca* parentage supports a probability rating of 'very low' for the importation of *Drosophila suzukii* on fresh concord grapes.

Moraceae (Mulberry– *Morus* spp. and *Ficus*–figs)

- Undamaged *Morus alba* has been recorded to be attacked by *Drosophila suzukii* in Japan (Kanzawa 1939). More recently, high infestation rates of *Drosophila suzukii* in mulberries have been reported in Japan with 300 adults emerging from 60 fruit collected from the tree (Sato and Sasaki 1995c).
- In North America, *Drosophila suzukii* has been reported to attack *Morus rubra* in Florida (FDACS 2010a) and *Morus* spp. in British Columbia (BCMAL 2009). In Italy, oviposition occurred in *Morus nigra* berries under rearing conditions (Grassi *et al*. 2011).
- Figs have been recorded as a host in Europe (Lee *et al*. 2011b; Grassi *et al*. 2011). In Italy, many eggs have been recorded from fruit still on the tree (Grassi *et al*. 2011) although it is not clear if this was from a commercial orchard.
- In Spain, commercially produced figs for fresh consumption have been confirmed as being attacked in early June when fruit was unripe and infestation increased until harvest in late June (Pers. comm., Dr Adriana Escudero, IRTA, 11 February 2012).
- In the USA, there are still no reports of commercially produced figs infested with *Drosophila suzukii*. However, there are an increasing number of reports that non-commercial figs are a host for *Drosophila suzukii* (Brewer *et al*. 2012; Dreves and Langellotto-Rhodaback 2011) and figs of unknown status (Caprile 2012).

The known association with fruit, the presence of internal life stages that can be very difficult to detect by the naked eye and its ability to survive the duration of transport support a probability rating of 'high' for the importation of *Drosophila suzukii* on mulberries and figs.

Hardy kiwi (*Actinidia arguta*)

- Hardy kiwi has been confirmed as a host of *Drosophila suzukii* in Oregon, USA, with adults reared from field collected fruit (ODA 2009; DAFF 2010). In Canada, *Drosophila suzukii* is suspected to attack hardy kiwi in British Columbia; larvae have been recorded infesting fruit at one location though these have not been reared out to adults to confirm identification (BCMAL 2009; Pers. comm., Tracey Hueppelsheuser, BC Ministry of Agriculture and Lands, 1 September 2010).
- Hardy kiwi is native to northern Asia (CRFG 2010) and there are no reports of damage by *Drosophila suzukii* from this region.
- Monitoring programs in the northwest of the USA and Canada show *Drosophila suzukii* are trapped in hardy kiwi orchards (OSU 2010b; OSU 2010c; BCMAL 2010; Peerbolt 2010). However, there are no reports of commercial damage to hardy kiwi fruit.
- *Drosophila suzukii* was reported on hardy kiwi from an orchard in Austria. However, only adults were trapped and no larval infestation was reported (EPPO 2012; Pers. comm., Françoise Petter EPPO, 29 March 2012).

The presence of internal life stages that can be very difficult to detect by the naked eye and its ability to survive the duration of transport could support a probability rating of high. However, the lower association with hardy kiwi, compared to other hosts, and the lack of reports of commercial damage support a probability rating of 'low' for the importation of *Drosophila suzukii* on hardy kiwi fruit.

Other recorded fresh fruit hosts

- There is little information on the association of *Drosophila suzukii* with these hosts.
- There is a report of *Drosophila suzukii* in red bayberry (*Myrica rubra*) in China and trapping efficacy studies have been conducted for *Drosophila suzukii* as it is considered a pest (Wu *et al*. 2007). However, the main host resource is fallen fruit (Wu *et al*. 2007).
- In Japan, *Drosophila suzukii* have been reared from fruit picked from the plant for pokeweed (*Phytolacca americana*) and silverberries (*Elaeagnus multiflora*), at low to moderate levels (Sato and Sasaki 1995c).
- In Canada, several *Drosophila suzukii* adults have been reported to emerge from dogwood (*Cornus kousa*) fruits collected directly from the plant in one location (Pers. comm., M. Damus CFIA, 16 December 2010).

The presence of internal life stages that can be very difficult to detect by the naked eye and its ability to survive the duration of transport support a probability rating of high for *Cornus kousa*, *Myrica rubra*, *Phytolacca americana* and *Elaeagnus multiflora*. However, as these hosts have only been reported infrequently as hosts with low to moderate levels of attack, and considering the uncertainty around these host associations, this information supports a probability rating of 'moderate' for the importation of *Drosophila suzukii* on *Cornus kousa*, *Myrica rubra, Phytolacca americana* and *Elaeagnus multiflora* on fresh fruit.

Probability of distribution

The likelihood that *Drosophila suzukii* will be distributed within Australia in a viable state with imported fruit and transfer to a suitable host: **HIGH**.

- Fresh fruit infested with *Drosophila suzukii* would 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.
- During distribution, fruit may be kept at cool temperatures that may affect the survival of *Drosophila suzukii* (Kanzawa 1939). However, the perishable nature of fresh fruit would mean transit times will be short, and transit temperatures are likely to be above lethal levels (Kanzawa 1939; Woolworths 2010). At retail outlets, fruit will then be displayed at ambient temperature that would promote the survival and development of *Drosophila suzukii*.
- Hosts of *Drosophila suzukii* from undamaged fruit include 41 taxa from 10 plant families and there are many other additional recorded hosts when fruit is grown in backyard and natural environments or when the fruit is over-ripe (Appendix B). Preferred hosts of *Drosophila suzukii* include strawberry, caneberry, cherry, stone fruit, blueberry and some grape varieties (Kanzawa 1939; Sasaki and Sato 1995a; Kawase and Uchino 2005; EPPO 2010a; OSU 2010b). These species are widely distributed in commercial and domestic environments within Australia (AVH 2010).
- Although *Drosophila suzukii* is currently restricted in distribution to the northern hemisphere, and fresh fruit would be imported mostly out of season, the broad host range would most likely result in some plant hosts in Australia having fruit during the import period and throughout the year. In addition, the continuous supply of fruit through the retail sector would ensure host fruits are available throughout the year in residential areas.
- Fresh fruit infested by mature larvae of *Drosophila suzukii* have a sunken surface and become rotten and unsuitable for sale (OSU 2010a; Bolda *et al*. 2010). Symptomatic fruits are likely to be considered unmarketable by wholesalers and retailers. These fruits are likely to be disposed of with general garbage or in compost bins prior to sale to the consumer.
- Asymptomatic fruit, with only eggs or recently hatched larvae, in sound condition would be distributed and sold through markets and retail chains.
- On imported fruit purchased at retail outlets for consumption, emerging flies would only need to move to fruit of a suitable host that may be in residential environments, including fruit bowls. The ability of *Drosophila suzukii* to utilise over ripe and damaged fruit will maximise the range and availability of host material they could reproduce on.
- 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 and commercial waste.

- Adult *Drosophila suzukii* associated with imported fruit could readily move to new host material. Adults are considered to be active fliers, can fly for several hours in a day, and are very active at temperatures between 20–25 °C (Kanzawa 1939). Closely related species of *Drosophila* are known to fly hundreds of metres towards preferred habitat (Coyne *et al*. 1987).
- The transfer of immature stages of *Drosophila suzukii* from fruit waste to a host would occur if they successfully completed development and emerged as an adult. *Drosophila suzukii* is known to complete development from egg to adult at high levels in sound fruit and at lower levels in rotten fruit (Kanzawa 1939).

The presence of internal life stages that can be very difficult to detect by the naked eye, its ability to survive the duration of transport, complete development, proven ability to move independently by flight and find one of its numerous hosts support a probability rating of 'high' for the distribution of *Drosophila suzukii* on fruit.

Overall probability of entry

The overall probability of entry is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2 on page 13.

The likelihood that *Drosophila suzukii* will enter Australia with imported fruit and transfer to a suitable host is summarised below:

Pathway	importation	distribution	Entry
Cherry	H	H	**H**
Caneberries	H	H	**H**
Stone fruit	H	H	**H**
Strawberry	H	H	**H**
Blueberry	H	H	**H**
Currant & Gooseberry	L	H	**L**
Table grape	M	H	**M**
Concord grape	VL	H	**VL**
Mulberry & Fig	H	H	**H**
Hardy kiwi	L	H	**L**
Other hosts			
Dogwood	M	H	**M**
Silver berry	M	H	**M**
Red bayberry	M	H	**M**
American pokeweed	M	H	**M**
N = Negligible, **EL** = Extremely low, **VL** = Very low, **L** = Low, **M** = Moderate, **H** = High			

5.2 Pathway 2 – Fresh Flowers

5.2.1 Probability of entry

Probability of importation

The likelihood that *Drosophila suzukii* will arrive in Australia with the trade in fresh flowers in a viable state from countries where the pest is present: **EXTREMELY LOW**.

- *Drosophila suzukii* is known to feed in flowers (*Styrax japonicus and Camellia japonica*) and adults can successfully emerge from fallen flowers (Mitsui *et al*. 2010; Damus 2010a). However, only small numbers of adults have only been recorded to emerge from fallen flowers and it is unclear if *Drosophila suzukii* attacks flowers still attached to the plant.
- Later information has confirmed that *Drosophila suzukii* attacks old flowers still attached to the plant, although this only occurs very rarely and it is unlikely to be attracted to new flowers (Damus 2010b). There are no reports of newly formed flowers being attacked. Commercial quality cut flowers for importation are even less likely to be attacked by *Drosophila suzukii* as they would be still in bud to prolong shelf life after importation.
- Flowers are only known to be attacked by *Drosophila suzukii* in the absence of host fruit. Flowers have only been recorded to be attacked in spring, after adults emerge from winter diapause and before host fruit ripens in late spring (Mitsui *et al*. 2010; Damus 2010a).
- It is not widely reported that *Drosophila suzukii* can successfully emerge from fresh flowers, eggs are small (Kanzawa 1939), and there is no information on the visual symptoms larval feeding may produce. It is likely that damage in *Drosophila suzukii* infested flowers could be easily over looked.
- Total development times from egg to adult can range from 25 days at 15 °C and eight 13 days at 25 °C in fruit (Kanzawa 1939. It is not known whether development times would be different for larvae feeding in flowers.
- Commercial flowers and nursery stock are likely to be transported at 2–4 °C to preserve freshness (Gollnow and Wade 2002).
- Eggs and larvae of *Drosophila suzukii* have been shown to be susceptible to cold (Kanzawa 1939). However, at temperatures tested in the range of –0.6– 2.2 °C, of the eggs and larvae tested, 5.5% survived for 72 hours and all eggs and larvae tested were dead by 96 hours (Kanzawa 1939). Although cold storage could increase mortality of *Drosophila suzukii* in flowers, the only study published was preliminary, with very low levels of replication, did not replicate commercial conditions and was conducted at temperatures lower than used commercially (Bolda 2009; Gollnow and Wade 2002).
- Adult *Drosophila suzukii* can successfully diapause over winter, and in the following spring become sexually active. During this period females can live on average for over 200 days (maximum of 301 days) (Kanzawa 1939). The ability of

adults to survive cold conditions for extended periods could allow them to survive flower transport conditions. Adult flies associated with fresh flowers are likely to be active; over-wintering flies hibernate in litter and soil and are not known to be associated with flowers (Kanzawa 1939).

