Liriomyza trifolii
Contingency Plan

Prepared for Horticulture Innovation Australia, as part of Project MT16004 (*RD&E program for control, eradication and preparedness for vegetable leafminer*)

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CONTINGENCY PLAN

AMERICAN SERPENTINE LEAFMINER (*LIRIOMYZA TRIFOLII*)

Central Science Laboratory, Harpenden, British Crown, Bugwood.org

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1. PURPOSE AND BACKGROUND OF THIS CONTINGENCY PLAN

The American serpentine leafminer (*Liriomyza trifolii*) is an exotic leafminer that affects a wide range of horticultural industries, including the vegetable and melon industries. It is currently widespread overseas and is present in nearby countries such as Indonesia.

This Contingency Plan provides background information on American serpentine leafminer to assist in determining the requirements for the initial response to a detection of this species in Australia. Only key information for immediate response is provided in this document.

Additional information can be found in the following supporting material:

- Awareness material such as the fact sheets from Plant Health Australia (PHA), AUSVEG, and commonwealth, state and territory jurisdictions.
  - www.planthealthaustralia.com.au/pests/american-serpentine-leaf-miner/
  - www.agriculture.gov.au/pests-diseases-weeds/plant/leaf-miner
  - www.dpi.nsw.gov.au/biosecurity/plant/insect-pests-and-plant-diseases/exotic-leaf-miners
  - https://ausveg.com.au/biosecurity-agrichemical/biosecurity/mt16004/
- Overseas websites with additional information
  - https://gd.eppo.int/taxon/LIRITR
  - www.cabi.org/cpc/datasheet/30965
  - https://cipotato.org/riskatlasforafrica/liriomyza-trifolii/
  - http://entnemdept.ufl.edu/creatures/veg/leaf/a_serpentine_leafminer.htm
  - http://ipm.ucanr.edu/PMG/r280300911.html
  - http://ipm.ucanr.edu/PMG/r783300911.html

2. PEST DETAILS

Preferred common name	American Serpentine Leafminer
Other common names	Serpentine leafminer; Broad bean leafminer; Californian leafminer; Celery leafminer; Chrysanthemum leafminer
Scientific name:	*Liriomyza trifolii* Burgess
Synonyms:	*Agromyza phaseolunata;* *Liriomyza alliivora;* *Liriomyza phaseolunata;* *Oscinis trifolii*
Taxonomic position:	Class: Insecta Order: Diptera Family: Agromyzidae Genus: *Liriomyza* Species: *Liriomyza trifolii*

2.1 Background and impact of pest

The Agromyzidae are a well-known group of small, morphologically similar flies whose larvae feed internally on plants, often as leaf and stem miners. Nearly all species are very host-specific, but a few highly polyphagous species have become important pests of agriculture and horticulture in many parts of the world.

The American serpentine leafminer is of concern as it has a wide host range including many horticulture crops in which it can cause significant yield losses and quality reductions (see Appendix 1). The American serpentine leafminer is widespread overseas being present in North and South America, Asia, Africa, Europe and some Pacific islands.

2.2 Life cycle

The lifecycle of the American serpentine leafminer consists of an egg inserted by the female just under the surface of a leaf of a host plant when temperatures are above 12°C (Capinera 2014). The egg hatches in 2-5 days (CABI 2018). The larvae then begin to feed within the leaf creating tunnels or mines that get larger as the larvae moult and mature. After passing through three larval stages in 4+ days the larva leaves the plant to form a puparium in the soil underneath the host plant (or occasionally inside the leaf on some hosts such as onions (CABI and EPPO date unknown)). After 7-14 days (at 20°C and 30°C) an adult emerges and begins to reproduce (Leibee 1984; CABI 2018). The times taken to complete each life stage vary depending on host and temperature. Leibee (1984) determined growth at a constant 25°C, and reported that it takes 19 days from egg deposition to emergence of the adult. Development rates become quicker as temperatures increase, with the complete life cycle taking only 12 days on celery at 35°C (Leibee 1982). Similarly, development times become longer at low temperatures. American serpentine leafminer are reported to have a diapause (delay of development) at low temperatures allowing them to survive winter conditions.

2.3 Host range

American serpentine leafminer is a polyphagous pest of many agricultural and ornamental hosts (see Appendix 1It has been recorded from ~170 plant species representing 29 plant families. Its preferred hosts tend to be in the Asteraceae family (Spencer 1973).

Important agricultural hosts include sunflower, safflower, lettuce, celery, cucumber, melons, onion, potato, tomato, eggplant, legume vegetables and pulse crops and a wide range of ornamental species such as chrysanthemum.

A detailed host list is included in Appendix 1.

2.4 Signs and symptoms

Adult flies are small (less than 2 mm long with a wing length of 1.25-1.9 mm) with a shiny black mesonotum and yellow markings on the head and body (Figure 1).