- While fruit pathways were considered most important when *Drosophila suzukii* invaded the USA, the recent evidence of Mitsui *et al*. (2010) has shown fresh flowers could also be a pathway.

The limited presence of internal life stages that could be difficult to detect with the naked eye, and its ability to survive the duration of transport could support a probability rating of ‘low’ for the importation on flowers. However, the pest is not known to attack young flowers attached to the plant, has only been infrequently recorded to emerge from fallen flowers, and then only for a restricted period of the year, support a probability rating of ‘extremely low’ for the importation of *Drosophila suzukii* on flowers.

Probability of distribution

The likelihood that *Drosophila suzukii* will be distributed within Australia in a viable state with imported flowers and transfer to a suitable host: **MODERATE**.

- Fresh flowers or nursery stock infested with *Drosophila suzukii* will be distributed for retail sale, or commercial propagation facilities, to multiple destinations within the PRA area, so a portion of the flower consignment is likely to reach areas of host abundance.
- It is not widely reported that *Drosophila suzukii* can successfully emerge from flowers, eggs are small (Kanzawa 1939), and there is no information on the visual symptoms larval feeding may produce. It is likely *Drosophila suzukii* infested flowers could be easily over looked. However, *Drosophila suzukii* has only been recorded from old or fallen flowers (Mitsui *et al*. 2010; Damus 2010a & b).
- During distribution flowers may be kept at cool temperatures that may affect the survival of *Drosophila suzukii* (Kanzawa 1939). However, the perishable nature of fresh flowers or nursery stock would mean transit times will be short and transit temperatures are likely to be above lethal levels (Kanzawa 1939; Gollnow and Wade 2002). After purchase, flowers will then be displayed at ambient temperature that would promote the survival and development of *Drosophila suzukii*.
- Hosts of *Drosophila suzukii* include 41 taxa from 10 plant families (Appendix B). Preferred hosts of *Drosophila suzukii* include the fruit of strawberry, cane berry, cherry, stone fruit, blueberry and grapes (Kanzawa 1939; Sasaki and Sato 1995a; Kawase and Uchino 2005; EPPO 2010a; OSU 2010b). These species are widely distributed in commercial and domestic environments within Australia (AVH 2010).
- Although *Drosophila suzukii* is currently restricted in distribution to the northern hemisphere, and flowers could be imported out of season, the broad host range would most likely result in some plant hosts are in fruit in the environment throughout the year. In addition, the continuous supply of fruit through the retail sector would ensure host fruits are available throughout the year in residential areas.
- On imported flowers purchased at retail outlets for residential display, emerging flies would only need to move to fruit of a suitable host in the domestic fruit bowl.

The ability of *Drosophila suzukii* to utilise over ripe and damaged fruit (Kanzawa 1939) will maximise the range and availability of host material they could reproduce on.

- However, the ability of immature stages of *Drosophila suzukii* to successfully emerge from flowers is likely to be less than from its preferred fresh fruit hosts. For example, successful emergence in fruit is limited by decreasing sugar levels (Malguashca *et al*. 2010) and flowers are likely to have lower sugar levels than ripe fruit.
- Adult *Drosophila suzukii* associated with imported flowers could readily move to new host material. Adults are considered to be active fliers, can fly for several hours in a day, and are very active at temperatures between 20–25 °C (Kanzawa 1939).
- The transfer of *Drosophila suzukii* from flower waste to a host would occur if the larvae successfully completed development and emerged as an adult. It is not known how effectively *Drosophila suzukii* develops in fresh flowers (Kanzawa 1939). There is a clear preference by females to oviposit in ripe fruit and successful adult emergence is reduced in less suitable fruit (Kanzawa 1939). It is considered likely that successful emergence from flowers will be lower than in ripe fruit.

The presence of internal life stages at low numbers, that can be very difficult to detect, its ability to survive the duration of transport and the likely lower successful emergence from flowers, compared to fruit, support a probability rating of 'low' for the distribution of this species on flowers.

Overall probability of entry

The overall probability of entry is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2 on page 13.

The likelihood that *Drosophila suzukii* will enter Australia with imported flowers and transfer to a suitable host: **EXTREMELY LOW**.

5.3 Establishment and Spread

5.3.1 Probability of establishment

The likelihood that *Drosophila suzukii*, having entered on imported fresh fruit or fresh flowers and been transferred to a susceptible host, 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**.

- *Drosophila suzukii* can attack a broad range of undamaged fruits including 46 taxa (plus five suspected species in the *Morus*, *Rubus* and *Prunus* genera) from 10 plant families (Appendix B). In addition, *Drosophila suzukii* is known to attack the fruit of another 54 species when they are damaged or over ripe (Appendix B). The broad host range, including fruit that is commercially available all year, including damaged and over ripe fruit, would ensure host material is available throughout the year and across the PRA area.

- The distribution of *Drosophila suzukii* is currently limited to the northern hemisphere (Table 3.1) and imported fruit are likely to arrive mostly out of season in Australia. However, the broad range of host that *Drosophila suzukii* can attack and persist in increase the chances of this pest finding a suitable range of hosts to attack throughout the year. For example, strawberries are grown throughout winter in parts of Australia (SISP 2009) and would provide suitable host material for the establishment of this pest (Kanzawa 1939; Bolda 2009; Dreves *et al*. 2009).

- *Drosophila suzukii* occurs in Asia (China, Korea, Japan, Thailand, Myanmar), the sub continent (India and Pakistan), Europe (Spain, France, Italy and many other countries) and North America (Canada and the USA– Hawaii and most of the 48 contiguous states), and Mexico (Table 3.1).

- The climatic regions across this range are diverse and include Mediterranean, marine west coast, humid continental, sub tropical savannah, humid subtropical and tropical savannah (Espenshade 1990). There are similar climatic regions over large parts of Australia that would be suitable for the establishment of *Drosophila suzukii* throughout the year.

- It is not known what number of individuals are required to establish a sustainable population. However, *Drosophila suzukii* is native to Asia and has successfully established in a broad range of locations including, Hawaii, the west and east coast of the USA, Canada, Spain, France (including Corsica), Italy, Switzerland, Germany and Slovenia (Table 3.1).

- Although *Drosophila suzukii* has been recorded from a diverse range of climatic regions, it is limited by environmental conditions.

- The negative effect of high temperature has been recorded experimentally where 75% of female *Drosophila suzukii* die at a constant temperature of 33.3 °C for 24 hours (Kimura 2004). Males flies are less tolerant of high temperature and 75 % mortality is reached at temperatures of 32.6 °C (Kimura 2004). Under laboratory conditions, adults will die if kept at 35 °C for three hours (Walton *et al*. 2010a).

- Larval development does not occur above 31 °C (Brewer et al. 2012) and higher temperatures have been shown to kill immature stages of *Drosophila suzukii* over several days when the maximum daily temperature is above 35 °C (Sasaki and Sato 1995b). Pupae will not emerge at temperatures of 32 °C and above (Sasaki and Sato 1995b).

- The effect of temperature on *Drosophila suzukii* under experimental conditions is supported by field observation. In Yamanashi Prefecture in central Honshu, Japan, numbers of adults are greatest during early summer and autumn with a sharp decrease in numbers through the hottest period of summer (Kanzawa 1939; Mitsui *et al*. 2010). The decrease in adult numbers during the heat of summer is unlikely to be because of a lack of host material; *Drosophila suzukii* can attack a range of common hosts that fruit throughout the season in Japan (Sasaki and Sato 1995b).

- Further north in Honshu, in Fukushima Prefecture, where mean maximum temperatures are several degrees cooler in summer (JMA 2010), the bimodal peak in *Drosophila suzukii* abundance was not recorded during the 1993 season (Sasaki and Sato 1995c). Here, the abundance of *Drosophila suzukii* steadily increases on a range of hosts until a peak population is reached in autumn. However, in 1991 and 1992, when mean summer temperatures were 2–4 °C higher than 1993 (JMA 2010), numbers of *Drosophila suzukii* decrease during the hottest period of summer (Sasaki and Abe 1993).

- In Florida, USA, populations of *Drosophila suzukii* have so far been very low through the hot summer months and significant population growth has only occurred during suitable cooler temperatures of winter (Dean 2010).
- *Drosophila suzukii* adults are extremely sensitive to low moisture/humidity. Adult flies will die under room temperature conditions in 6–24 hours without a moisture source (DAFF 2010; Kellermann *et al*. 2012). The sensitivity of *Drosophila suzukii* to low humidity is consistent with other *Drosophila* spp. that require humidity levels >70% for successful culture (Ashburner *et al*. 2005).
- In the USA, although recorded to be present in the central valley of California (Hauser 2010)*, Drosophila suzukii* has not been recorded in high numbers and there are no reports of damage on any host during summer. The hot arid conditions of the central valley could limit *Drosophila suzukii* populations (Van Steenwyck 2010).
- Recent monitoring shows the number of *Drosophila suzukii* adults trapped decrease over summer and numbers approach zero in San Joaquin County, central valley, California (Brewer *et al*. 2011; Dalton *et al*. 2011; Caprille 2012).
- Over wintering survival can be affected by low temperatures where a constant temperature of –1.8 °C and –0.7 °C for 24 hours can kill 75 % of the females and males respectively (Kimura 2004).
- In Hokkaido, the far north of Japan, *Drosophila suzukii* is considered a domestic species associated with human habitation (Toda and Fukuda 1985). The species is believed to survive the cold winters in sheltered human habitation sites and then re-invades rural areas during summer.
- In Oregon, USA, over wintering experiments have shown very low survival with only one adult in 1 000 surviving until spring (DAFF 2010). Further studies have confirmed the type of over wintering sites influence survival (Brewer *et al*. 2012). A crawl space provided the best shelter of the sites tested with adults surviving up to 158 days over winter when provided with food and water (Brewer *et al*. 2012).
- In over wintering trials in Japan, survival can vary from 0–23% and moisture may also play a role in the survival of adults during winter (Sasaki and Sato 1995b).
- The distribution of *Drosophila suzukii* in North America has been predicted based on current distribution and tolerance to environmental factors (Damus 2009). This model predicts *Drosophila suzukii* has preference for temperate maritime climates and abundance is limited by cold winters, high summer temperatures and low humidity (Damus 2009).
- In Australia, the moderate winters (compared to northern Asia and North America) across most regions are unlikely to limit the abundance of *Drosophila suzukii*. Recent evidence has shown that larvae and pupae can survive winter at low levels when the temperature is moderate (Walsh *et al*. 2011).

- The temperature requirements for reproduction (Toda 1979) may allow oviposition to continue through winter in warmer coastal and northern areas. However, typical summer conditions away from the coast in Australia, high temperature (many days > 35 °C) and low humidity (BOM 2010), are likely to be less suitable for fly reproduction and survival.
- *Drosophila suzukii* has a very high rate of reproduction with multiple generations per year. After pupal emergence, the adults typically become sexually mature in one to two days with a maximum of 13 days recorded (Kanzawa 1935; Kanzawa 1939).
- *Drosophila suzukii* is not known to be parthenogenic and newly emerged females would need to mate to produce viable eggs. It is not known if pheromones are used by *Drosophila suzukii* to attract mates. In other *Drosophila* spp., sex pheromones are known to elicit male courtship behaviour (Ashburner *et al*. 2005) but it is not known over what distance they can attract potential mates.
- Adult *Drosophila suzukii* are known to be associated with packing houses and they are attracted to picked fruit (BCMAL 2010; WSUE 2010). Adult females associated with imported fruit, that were mated prior to import, are likely to produce viable eggs. In the closely related species, *Drosophila melanogaster*, sperm are known to remain viable for at least two weeks after fertilisation (Ashburner *et al*. 2005).
- Females can oviposit on average 7–16 eggs per day with 384 eggs on average in laboratory trials (Kanzawa 1939). A maximum of 160 eggs have been recorded to be laid in a single day (DAFF 2010). Eggs, larvae and pupae all vary in development time depending on the generation in the field.
- Generations over summer have the shortest development times. Eggs typically hatch in 1 day and on average larvae take between four to nine days to complete feeding (Kanzawa 1939). Pupae require on average four to 13 days in the field to emerge as adults (Kanzawa 1939). The total development time from egg to adult ranges from eight to 23 days in the field (Kanzawa 1935; Kanzawa 1939).
- The short development time of *Drosophila suzukii* allows the fly to complete several generations in a season; up to 13 generations recorded in field conditions in Japan (Kanzawa 1939).
- During autumn, when the temperature is below 5 °C, newly emerged *Drosophila suzukii* adults do not sexually mature and seek out over wintering sites under leaf litter and stones, and enter a winter diapause (Kanzawa 1939). Sexually mature adults can also enter diapause and will not recommence sexual activity until the following season (Kanzawa 1939). The adult diapause over winter is reported to be in response to temperature (Toda 1979).
- Individual females can successfully oviposit hundreds of eggs prior to autumn, diapause over winter, and in the following spring recommence oviposition. During this period females can live on average for over 200 days (maximum of 301 days) and oviposit on average 260 eggs (Kanzawa 1939).
- Bruck *et al*. (2011) have tested several types of insecticides that are effective in managing *Drosophila suzukii* and many of these are available in Australia. However, there are currently no insecticides registered for the control of *Drosophila suzukii* in Australia (PUBCRIS 2010). However, insecticide application for other

internal feeding pests (e.g. *Bactrocera tyroni*) may limit the establishment of *Drosophila suzukii* in commercial fruit production areas that require such control measures.

- In urban environments, insecticide applications just prior to harvest are unlikely to be common and would not occur in picked fruit that can serve as a host.

The suitability of the environment, presence of multiple host species throughout the PRA area and the year, high reproductive potential and proven ability to establish in several climatically different new regions supports an assessment of 'high' for the establishment of *Drosophila suzukii*.

5.3.2 Probability of spread

The likelihood that *Drosophila suzukii*, having entered on imported fresh fruit or flowers and established, 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**.

- *Drosophila suzukii* was first reported in North America in 2008 in California and by 2009 was widespread in a range of hosts from Oregon, Washington (Hauser *et al*. 2009) and British Columbia (BCMAL 2009). This demonstrates the ability of *Drosophila suzukii* to spread if suitable hosts are present and climatic conditions are favourable.
- More recently in the USA, *Drosophila suzukii* has spread to South and North Carolina, Louisiana, Utah, Minnesota and the entire north east of USA (Burrack 2010; OSU 2010c; Stocks and Hodges 2011; CAPS 2012).
- The spread of *Drosophila suzukii* in North America has been repeated in Europe. The fly was first detected in Rasquera, Spain, in the autumn of 2008, then Alpes Maritimes and Montpellier, France, in late summer–early autumn of 2009 and then in Trentino Province, Italy, in autumn 2009 (Calabria *et al*. 2012; EPPO 2010a).
- By July 2010, *Drosophila suzukii* has been reported from additional regions in Italy of Calabria and Tuscany (EPPO 2010c). By September 2010, *Drosophila suzukii* has been reported from additional regions in France in the Departments of Corsica, Var, Gard, Tarn et Garonne, Isere and Rhone (Cazaubon 2010; Seigle Vatte 2010).
- In Europe, *Drosophila suzukii* has now been reported from multiple locations in additional countries of Belgium, Switzerland, Slovenia, Germany (Fischer *et al*. 2011; Seljak 2011a; BFB 2012; EPPO 2012a & b).
- At a regional level the rapid spread of *Drosophila suzukii* is demonstrated in Florida. *Drosophila suzukii* was first detected in Florida in August 2009 at two locations three miles apart in Hillsborough County (Steck *et al*. 2009). Since this first detection, *Drosophila suzukii* has spread across the southern Florida peninsula and has been recorded from 24 counties by June 2010 (Snyder 2010). The recorded spread in Florida includes distances of over 300 km in 11 months.
- There are similarities in the natural and managed environments of the above regions with many of those in Australia, which suggests that *Drosophila suzukii* could spread in Australia.

- Host plants that would support the spread of *Drosophila suzukii* are widespread in cities, towns and horticultural production areas throughout Australia and in the natural environment. For example, blackberry and other *Rubus* spp. are grown in horticultural and residential areas for fruit and they are widespread as weeds in agricultural and natural environments across much of temperate Australia (Parsons and Cuthbertson 2001).
- *Drosophila suzukii* feeds and reproduces on undamaged taxa from 10 plant families, including many commonly cultivated species including strawberry, peaches, nectarines, plums and grapes (Appendix B; AVH 2010). The host range of *Drosophila suzukii* on damaged or over-ripe taxa is even greater (Appendix B).
- The similarities in climate between the current distribution of *Drosophila suzukii* and horticultural, residential and natural regions where hosts are present within Australia would suggest that this species could spread naturally in these areas.
- *Drosophila suzukii* is native to temperate and sub tropical Asia (Hauser *et al*. 2009; Espenshade 1990) and once it established in new regions, spread through the Hawaii Islands (Kaneshiro 1983; O'Grady 2002), the west and east coast of North America (Hauser *et al*. 2009; Dreves *et al.* 2009; WSU 2009; BCMAL 2009; Synder 2010), and Europe (EPPO 2010c; Calabria *et al*. 2012) demonstrating its capacity to spread within a range of environments.
- *Drosophila suzukii* occurs in Asia (China, Korea, Japan, Thailand and Myanmar) and the sub continent (India and Pakistan) (Table 3.1).
- The climatic regions across this range are diverse and include Mediterranean, marine west coast, humid continental, sub tropical savannah, humid subtropical and tropical savannah (Espenshade 1990). There are similar climatic regions over large parts of Australia that would be suitable for the spread of *Drosophila suzukii* through large regions of Australia.
- The presence of natural barriers such as arid areas, mountain ranges, climatic differentials and possible long distances between hosts may prevent long-range natural spread of *Drosophila suzukii*.
- *Drosophila suzukii* is able to disperse independently and is considered an active flier although actual dispersal distances are not mentioned (Kanzawa 1939). In the closely related *Drosophila melanogaster*, directional flights to preferred habitats of several hundred meters have been recorded (Coyne *et al.* 1987). However, there is indirect evidence to support flight distances of 10–20 kilometres across unsuitable environments (Coyne *et al.* 1987).
- The arid regions surrounding many horticultural production areas in Australia may provide a natural barrier to the spread of this pest (Van Steenwyck 2010). For example, *Drosophila suzukii* reproduction is reduced at temperatures above 30 °C and mortality is 100% at 35 °C for three hours (Van Steenwyck 2010; Walton *et al.* 2010a).
- *Drosophila suzukii* will take advantage of temperate and humid conditions during suitable seasons, and throughout the year in suitable regions, to multiply rapidly (Damus 2009; Dean 2010).

- Areas with cold winters may act as a barrier to spread as *Drosophila suzukii* can have poor over-wintering survival (Kanzawa 1939; Damus 2009; Sato and Sasaki 1995b). However, Australia has relatively short mild winters compared to Northern Asia and North America where this species is established (BOM 2010; JMA 2010; Worldclimate 2010).

- Should *Drosophila suzukii* be introduced to major commercial production areas (of host fruit) in Australia physical barriers are unlikely to be a limiting factor to the spread as the fly has the potential to gradually spread by human activity to all areas in Australia.

- Movement of host fruit would help the dispersal of *Drosophila suzukii* because it infests fruit. The movement of infested fruit is considered a major means of spread for *Drosophila suzukii* (Hauser *et al* 2009; ODA 2010a; EPPO 2010c; EPPO 2011; MPI 2012).

- Initial studies in the native range found one parasite, a gall wasp (*Phaenopria* spp.), that was identified attacking *Drosophila suzukii* (Kanzawa 1939). The generation time of the wasp is twice as long as *Drosophila suzukii* and its value in limiting the population of *Drosophila suzukii* is considered limited (Kanzawa 1939).

- A study across the four main islands of Japan has found *Drosophila suzukii* pupae were parasitised by three parasitoid species; *Asobara tabida*, *Asobara japonica* and *Ganaspis xanthpoda* (Mitsui *et al*. 2007). The rate of parasitism in this study (4.2%) is unlikely to contribute to the control of *Drosophila suzukii* populations in any substantial way. Other studies have confirmed the low association of *Ganaspis xanthpoda* with *Drosophila suzukii* in Japan (Mitsui and Kimura 2010; Kasuya *et al*. 2013).

- Researchers in the USA are also collaborating with researchers in South Korea to identify biological control agents with surveys conducted in 2011 (Brewer *et al*. 2012). Additional surveys were planned for 2012 in cherry producing areas of China (Brewer *et al*. 2012).

- In the USA an *Orius* spp., a native predator, has been observed feeding on the larvae of *Drosophila suzukii* (DAFF 2010). In preliminary laboratory trials predation levels of 11–68% have been recorded when *Orius* spp. are forced to feed on *Drosophila suzukii* (Pers. comm., Dr Jana Lee, ARS, 19 August 2010). Under experiments designed to maximise predation or be more representative of field conditions, predation rates decreased from 68 to 12% respectively (Brewer *et al*. 2011).

- The wasp parasitoid, *Pachycrepoideus vindemiae*, has been collected from *Drosophila suzukii* pupae in the Mid-Columbia and Willamette Valley regions of Oregon (Brewer *et al*. 2012). The abundance of the ecoparasitoid increased during the season as *Drosophila suzukii* population increased (Brewer *et al*. 2011). However, the work of Brewer *et al*. (2011) does not report whether the rate of parasitism increases through the season and whether this would contribute to a significant population effect on *Drosophila suzukii*.

- *Pachycrepoideus vindemiae* has also been recorded attacking *Drosophila suzukii* pupae in Italy and is able to complete a second generation under controlled conditions (Rossi Staconni *et al*. 2013). No information is provided on the level of parasitism although further studies are planned.

- It is not known if native parasites and predators in Australia would limit the abundance and spread of *Drosophila suzukii*. However, laboratory studies in Europe suggest that specialist native parasitoids do not switch host easily (Chabert *et al*. 2012) and *Drosophila suzukii* has also been shown to be resistant to novel parasitic wasp larvae (Kacsoh and Schlenke 2012; Poyet *et al*. 2013). The observed resistance of *Drosophila suzukii* to parasitic wasps could limit successful population suppression by these types of parasitoids.

The suitability of the environment, presence of multiple host species throughout the PRA area, potential for spread in domestic commodities, its ability to disperse independently and proven ability to spread rapidly supports an assessment of 'high' for the spread of this species.

5.3.3 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 13.

The likelihood that *Drosophila suzukii* having entered on imported fruit, or fresh flowers, be distributed in a viable state to suitable hosts, establish in the PRA area and subsequently spread throughout Australia: **Extremely low – High** depending on the host species.

5.4 Consequences

The consequences of the entry, establishment and spread of *Drosophila suzukii* 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 *Drosophila suzukii*	
Criterion	**Estimate and justification**
Direct	
Plant life or health	**F –** Major significance at the regional level *Drosophila suzukii* is known to attack a range of important commercial crops including (and not limited to) strawberry, cherry, stone fruit and grapes (Kanzawa 1939; Bolda *et al* 2010; OSU 2010b). These industries are significant in Australia; – The berry industry (raspberry and other caneberry) is valued at $25 million (PHA 2011). – The strawberry industry production was valued at $308 million in the financial year 2007/2008 (SISP 2009). – The cherry industry was valued at $100 million a year in 2010 (CGA 2010). – The stone fruit industry was valued at approximately $110 million in 2010 at the farm gate (Summerfruit Australia 2010). – The table grape industry is valued at approximately $250 million in financial year 2010/11 (PHA 2011). – The wine grape industry was valued at $4.6 billion in the financial year 2005/2006 (ABS 2007). In the 1930's, *Drosophila suzukii* was considered a major pest on cherry

	and grapes in Japan with damage reaching 80–100% in years and localities (Kanzawa 1939 & 1935). More recently, *Drosophila suzukii* has been recorded to be the main pest damaging cherry in Fukushima Prefecture (Sasaki and Sato 1995a). Damage levels are low at the start of harvest and have been recorded to reach a maximum of 77% by the end of the season (Sasaki and Sato 1995a). Peaches are considered a major host and crop losses of 80% at localities have been recorded (OSU 2010b; ODA 2010a; CPAN 2009). Maximum crop losses of 40% for blueberries, 70% for blackberries and raspberries, and 33% for cherries have been observed in the USA (Bolda *et al* 2010). Similar high levels of damage have been recorded in Italy with damage on a range of crops including apricots (20–50%), cherries (3–46%), strawberries (2–80%), blueberries (30–100%), caneberries (30–100%), and grapes (25–70% (Grassi *et al*. 2011; Grassi and Pallaoro 2012). In Spain, damage in cherry (100%), peaches (10-40%), plums (20%) and strawberry (20%) has also been reported (Escudero *et al*. 2011; Sarto and Sorribas 2011). Similarly, In France, significant damage has been reported on raspberry, strawberry, and cherry (up to 100%) and peach and, apricot (Weydert 2011). An economic analysis for the Italian province of Trentino reports the financial losses to *Drosophila suzukii* for raspberry, strawberry, blackberry, blueberry and cherry were more than €3 000 000 per year or about 11% of the total fruit revenue (Ros *et al*. 2012). Wine grapes are also considered at risk since *Drosophila suzukii* damage allows secondary infections to occur that could reduce the quality of the grape juice (OSU 2009; Walsh *et al*. 2010; Reign of Terroir 2010a). *Drosophila suzukii* has recently been confirmed to have a high association with a species of yeast (Hamby *et al*. 2012). Based on these initial reports in 2009, an estimated average damage across all growing regions could result in a combined damage of US$500 million per year (Bolda *et al* 2010). Bolda *et al*. (2010) caution the values used across industries are estimates and the realised damage into the future will depend on many factors. Later work that accounts for price elasticity due to decreased supply estimate a lower cost to producers through increased prices for the remaining produce that meets commercial requirements (Goodhue *et al*. 2011). In the USA in 2010, the levels of damage are much lower and no significant damage has been recorded (Bolda 2009; OSU 2010c; ODA 2010b). The low damage levels observed in 2010 are considered to be due to the adoption of monitoring and spraying programs by commercial growers (Bolda 2009; OSU 2010c). Recent economic analysis supports the cost effectiveness of applying insecticides to control *Drosophila suzukii* (Goodhue *et al*. 2011). In contrast, residential and 'pick your' growers, are recording high levels of damage (OSU 2010c). In commercial situations in Oregon and Washington, when orchards are poorly managed, trap catches of *Drosophila suzukii* are increasing as the season progresses and there is potential for commercial losses (OSU 2010c). However, it is likely the distribution and abundance of *Drosophila suzukii* will be affected by environmental conditions (see section 3.4.3 Ecology). High levels of damage are more likely in regions with moderate temperatures and high humidity. For example, there are no reports of damage over summer from the arid central valley of California. In Australia, the climatic conditions of the major inland fruit producing regions (e.g. the Riverland, Sunraysia and the Riverina) have similar climates to the central valley (BOM 2010). If not managed, this pest could threaten the economic viability of commercial producers in a range of commodities across Australia where the environment is suitable. Other host plants in the environment, including residential plants will be affected by *Drosophila suzukii* attack. Infested fruit is not suitable for consumption.
Any other aspects of environment	**B-** Minor significance at local level There may be some impact on insect or animal species that feed on host

	plants due to the reduced availability of fruits through larval competition or highly damaged fruits. *Drosophila suzukii* is less likely to affect the reproduction of plants as there is no record that larval feeding affects seed production or viability. However, poor quality fruit from larval feeding may reduce bird and mammal dispersal of seeds.
Indirect	
Eradication, control, etc.	**E-** Major significance at district level There are no insecticides registered for the control *of Drosophila suzukii* (PUBCRIS 2010). However, there are several insecticides registered for use on host plants in Australia that have been shown to be effective in the USA (OSU 2010d). The use of some key insecticides, for internal feeding pests, permitted for use in several crops in Australia are currently under review and their use has been restricted (APVMA 2011 and 2012). Trapping of *Drosophila suzukii* proved cost effective in limiting damage over four years at multiple locations with damage reduced from 50% to 3.6% in Japan (Kanzawa 1939). However, effective control was obtained by placing a trap on every fruit bearing tree that was inspected every three days (Kanzawa 1939). Today's labour costs may limit the cost effectiveness of this type of trapping. Eradication of *Drosophila suzukii* would require the removal of large numbers of native, amenity, weedy and commercial host fruit within the vicinity of outbreaks and/or the broad scale application of insecticides to control adult and juvenile life stages. Due to the large number of host plants affected, the likely human assisted and natural spread the costs of any eradication campaign are likely to be substantial. However*, Drosophila suzukii* has recently been found in multiple countries and none have attempted eradication. The high reproductive capacity and dispersal abilities of this pest would make early detection vital if eradication was to be successful. According to information supplied by the USA reports there has been no damage recorded for host commodities from commercial orchards with targeted management strategies (USDA 2010). However, recent reports show infested fruit can be detected at pack house when commercial insecticide application has occurred (WSU 2012). While potentially able to be managed in commercial production, the presence of *Drosophila suzukii* will increase the production costs through the regular application of broad spectrum insecticides (OSU 2010c; Bruck *et al*. 2011). The application of insecticides could also affect integrated pest management programs that could allow currently manageable pests to increase in importance. *Drosophila* spp. have been shown to vector plant pathogens (Schneider 2000) and *Drosophila suzukii* has been reported to vector yeasts and bacteria (Walsh *et al*. 2010; Hamby *et al*. 2012). However, it is not clear whether oviposition by *Drosophila suzukii* vectors yeasts and bacteria or simply allows an entry point for endemic species to colonise fruit that are subsequently associated with *Drosophila suzukii*. The yeast most commonly associated with *Drosophila suzukii* in the USA, *Hanseniaspora uvarum* (Hamby *et al.* 2012), is present in Australia (APPD 2012). However, no new pathogens have been reported from areas where *Drosophila suzukii* have established in recent years. The consequences of yeast or bacteria that may be associated with the pest are likely to be low.
Domestic trade	**E** Major significance at district level The presence of *Drosophila suzukii* in production areas would likely result in domestic movement restrictions for host commodities. Currently, the only effective post harvest control control methods are methyl bromide fumigation or SO_2/CO_2 fumigation followed by a six day cold treatment. These post harvest treatments could significantly affect the quality of fruit and production costs.
International trade	**E-** Major significance at district level

	The presence of *Drosophila suzukii* in production areas would limit access to some overseas markets and make market access negotiations more difficult. Some important markets for Australian host fruit, such as Japan, Korea, Thailand and China, already have the pest but other areas do not (e.g. New Zealand). Due to the importance and value of some host fruits, disruption to trade is expected to be significant to growers and production areas.
Environmental and non-commercial	**D –** Significant at local level Large scale removal of alternate host plants may affect the environment. Broad-scale application of broad spectrum insecticides directed against *Drosophila suzukii* would have some impacts on native insects.

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**.

5.5 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 *Drosophila suzukii* for fresh fruit and fresh flower pathways are set out in Table 5.1.

5.6 Risk assessment conclusion

The results of the pathway risk assessments for *Drosophila suzukii* are set out in Table 5.1.

The unrestricted risk for *Drosophila suzukii* for the fruit pathways, depending on the host, has been assessed as from '**low**–**high'**, which is above Australia's ALOP. Therefore, specific risk management measures are required to ensure that the pest does not enter, establish and spread though the fresh fruit pathway.

The unrestricted risk for *Drosophila suzukii* for the fresh flower pathways has been assessed as '**very low'**, which achieves Australia's ALOP. Therefore, specific risk management measures are not required to ensure that the pest does not enter, establish and spread though the fresh flower pathways.

Table 5.1: Summary of pathway risk assessments for *Drosophila suzukii*

<table>
<tr><th rowspan="3">Pathway</th><th colspan="3">Entry</th><th rowspan="3">Establishment</th><th rowspan="3">Spread</th><th rowspan="3">P[EES]</th><th colspan="7">Consequences</th><th rowspan="3">URE</th></tr>
<tr><th rowspan="2">importation</th><th rowspan="2">distribution</th><th rowspan="2">Overall</th><th colspan="2">direct</th><th colspan="4">indirect</th><th rowspan="2">Overall</th></tr>
<tr><th>PLH</th><th>OE</th><th>EC</th><th>DT</th><th>IT</th><th>ENC</th></tr>
<tr><td>Rubus spp.</td><td>H</td><td>H</td><td>H</td><td rowspan="16">H</td><td rowspan="16">H</td><td>H</td><td rowspan="16">F</td><td rowspan="16">B</td><td rowspan="16">E</td><td rowspan="16">E</td><td rowspan="16">E</td><td rowspan="16">D</td><td rowspan="16">H</td><td rowspan="7">H</td></tr>
<tr><td>Cherry</td><td>H</td><td>H</td><td>H</td><td>H</td></tr>
<tr><td>Stone fruit</td><td>H</td><td>H</td><td>H</td><td>H</td></tr>
<tr><td>Strawberry</td><td>H</td><td>H</td><td>H</td><td>H</td></tr>
<tr><td>Blueberry</td><td>H</td><td>H</td><td>H</td><td>H</td></tr>
<tr><td>Table grape</td><td>M</td><td>H</td><td>M</td><td>M</td></tr>
<tr><td>Mulberry & figs</td><td>H</td><td>H</td><td>H</td><td>H</td></tr>
<tr><td>Hardy kiwi</td><td>L</td><td>H</td><td>L</td><td>L</td><td rowspan="2">M</td></tr>
<tr><td>Currant & gooseberry</td><td>L</td><td>H</td><td>L</td><td>L</td></tr>
<tr><td>Concord grape</td><td>VL</td><td>H</td><td>VL</td><td>VL</td><td>L</td></tr>
<tr><td colspan="4">Other host fruit</td><td></td><td></td></tr>
<tr><td>Silver berry</td><td>M</td><td>H</td><td>M</td><td>M</td><td>H</td></tr>
<tr><td>Dogwood</td><td>M</td><td>H</td><td>M</td><td>M</td><td>H</td></tr>
<tr><td>Red bayberry</td><td>M</td><td>H</td><td>M</td><td>M</td><td>H</td></tr>
<tr><td>Pokeweed</td><td>M</td><td>H</td><td>M</td><td>M</td><td>H</td></tr>
<tr><td>Fresh flowers</td><td>EL</td><td>M</td><td>EL</td><td>EL</td><td>VL</td></tr>
</table>

Key to Table 5.1

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

Assessment of consequences from pest entry, establishment and spread

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
A-G	consequence impact scores are detailed in section 2.2.3

- A Indiscernible at the local level
- B Minor significance at the local level
- C Significant at the local level
- D Significant at the district level
- E Significant at the regional level
- F Significant at the national level
- G Major significance at the national level

URE unrestricted risk estimate. This is expressed on an ascending scale from negligible to extreme

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 *Drosophila suzukii* 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 assessment identified many fruit hosts that had an unrestricted risk above Australia's ALOP. The proposed pest risk management measures and operational system proposed for *Drosophila suzukii* for these pathways are summarised in Table 6.1.

Table 6.1: Phytosanitary measures proposed for *Drosophila suzukii*

Pest	Pathway	Measures
Drosophila suzukii	Fresh fruit	Area freedom*; or Systems approach for fruit with pre- and post-harvest measures; or Fruit treatment known to be effective against all life stages of *Drosophila suzukii* (e. g. methyl bromide fumigation)
* Area freedom may include pest free areas, pest free places of production or pest free production sites		

This PRA was conducted to meet Australia's international obligations in response to the introduction of emergency measures for *Drosophila suzukii*. Unlike a commodity focused import risk analysis, that assesses the risk of pests establishing in Australia from one country, this PRA considers all pathways that could allow the introduction and establishment of this pest. Given the number of pathways *Drosophila suzukii* could enter Australia, and the number of countries from which commodities could be sourced, suitable risk management measures have not been developed for all pathways, or to a standard that they could be considered a standalone treatment.

Subject to the provision of suitable efficacy data, DAFF 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 *Drosophila suzukii* from all sources into Australia. While the following measures are considered feasible by DAFF, any other measure that provides an equivalent level of protection would be considered.

Note that these measures are for *Drosophila suzukii* and are in addition to the existing import conditions for the commodities covered by this PRA.

6.1.1 Fresh fruit

The pathway risk assessment identified fruits from several species 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 host fruit could be infested with the eggs, larvae and/or pupae, or contaminated with adults of *Drosophila suzukii* and that these infested fruit or adult flies may not be detected and enter Australia, leading to the establishment and spread of *Drosophila suzukii*. A number of options may be available to reduce these risks.

Area freedom from *Drosophila suzukii*

Area freedom is a measure that might be applied to manage the risk posed by *Drosophila suzukii.* 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 *Drosophila suzukii* 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 DAFF.

Systems approach for fruit

A systems approach that uses the integration of different risk management measures, at least two of which act independently, and which cumulatively achieve the required level of phytosanitary protection could be used to reduce the risk of *Drosophila suzukii* being imported to Australia with consignments of host fruit. More information on a systems approach is set out in ISPM No. 14: *The use of integrated measures in a systems approach for pest risk management* (FAO 2002).

DAFF considers a systems approach to address the risks posed by *Drosophila suzukii* on host fruit may be feasible. This approach could be based on a combination of fruit protection, crop monitoring and pest control with post-harvest measures. Crop monitoring could support areas of low pest prevalence as per ISPM No. 22: *Requirements for the establishment of areas of low pest prevalence* or a 'seasonal window' when climatic conditions limit the activity of *Drosophila suzukii*. The approach could be used to progressively reduce the risk of infested fruit being imported to Australia with consignments of fruit.

DAFF will consider the effectiveness of any system proposed by exporting countries for their commodities.

Treatment of fruit

A treatment that is known to be effective against all life stages of *Drosophila suzukii* is a measure that might be applied to manage the risk posed by this pest in imports of host fruit. Treatment of fruit, with suitable efficacy, would reduce the probability of entry of infested fruit to at least 'extremely low'. The unrestricted risk would then be reduced to at least 'very low', which would achieve Australia's ALOP.

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

Methyl Bromide fumigation

DAFF reviewed preliminary methyl bromide fumigation efficacy data supplied by the USA that has shown 100% mortality on all life stages. Methyl bromide fumigation of exported fruit is a treatment that could achieve Australia's ALOP as a standalone treatment. However, before methyl bromide could be recommended as a permanent quarantine measure for *Drosophila suzukii* in a specific fruit, a complete efficacy treatment proposal would need to be reviewed and accepted by DAFF. Subsequent to the draft PRA report, the USA provided full treatment efficacy reports for several host fruit species for Australia's consideration. The data presented included:

Strawberry

The USA provided a report supporting methyl bromide fumigation as a standalone measure to manage *Drosophila suzukii* in fresh strawberry. The rate proposed was the existing methyl bromide schedule in ICON:

48gm/m^3 for three hours at a pulp temperature of 18 °C or greater.

DAFF reviewed this information and considered it suitable to manage the risk of *Drosophila suzukii* on fresh strawberries from the USA. This work was later published (Walse *et al*. 2012). Stakeholders were notified of the acceptance of this treatment on 6 April 2011 by a public quarantine alert (PQA0715).

Cherry

The USA provided a report supporting methyl bromide fumigation as a standalone measure to manage *Drosophila suzukii* in fresh cherry. The rates proposed were:

48gm/m^3 for two hours at a pulp temperature of 13.9 °C or greater

56gm/m^3 for two hours at a pulp temperature of 12.2 °C or greater

64gm/m^3 for two hours at a pulp temperature of 10.6 °C or greater

72gm/m^3 for two hours at a pulp temperature of 8.3 °C or greater.

DAFF reviewed this information and considered it suitable to manage the risk of *Drosophila suzukii* on fresh cherries from the USA. Stakeholders were notified of the acceptance of this treatment on 23 April 2012 by a public quarantine alert (PQA0810).

Stone fruit (peaches and nectarines only)

The USA provided a report supporting methyl bromide fumigation as a standalone measure to manage *Drosophila suzukii* in fresh peaches and nectarines. The rate proposed was:

48gm/m^3 for two hours at a pulp temperature of 13.9 °C or greater

DAFF reviewed this information and considered it suitable to manage the risk of *Drosophila suzukii* on fresh stone fruit from the USA. The acceptance of this treatment for *Drosophila suzukii* completes the outstanding requirements for the USA stone fruit

IRA[3]. Peaches and nectarines can now be allowed entry subject to operational arrangements being developed.

Cold treatment

Cold treatment is another measure that may be suitable in managing the risk of *Drosophila suzukii* infested fruit. There is original research conducted in Japan that shows mortality of eggs and larvae can reach 100% after 96 hours exposure to temperatures of 1.7–2.2 °C (Kanzawa 1939). However, replication levels in this trial are low (<100 eggs or larvae), did not replicate commercial conditions and were not conducted to current international standards accepted by importing countries. However, before a cold treatment could be recommended as a quarantine measure, a complete efficacy treatment proposal, showing mortality of all life stages, would need to be reviewed and accepted by DAFF. Alternatively, a cold treatment effective against internal life stages combined with a treatment to remove external life stages (adults) could be considered suitable. Subsequent to the draft PRA report, the USA provided a full treatment efficacy report for table grapes for Australia's consideration. The data presented included,

Table grape

The USA provided a report supporting a combination treatment of SO_2/CO_2 fumigation followed by a cold disinfestation treatment as a measure to manage *Drosophila suzukii* in fresh table grapes. The treatment proposed was;

> 6% carbon dioxide (CO_2) and 1% sulfur dioxide (SO_2) by volume for 30 minutes, at a pulp temperature of 15.6°C (60°F) or greater, followed by;
>
> A cold treatment for 6 days or more at a pulp temperature of –0.50°C ± 0.50°C

DAFF reviewed this information and considered it suitable to manage the risk of *Drosophila suzukii* on fresh table grapes from the USA. Stakeholders were notified of the acceptance of this treatment on 12 June 2012 by a public quarantine alert (PQA0822).

Additional post treatment security measures may be required in the packing house to limit post harvest contamination by flies that are attracted to ripe fruit.

Alternate treatments

If other treatments effective against *Drosophila suzukii* could be demonstrated to a suitable efficacy for host fresh fruit, 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.

Treatments for fruit by other methods will be considered by DAFF if proposed by the exporting country.

Commercial fruits not considered as hosts for *Drosophila suzukii*

The PRA identified fruit pathways, based on the consideration of commercial quality fruit, as defined in the scope of the PRA. In addition to the host fruits assessed to be

[3] http://www.daff.gov.au/ba/ira/final-plant/stonefruit-usa

above Australia's ALOP, the PRA also identified several fruits that can be attacked by *Drosophila suzukii* when damaged or over-ripe, and provide a pathway for this pest to enter Australia (Appendix B). It is likely that *Drosophila suzukii* could attack a wide range of fresh fruits if they are damaged or over-ripe. To ensure fresh fruits that are not considered hosts of *Drosophila suzukii* are not pathways for the entry and establishment of this pest, commercial fruit quality standards will need to be maintained for fresh fruit by the exporting country where *Drosophila suzukii* is known to occur.

The mandatory DAFF inspection of commodities (off-shore pre-shipment or on-arrival), for imported fresh fruit from countries where *Drosophila suzukii* is known to occur, will verify the quality standard of the fruit exported to Australia. Mandatory off-shore pre-shipment inspection is not considered necessary to manage the risk of adults associated with non-host commodities. For example, there have been no detections of *Drosophila suzukii* on currently imported commodities from Asian countries where the pest is native.

Suspected and other fruit hosts

The PRA identified the fruits of several taxa from *Rubus* and *Prunus* genera that have been recorded to be associated with *Drosophila suzukii* without confirmation that undamaged ripe fruit can be attacked before harvest. These species are suspected to be fruit hosts because of the high association of *Drosophila suzukii* with other species in those genera (Appendix B). The PRA also identified the fruits of many other species associated with *Drosophila suzukii* from non-commercial situations such as backyards or wild environments (Appendix B). If an application to import the fruit of these species, or other species from those genera, identified in Appendix B is made, DAFF will review the latest information on the host association of these suspected and other fruit hosts, before these species can be imported into 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.

DAFF 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 production sites

All export production sites (e.g. green houses, orchards etc) and growers will be required to be registered with the NPPO.

The objectives of this proposed procedure are to ensure that:

- fruit is only sourced from registered commercial production sites as the pest risk assessments are based on commercial quality fruit
- fruit is only sourced from NPPO registered export production sites that can be used for trace-back and auditing purposes.

Registration of packing houses/treatment facilities and auditing of procedures

All packing houses and treatment facilities 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 export production sites, or another suitable identifier, so cartons and pallets (that is, one source per pallet) can be labelled for identification. Packed cartons and pallets must carry this information.

The objectives of this proposed procedure are to ensure that:

- fruit is only sourced from NPPO registered packing houses/treatment facilities where fruit is cleaned and graded to export standard to ensure it is not contaminated by quarantine pests or regulated articles[4]
- registration details must be provided to DAFF on request for trace-back and auditing purposes. Where fruit is treated prior to export, this process must only be undertaken in facilities that have been approved by the NPPO for that purpose. Copies of registration and treatment facility test records would need to be made available to DAFF on request.
- Audits may be conducted on the entire phytosanitary system at the discretion of DAFF and as a component of any off-shore pre-shipment inspection arrangement, if such an arrangement is entered into.

Packaging and labelling

The objectives of this proposed procedure are to ensure that:

- secure packaging is used to ensure that fruit of host species is not re-contaminated after washing, grading and packing with quarantine pests or regulated articles (e.g. trash, soil and weed seeds)

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[4] 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’.

- 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 DAFF conditions (see DAFF publication '*Cargo Containers: Quarantine aspects and procedures*' at http://www.daff.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 DAFF.

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 conduct pre-export inspections 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. This equates to a level of zero units infested/infected by quarantine pests in a random sample size of 600 units from the homogenous inspection lot[5] in the consignment[6], where one unit is one fruit or one bunch of fruit depending on the commodity.

NPPO pre-export inspection will be undertaken prior to the DAFF inspection.

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 DAFF 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.

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5 An inspection lot is the number of boxes presented for a single phytosanitary inspection.

6 A consignment is the number of boxes of fresh fruits in a shipment to Australia covered by one phytosanitary certificate.

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 for known fruit hosts

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 host fruit of* Drosophila suzukii *to Australia and inspected and found free of quarantine pests*

This is 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 DAFF verifying that the relevant measures have been undertaken offshore.

Off-shore pre-shipment or on-arrival phytosanitary inspection by DAFF

Consignments will be inspected by DAFF using the standard DAFF inspection procedures. 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[7]. No land bridging of goods will be permitted unless goods have cleared quarantine.

In consultation with the NPPO, DAFF may complete the inspection as an off-shore pre-shipment inspection in the exporting country. For off-shore pre-shipment inspections, DAFF will confirm documentation requirements for an expression of interest to export, where applicable. Consignments inspected and passed by DAFF officers pre-shipment may be released on arrival following a verification of the documentation accompanying the consignment to confirm the status of the fruit.

The objectives of this proposed procedure are to ensure that:

- all consignments/inspection lots are inspected by DAFF 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.

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

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 DAFF is satisfied that trade can recommence under the conditions set out in this pest risk analysis.

7 Conclusion

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

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

Appendices

Appendix A: Categorisation of spotted wing drosophila (*Drosophila suzukii*)

Pest	Distribution	Potential to be present on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
DOMAIN ANIMALIA						
Order DIPTERA						
Drosophila suzukii Matsumura [Drosophilidae]	Asia, North America, Central and South America, Europe (see Table 3.1).	Yes. *Drosophila suzukii* is known to infest a range of fresh fruit before harvest (Kanzawa 1939) and has the potential to be imported on a number of fresh fruit pathways	No records found.	Yes. *Drosophila suzukii* has established and spread outside its native range (Hauser *et al*. 2009).	Yes. *Drosophila suzukii* is known to cause economic damage to a range of commercial fruits (Bolda *et al*. 2010).	**Yes**

Appendix B: Plant taxa associated with spotted wing drosophila (*Drosophila suzukii*)

Host	Common name	Host association	Present in Australia	Consider further
Actinidiaceae				
*Actinidia arguta (*Siebold & Zucc.) Planch. ex Miq.	Hardy kiwis	Adult flies reared from field collected fruit (Dreves *et al*. 2009; DAFF 2010).	Yes (Hibbert 2004)	**Yes**
Actinidia chinensis Planch.	Chinese gooseberries	*Actinidia* spp. have been recorded as potential hosts in Canada though the plant species was not recorded and larvae were not reared out to species to confirm *Drosophila suzukii* (Hueppelsheuser 2009; BCMAL 2009). DAFF has contacted the author the pest alerts and they confirmed fly maggots were found in *Actinidia arguta* (Pers. comm., Tracey Hueppelheuser, British Columbia Ministry of Agriculture and Lands, 1 Sept 2010). *Actinidia deliciosa* and *Actinidia deliciosa* are grown in Northwest USA (Strik 2005) and there are no reports of either species being attacked by *Drosophila suzukii.*	Yes (Hibbert 2004)	No
Actinidia deliciosa (A. Chev.) C. F. Liang & A. R. Ferguson	Kiwi fruit		Yes (Hibbert 2004)	No
Adoxaceae				
Viburnum dilatatum Thunb.	Linden viburnum	Reared from fallen fruit only (Mitsui *et al*. 2010).	Yes (Randall 2007)	No
Sambucus cerulea Raf.	Blue elderberry	Recorded as a non-crop host from Canada (Acheampong 2011a). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species	Yes (Randall 2007)	No

Host	**Common name**	**Host association**	**Present in Australia**	**Consider further**
Sambucus nigra L.	Black elder, European elder	Recorded as a non-crop host from Italy (Grassi *et al*. 2011). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species	Yes (Randall 2007)	No
Berberidaceae				
Berberis aquifolium Pursh [=*Mahonia aquifolium*]	Oregon-grape	Recorded as a non-crop host from Canada (Acheampong 2011a). In one study, larvae in over-ripe fruit did not complete development to adults (Brewer *et al*. 2012). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species	Yes (Randall 2007)	No
Buxaceae				
Sarcococca hookeriana Baill.	Sweet box	Reported as a host from non commercial fruit (Brewer *et al*. 2012). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Yes (Randall 2007)	No
Caprifoliaceae				
Lonicera japonica Thunb.	Japanese honey suckle	Reported as a host from non commercial fruit (Dreves and Langelloto-Rhodaback (2011). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Yes (Randall 2007)	No

Host	Common name	Host association	Present in Australia	Consider further
Symphoricarpos spp.	Snowberrry	Reported as a host from non commercial fruit (Dreves and Langelloto-Rhodaback (2011). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Several species of the genus are present in Australia (Randall 2007)	No
Cornaceae				
Alangium platanifolium (Sieb. et Zucc.) Harms		Reared from fallen fruit only (Mitsui *et al*. 2010).	Yes (Hibbert 2004)	No
Cornus amomum Mill.	Silky dogwood	Recorded as a non crop host (Isaacs 2012). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Yes (Randall 2007)	No
Cornus controversa Hemsl. ex Prain	Dogwood	Reared from fallen fruit only (Mitsui *et al*. 2010).	Yes (Hibbert 2004)	No
Cornus foemina Mill.	Stiff dogwood	Recorded as a non crop host (Isaacs 2012). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	No record found	No
Cornus kousa Hance	Dogwood, Japanese dogwood	Recorded as a host (BCMAL 2009). Several adults have been reported to emerge from fruits collected directly from the plant in one location (Pers comm., M. Damus, 16 December 2010).	Yes (Hibbert 2004)	**Yes**

Host	**Common name**	**Host association**	**Present in Australia**	**Consider further**
Cornus serica L.	Red-twig dogwood	Reported as a host from non commercial fruit (Brewer *et al*. 2012). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Yes (Randall 2007)	No
Ebenaceae				
Diospyros kaki Thunb.	Persimmon	Although listed as a host (ODA 2009), adults have only emerged from fruit that was either split, damaged, dropped or cut (Kanzawa 1939).	Yes (Hibbert 2004)	No
Diospyros virginiana L	American persimmon	Recorded as a larval host from backyard grown fruit (Maier 2012). There are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Yes (Randall 2007)	No
Elaegnaceae				
Elaeagnus multiflora Thunb.	Silver berry	Recorded from whole fruit (Kanzawa 1939).	Yes (Hibbert 2004)	**Yes**
Elaeagnus umbellata Thunb.	Autumn olive	Recorded as a non crop host (Isaacs 2012). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Yes (Randall 2007)	No
Hippophae rhamnoides L.	Sea buckthorn	Reported as a host from non commercial fruit (Dreves and Langelloto-Rhodaback (2011). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Yes (Randall 2007)	No

Host	Common name	Host association	Present in Australia	Consider further
Ericaceae				
Arbutus unedo L.	Strawberry tree	Infested fruit collected from uncultivated environments (EPPO 2012c). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	A hybrid with *Arbutus unedo* a parent in present in Australia (Randall 2007)	No
Gaultheria adenothrix (Miq.)	Akamono	Reared from fallen fruit only (Mitsui *et al*. 2010).	Yes (Randall 2007)	No
Gaultheria shallon Pursch	Salal	Reported as a host from non commercial fruit (Brewer *et al*. 2012). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Yes (Randall 2007)	No
Vaccinium myrtillus L.	Bilberry	Recorded host under rearing conditions (Grassi *et al*. 2011)	Yes (Randall 2007)	**Yes**
Vaccinium angustifolium Aiton	Blueberry	Injurious to fruit in Japan (Uchino 2005).	Yes (Hibbert 2004)	**Yes**
Vaccinium corymbosum L.				

Host	**Common name**	**Host association**	**Present in Australia**	**Consider further**
Vaccinium macrocarpon Aition	Cranberry	It has been reported in the media that cranberry may be a host (Yardborough 2012) and there is now a report of commercial cranberry being attacked without details of the status of the attacked fruit (Demchak *et al*. 2012). Recent work has shown that cranberry does not appear to be a host for *Drosophila suzukii* as no eggs were detected at any stage of cranberry ripeness in laboratory oviposition trials (Brewer *et al*. 2012). Although import conditions for fresh fruit from New Zealand exist, imports do not occur from where *Drosophila suzukii* is known to occur, DAFF will continue to assess the host status of this species,	Yes (Randall 2007)	No
Garryaceae				
Aucuba japonica Thunb.	Spotted laurel, Japanese laurel	Reared from fallen fruit only (Mitsui *et al*. 2010). Another unnamed species is recorded as an oviposition host but adults failed to develop (Brewer *et al*. 2012).	Yes (Hibbert 2004)	No
Grossulariaceae				
Ribes spp.	Black currant, Red currant	Recorded as a host (NAPPO 2010a). However, Canadian authorities have confirmed *Ribes* spp. are hosts only when damaged (Pers. comm., Martin Damus, CFIA, 22 April 2010).It is recommended that commercial currants are sprayed to manage *Drosophila suzukii* in the USA (DeFrancesco and Bell 2012) but there are no records that damage has occurred in the USA. Currants have been confirmed as a host from non-commercial fruit in British Columbia (BCMA 2011). There are import conditions for fresh fruit exist and these species will be considered in more detail.	Yes (Hibbert 2004)	**Yes**

Host	Common name	Host association	Present in Australia	Consider further
Ribes uva-crispa	Gooseberry	It is recommended that commercial gooseberries are sprayed to manage *Drosophila suzukii* in the USA (DeFrancesco and Bell 2012) but there are no records damage has occurred. There is a single report that gooseberry is a development host under laboratory conditions (Brewer *et al*. 2012).	Yes (Hibbert 2004)	**Yes**
Lauraceae				
Lindera benzoin (L.) Blume	Spice bush	Recorded as a non crop host (Isaacs 2012). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Yes (Randall 2007)	No
Moraceae				
Ficus carica L.	Figs	Recorded as a host (Dreves *et al*. 2010; OSU 2010b) although there are no reports of damage even though *Drosophila suzukii* has been trapped near figs (Peerbolt 2010). Figs have only been recorded to be attacked when the fruit is over-ripe (Pers. comm., Dr Vaughn Walton, OSU, 12 October 2010). However, figs were recorded as a host in Italy (Grassi *et al*. 2011).	Yes (Hibbert 2004)	**Yes**
Maclura pomifera (Raf.) C. K. Schneid.	Osage orange	Reported as a host from non commercial fruit (Dreves and Langelloto-Rhodaback (2011). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Yes (Randall 2007)	No
Morus alba L.	Mulberry	Adult flies can emerge from whole fruit (Kanzawa 1939).	Yes (Hibbert 2004)	**Yes**

Host	**Common name**	**Host association**	**Present in Australia**	**Consider further**
Morus australis Poir. [=*Morus bombycis* Koidz.]	Silkworm mulberry	Reared from fallen fruit only (Mitsui *et al*. 2010). However, other species in this genus have been confirmed to be attacked at high levels and this species is a suspected host.	Yes (Hibbert 2004)	**Yes**
Morus nigra L.	Black mulberry	Recorded host under rearing conditions (Grassi *et al*. 2011)	Yes (Randall 2007)	**Yes**
Morus rubra L.	Red mulberry	Recorded as a host (FDACSa 2010).	Yes (Randall 2007)	**Yes**
Musaceae				
Musa acuminata Colla x *M. balbisiana* Colla	Bananas	Over ripe fruit only (Price and Nagle 2009).	Yes (BA 2008)	No
Myricaceae				
Myrica rubra Lour.	Red Bayberry	Recorded as a host (Wu *et al*. 2007).	Yes (Randall 2007)	**Yes**
Myrtaceae				
Eugenia uniflora L.	Surinam Cherry	Recorded as a host (FDACS 2010a). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Yes (Hibbert 2004)	No
Psidium cattleianum Sabine	Strawberry guava	Recorded from rotting fruit only (Kido *et al*. 1996).	Yes (Randall 2007)	No
Phytolaccaceae				
Phytolacca americana L.	American pokeweed	Adult flies reared from field collected fruit (Sasaki & Sato 1995c).	Yes (Hibbert 2004)	**Yes**

Host	Common name	Host association	Present in Australia	Consider further
Rhamnaceae				
Frangula alnus Mill (*syn = Rhamnus frangula* L.)	Alder buckthorn	Recorded as a non-crop host from Italy (Grassi *et al*. 2011). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Yes (Randall 2007)	No
Rhamnus alpina L. ssp *fallax* (Bioss.) Maire & Petitm.		Recorded as a non-crop host from Italy (Cini *et al*. 2012). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	No record found	No
Rosaceae				
Cerasus mahaleb L. *(*syn=*Prunus mahalab)*	Mahaleb cherry	Recorded as a host from whole fruit (Kanzawa 1939).	Yes (Hnatiuk 1990)	**Yes**
Cerasus vulgaris L. (syn=*Prunus cerasus)*	Dwarf cherry	Recorded as a host from whole fruit (Kanzawa 1939).	Yes (Hibbert 2004)	**Yes**
Cotoneaster sp. *(species not identified)*	Cotoneaster	A species from this genus is reported as an oviposition host but larvae failed to develop to adults (Brewer *et al*. 2012).	Yes (Randall 2007)	No
Crataegus spp.	Hawthorne	Reported as a host from non commercial fruit (Dreves and Langelloto-Rhodaback (2011). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Several species of the genus are present in Australia (Randall 2007)	No

Host	**Common name**	**Host association**	**Present in Australia**	**Consider further**
Eriobotrya japonica (Thunb.) Lindl.	Loquat	Only on damaged fruit or cut surfaces (Kanzawa 1939).	Yes (Hibbert 2004)	No
Fragaria x *ananassa* Duchesne ex Rozier (syn = *Fragaria* x *grandifolia,* Ehrs)	Strawberry	Recorded as a host from whole fruit (Kanzawa 1939).	Yes (Hibbert 2004)	**Yes**
Malus domestica Borkh.	Apples	Apples have been recorded as a host (ODA 2009; Dreves *et al*. 2009; APHIS 2010). However, only damaged or dropped fruit are attacked (Kanzawa 1939).	Yes (Hibbert 2004)	No (see section 4.1 for more detail)
Malus spp. (species not identified; possibly *Malus sylvestris* (L.) Mill.)	Crabapple	Crab apples from unmanaged environments have been recorded as a host (Caprile 2012).There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Yes (Randall 2007)	No
Prunus armeniaca L.	Apricots	Recorded as a host from dropped fruit (Kanzawa 1939). Attack has been recorded from very late fruit (Coates 2009). More recently it has been reported from Corsica (EPPO 2011; Grassi *et al*. 2011) from commercial apricots in Italy and North America (Shearer *et al*. 2010; Grassi *et al*. 2011).	Yes (Hibbert 2004)	**Yes**
Prunus armeniaca x *salicina*	Plumcots	Recorded as a host (Bolda 2009).	No record found	**Yes**
Prunus avium (L.) L.	Cherry	Preferred host (Kanzawa 1939).	Yes (Hibbert 2004)	**Yes**

Host	Common name	Host association	Present in Australia	Consider further
Prunus buergeriana Miq.	Shirozakura	Adult flies reared from field collected fruit (Sasaki & Sato 1995c).	No record found	**Yes**
Prunus caroliniana Aiton	Sherry laurel	Adults collected in a multi-lure trap set near *Prunus caroliniana* and there are no reports of larvae in fruit (Tri-ology 2009). Another publication states *P. caroliniana* is a host (FDACS 2010b).	Yes (Randall 2007)	**Yes**
Prunus domestica L.	Plum	Recorded as a host from whole fruit (Kanzawa 1939).	Yes (Hibbert 2004)	**Yes**
Prunus donarium Sieber	Wild cherry	Recorded as a host from whole fruit (Kanzawa 1939).	No record found	**Yes**
Prunus japonica Thunb.	Korean cherry	Adult flies reared from field collected fruit (Sasaki & Sato 1995c).	Yes (Randall 2007)	**Yes**
Prunus laurocerasus L.	cherry-laurel	Recorded host under rearing conditions (Grassi *et al*. 2011).	Yes (Randall 2007)	**Yes**
Prunus lusitanica L.	Portuguese laurel	Reported as a host from non commercial fruit (Brewer *et al*. 2012). This species will considered further because of the high association of *Drosophila suzukii* with the *Prunus* genus.	Yes (Randall 2007)	**Yes**
Prunus maritima Marshall	Beach plum	Recorded as a larval host from wild grown fruit (Maier 2012). However, the intact fruit of many other species in the genus have been recorded to be attacked and this species is a suspected host.	Yes (Randall 2007)	**Yes**
Prunus mume Siebold & Zucc.	Asian plum/Japanese apricot	Recorded as a host in California (Hauser & Damus 2009).	Yes (Hibbert 2004)	**Yes**

Host	Common name	Host association	Present in Australia	Consider further
Prunus nipponica Matsumura		Reared from fallen fruit only (Mitsui *et al*. 2010). However, the high association of *Drosophila suzukii* with this genus suggests this species is likely to be attacked and it is a suspected host.	Yes (Randall 2007)	**Yes**
Prunus persica (L.) Batsch	Peaches	Adult flies reared from field collected fruit (Sasaki & Sato 1995c).	Yes (Hibbert 2004)	**Yes**
Prunus persica var*. nucipersica* (Suckow) C. K. Schneid. (syn. = *Prunus persica var. nectarina* (Aiton) Maxim.)	Nectarines	Recorded as a host in California (Hauser & Damus 2009; Caprile 2012).	Yes (Hibbert 2004)	**Yes**
Prunus salicina Lindl.	Japanese plum	Recorded as a host in California (Bolda *et al*. 2009).	Yes (Hibbert 2004)	**Yes**
Prunus sargentii Rehder	Sargents cherry	Recorded as a host from whole fruit (Kanzawa 1935).	Yes (RBGSYD 2010)	**Yes**
Prunus serrulata Lindl. var. *spontanea* (Maxim.) E. H. Wilson (syn=*Prunus jamasakura* Siebold ex Koidz.)	Japanese mountain cherry	Adult flies reared from field collected fruit (Sasaki & Sato 1995c).	Yes (Hibbert 2004)	**Yes**
Prunus yedoensis Matsum.	Tokyo cherry	Adult flies reared from field collected fruit (Sasaki & Sato 1995c).	Yes (Hibbert 2004)	**Yes**

Host	Common name	Host association	Present in Australia	Consider further
Pyrus communis L.	Pears	Pears have been recorded a host (NAPPO 2010a). However, Canadian authorities have confirmed pears are hosts only when damaged (Pers. comm. Martin Damus, CFIA, 22 April 2010).	Yes (Hibbert 2004)	No (see section 4.1 for more detail)
Pyrus pyrifolia (Burm. f.) Nakai	Asian & nashi pears	Pears have been reported as a host (NAPPO 2010a). However, only cut fruit are attacked (Kanzawa 1939).	Yes (Hibbert 2004)	No (see section 4.1 for more detail)
Rosa rugosa	Wild rose, rose hips	*Rosa rugosa* and an unidentified *Rosa* spp. have been reported as a host from non commercial fruit (Dreves and Langelloto-Rhodaback (2011; Brewer *et al*. 2011; Maier 2012). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Several species of the genus are present in Australia (Randall 2007)	No
Rubus allegheniensis Porter	Allegheny blackberry	Recorded as a larval host from wild grown fruit (Maier 2012). However, the intact fruit of many other species in the genus have been recorded to be attacked and this species is a suspected host.	Yes (Randall 2007)	**Yes**
Rubus armeniacus Focke	Himalayan blackberry	A preferred host in natural environments (WSUE 2009).	Yes (AVH 2010)	**Yes**
Rubus crataegifolius Bunge.	niu die du	Reared from fallen hosts only (Mitsui *et al*. 2010). However, the intact fruit of many other species in the genus have been recorded to be attacked and this species is a suspected host.	No record found	**Yes**
Rubus fruticosus aggr.	Blackberry & Marionberry	Recorded as a host in California (Hauser & Damus 2009) and found in high numbers in blackberry (Kanzawa 1939).	Yes (Parsons and Cuthbertson 2001)	**Yes**

Host	**Common name**	**Host association**	**Present in Australia**	**Consider further**
Rubus idaeus L.	Raspberry	Recorded as a host in California (Hauser & Damus 2009).	Yes (Hibbert 2004)	**Yes**
Rubus laciniatus Willd.	Evergreen blackberry	A preferred host in natural environments (WSUE 2009).	Yes (AVH 2010)	**Yes**
Rubus loganobaccus L. H. Bailey	Boysenberry	Recorded as a host in California (Hauser & Damus 2009).	Yes (Hibbert 2004)	**Yes**
Rubus x *loganobaccus*	Loganberry	Recorded as a host in Washington (WSU 2009).	Yes (Hibbert 2004)	**Yes**
Rubus microphyllus L. f.		Reared from fallen fruit only (Mitsui *et al*. 2010). However, the intact fruit of many other species in the genus have been recorded to be attacked and this species is a suspected host.	No record found	**Yes**
Rubus parvifolius L. (syn. = *Rubus triphyllus* Thunb.)	Japanese Raspberry	Recorded as a host from whole fruit (Kanzawa 1939).	Yes (Hibbert 2004)	**Yes**
Rubus spectabilis Pursh	Salmon berry	Recorded as a host from wild grown plants (BCMA 2012). However, the intact commercial fruit of many other species in the genus have been recorded to be attacked and this species is a suspected host.	Yes (Randall 2007)	**Yes**
Sorbus spp.	Mountain ash	Reported as a host from non commercial fruit (Dreves and Langelloto-Rhodaback (2011). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Several species of the genus are present in Australia (Randall 2007)	No

Host	Common name	Host association	Present in Australia	Consider further
Rutaceae				
Citrus sinensis (L.) Osbeck	Orange	Recorded from Citrus in Florida (Tri-ology 2010). However, it is only recorded from fallen fruit (Price and Nagle 2009).	Yes (Hibbert 2004)	No
Citrus x *paradisi*	Grapefruit	Recorded from Citrus in Florida (Tri-ology 2010). However, it is only recorded from fallen fruit (Price and Nagle 2009).	Yes (Hibbert 2004)	No
Murraya paniculata (L.) Jack	Orange Jessamine	Recorded as a host (FDACS 2010a). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Yes (Hibbert 2004)	No
Skimmia japonica Thunb.	Red skimmia	This species is reported as an oviposition host but larvae failed to develop to adults (Brewer *et al*. 2012).	Yes (Randall 2007)	No
Sapindaceae				
Sapindus spp.	Soapberry	Reported as a host from non commercial fruit (Dreves and Langelloto-Rhodaback (2011). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Several species of the genus are present in Australia (Randall 2007)	No
Solanaceae				
Lycium barbarum L.	Goji berry	Reported as a host in Canada although there is little information on its status (Fisher *et al*. 2013). Australia does not have import conditions for fresh goji-berries and DAFF will continue to assess the host status of this species.	Yes (Randall)	No

Host	**Common name**	**Host association**	**Present in Australia**	**Consider further**
Lycopersicon esculentum L	Tomatoes	Attacked ripe fruit in the laboratory (ODA 2010a). Only on cut or damaged fruit in the field (Kanzawa 1939; Lee *et al*. 2011b; Siderman 2012).There is a report of cherry tomato being attacked in Oregon (Brewer *et al*. 2011). However the authors of the report have confirmed the fruit was damaged late season fruit. Commercial tomatoes are likely to be picked well before fruit are fully ripe and even before they are fully coloured (QDPI&F (2010).	Yes (Hibbert 2004)	No
Solanum dulcamara L.	Bitter sweet nightshade	Reported as a host from non commercial fruit (Dreves and Langelloto-Rhodaback 2011; Brewer et al. 2012). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruits of nightshade weed species. DAFF will continue to assess the host status of this species.	Yes (Randall 2007)	No
Solanum nigrum L. *or Solanum americanum* Mill. (species not specified)	Black nightshade	Reported as a host from unmanaged fruit (Caprile 2012). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruits of nightshade weed species. DAFF will continue to assess the host status of this species.	Yes (Randall 2007)	No
Solanum villosum Mill. (*syn.* = *Solanum luteum* Mill.)	Red nightshade	Infested fruit collected from uncultivated environments (EPPO 2012c). There is no information this species is attacked under commercial conditions and there are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Yes (Randall)	No

Host	Common name	Host association	Present in Australia	Consider further
Styracaceae				
Styrax japonicus Siebold & Zucc.	Japanese snowbell	Recorded as a host from field collected fruit of *Styrax japonicus* and *Prunus avium* that that are reported as a grouped sample (Mitsui and Kimura 2010).It is not clear if adults emerged from both species or only from *P. avium*; a well known host. There are no import conditions for fresh fruit of *S. japonicus* and DAFF will continue to assess the host status of this species.	Yes (Randall 2007)	No
Taxaceae				
Taxus cuspidata Siebold & Zucc.	Japanese yew	Recorded as a larval host from wild grown fruit (Maier 2012). There are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Yes (Randall 2007)	No
Torreya nucifera (L.) Siebold & Zucc.	Japanese torreya	Reared from fallen fruit only (Mitsui *et al*. 2010).	Yes (Randall 2007)	No
Vitaceae				
Ampelopsis glandulosa (Wall.) Momiy. var. brevipedunculata (Maxim.) Momiy. (*syn. = Ampelopsis brevipedunculata* (Maximowicz) Trautvetter)	Porcelain berry	Recorded as a larval host from wild grown fruit (Maier 2012). There are no import conditions for fresh fruit. DAFF will continue to assess the host status of this species.	Yes (Randall 2007)	No
Vitis vinifera L.	Table grapes Wine grapes	Preferred host (Kanzawa 1939; OSU 2009).	Yes (Hibbert 2004)	**Yes**

Host	**Common name**	**Host association**	**Present in Australia**	**Consider further**
Vitis labrusca L.	Concord grapes	Reported as a host (Kanzawa 1939; Seljak 2011a).	Yes (Randall 2007)	**Yes**

Appendix C: Australia's Biosecurity Policy Framework

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[8], 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.

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.

[8] The Australian Government Department of Health and Ageing is responsible for human health aspects of quarantine.

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).

DAFF takes the lead in biosecurity and quarantine policy development and the establishment and implementation of risk management measures across the biosecurity continuum, and:

- **Pre-border** conducts risk analyses, including IRAs, and develops recommendations for biosecurity policy as well as providing quarantine policy advice to the Director of Animal and Plant Quarantine
- **At the border** 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
- **Post-border** 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. DAFF works 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, DAFF 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. DAFF 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 Sustainability, Environment, Water, Population and Communities (SEWPaC) 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 SEWPaC directly for further information.

When undertaking risk analyses, DAFF consults with SEWPaC 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 keys 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.

However, this PRA has been conducted as a non-regulated analysis in accordance with the *Import Risk Analysis Handbook 2011.*

International agreements and standards

The process set out in the *Import Risk Analysis Handbook 2011* 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, DAFF:

- 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, DAFF 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 DAFF 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. DAFF assessment of risk may also take the form of a non-regulated analysis of existing policy or technical advice to relevant branches within the Department. Further information on the types of risk analysis is provided in the *Import Risk Analysis Handbook 2011*.

Glossary

Term	Definition
Additional declaration	A statement that is required by an importing country to be entered on a phytosanitary certificate and which provides specific additional information pertinent to the phytosanitary condition of a consignment in relation to regulated pests (FAO 2009).
Appropriate level of protection	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).
Area	An officially defined country, part of a country or all or parts of several countries (FAO 2009).
Consignment	A quantity of plants, plant products and/or other articles being moved from one country to another and covered, when required, by a single phytosanitary certificate (a consignment may be composed of one or more commodities or lots) (FAO 2009).
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO 2009).
DAFF	Department of Agriculture, Fisheries and Forestry
Endangered area	An area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss (FAO 2009).
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO 2009).
Establishment	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2009).
Establishment potential	Likelihood of the establishment of a pest.
Fresh	Living; not dried, deep-frozen or otherwise conserved (FAO 2009).
Fruits and vegetables	A commodity class for fresh parts of plants intended for consumption or processing and not for planting (FAO 2009).
Host	A species of plant capable, under natural conditions, of sustaining a specific pest.
Import Permit	Official document authorising importation of a commodity in accordance with specified phytosanitary import requirements (FAO 2009).
Infestation (of a commodity)	Presence in a commodity of a living pest of the plant or plant product concerned. Infestation includes infection (FAO 2009).
Inspection	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 2009).
Intended use	Declared purpose for which plants, plant products, or other regulated articles are imported, produced, or used (FAO 2009).
Interception (of a pest)	The detection of a pest during inspection or testing of an imported consignment (FAO 2009).
Introduction	The entry of a pest resulting in its establishment (FAO 2009).
Lot	A number of units of a single commodity, identifiable by its homogeneity of composition, origin etc., forming part of a consignment (FAO 2009).
National Plant Protection Organisation	Official service established by a government to discharge the functions specified by the IPPC (FAO 2009).

Term	Definition
Official control	The active enforcement of mandatory phytosanitary regulations and the application of mandatory phytosanitary procedures with the objective of eradication or containment of quarantine pests or for the management of regulated non-quarantine pests (FAO 2009).
Pathway	Any means that allows the entry or spread of a pest (FAO 2009).
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2009).
Pest categorisation	The process for determining whether a pest has or has not the characteristics of a quarantine pest or those of a regulated non-quarantine pest (FAO 2009).
Pest free area	An area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained (FAO 2009).
Pest risk analysis	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 2009).
Pest risk assessment (for quarantine pests)	Evaluation of the probability of the introduction and spread of a pest and the magnitude of the associated potential economic consequences (FAO 2009).
Pest risk management (for quarantine pests)	Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2009).
Phytosanitary certificate	Certificate patterned after the model certificates of the IPPC (FAO 2009).
Phytosanitary measure	Any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO 2009).
Phytosanitary regulation	Official rule to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests, including establishment of procedures for phytosanitary certification (FAO 2009).
Polymerase chain reaction	A technique that utilises a heat stable DNA polymerase to amplify a piece of DNA by *in vitro* enzymatic replication, initiating a chain reaction in which the DNA template is exponentially amplified, generating millions or more copies of the target DNA.
Polyphagous	Feeding on a relatively large number of host plants from different plant families.
Protected area	A regulated area that an NPPO has determined to be the minimum area necessary for the effective protection of an endangered area (FAO 2009).
Quarantine pest	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO 2009).
Regulated article	Any plant, plant product, storage place, packaging, conveyance, container, soil and any other organism, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved (FAO 2009).
Restricted risk	Risk estimates with phytosanitary measures applied.
Spread	Expansion of the geographical distribution of a pest within an area (FAO 2009).
SPS Agreement	WTO Agreement on the Application of Sanitary and Phytosanitary Measures (WTO 1995).
Stakeholders	Government agencies, individuals, community or industry groups or organisations, whether in Australia or overseas, including the proponent/applicant for a specific

Term	**Definition**
	proposal
Systems approach(es)	The integration of different risk management measures, at least two of which act independently, and which cumulatively achieve the appropriate level of phytosanitary protection (FAO 2009).
Unrestricted risk	'Unrestricted' risk estimates apply in the absence of risk management measures.

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