Female flies use their ovipositor to puncture the leaves of the host plants causing wounds which serve as sites for feeding (by both males and females) or oviposition. Feeding punctures appear as white speckles between 0.13 and 0.15 mm in diameter. Oviposition punctures are usually smaller (0.05 mm) and are more uniformly round. However, the appearance of the punctures does not differ between *Liriomyza* species so cannot used to separate species.

Pale coloured leaf mines are created by the feeding larvae and are the most obvious symptom of infestations of *Liriomyza* spp. (Figure 2). The larval mine of American serpentine leafminer is on the upper surface of the leaf in the leaf mesophyll tissue, it is shallow, at first greenish, then later whitish in colour. The trails of frass are distinctive in being deposited in black strips alternately at either side of the mine (like the related Vegetable leafminer, *L. sativae*), but becomes more granular towards the end of the mine (unlike *L. sativae*) (Spencer 1973).

Factsheets with more information on what to look for in the field can be found at the following websites:

- www.planthealthaustralia.com.au/pests/american-serpentine-leaf-miner/
- http://entnemdept.ufl.edu/creatures/veg/leaf/a_serpentine_leafminer.htm
- http://ipm.ucanr.edu/PMG/r783300911.html
- https://ausveg.com.au/biosecurity-agrichemical/biosecurity/mt16004/

Figure 1 Adult American serpentine leafminer. Source: Central Science Laboratory, Harpenden, British Crown, Bugwood.org

Figure 2 Leaf mines on chrysanthemum. Source: Central Science Laboratory, Harpenden, British Crown, Bugwood.org

2.5 Dispersal

Typically, *Liriomyza* leafminers are considered to have invaded countries via the movement of infested plants (generally ornamentals). While fully formed mines should be readily visible, signs of early infestations are much less obvious and are easily overlooked.

Agromyzid flies are considered as "moderate fliers" (Yoshimoto and Gressitt 1964) that also have the potential to be spread over large distances through wind dispersal. Flight mill experiments on the related *L. sativae* have shown that leafminers can fly up to 8.22 km but that the average flight distances was<1.0 km at 18-36ºC (Lei et al., 2002). Similar flight ability is expected for American serpentine leafminer.

Individual American serpentine leafminers within glasshouses have been shown to disperse on average 26 m but up to 100 m from original infestation points within 24 hours (Jones and Parella 1986) and in a field study were generally not found more than 50 m away from infested glasshouses (Ozawa et al 1999). Similarly, *Liriomyza huidobrensis* adults have been shown to disperse on average 46 m within 24 hours via a release recapture experiment (Fenoglio et al 2019). *Agromyza frontella*, a related agromyzid leafminer pest of lucerne with similar flight dynamics, was observed to spread at a rate of about 100 km per year (or averaging about 0.3 kms per day) during an incursion into the Midwestern United States (Venette et al. 1980). There is also some evidence of long distance dispersal of agromyzids via wind, with agromyzid species reportedly trapped as high as 900 min the air column (Hardy and Milne 1938; Glick 1960; White 1970), and over oceans (Cheng 1976, Yoshimoto and Gressit 1964).

However, windborne dispersal is likely to be a minor pathway of leafminer dispersal in Australia, and human-mediated pathways should be prioritised, particularly given the accumulation of research pointing to this as a major contributor to the movement of invasive species (Capinha et al. 2015; Wichmann et al. 2009). Such pathways include transport of contaminated produce, or "hitch-hiking" adults associated with the large volume of human movement.

The American serpentine leafminer has spread from North America to Central and South America, Europe, Africa and Asia through the movement of plant material (cuttings, cut flowers, etc) (Minkenberg and Van Lenteren 1986). This suggests that there is the potential for it to spread rapidly to new regions. Plant material should be considered as a potential pathway for the introduction and spread of this pest. The introduction of plant material from overseas is regulated, however illegal movement of plant material poses a potential risk for the entry of the pest into Australia.

2.6 Current geographic distribution

The American serpentine leafminer is thought to have originated in North America (Spencer 1973) and since spread to South America, Asia, Africa and Europe.

The current distribution of this pest is presented in Table 1. Note, American serpentine leafminer has also been found at various times in a number of European countries including; Czech Republic, Denmark, Finland, Hungary, Ireland, Netherlands, Poland, Slovenia, Sweden, United Kingdom, but has since been eradicated and is no longer found in those countries (EFSA Panel on Plant Health 2012).

Table 1. Countries where American serpentine leafminer is known to occur

COUNTRY/REGION	REFERENCE
American Samoa	CABI and EPPO (date unknown)
Angola	Černý and Von Tschirnhaus (2014)
Austria	CABI and EPPO (date unknown); EFSA Panel on Plant Health (2012)
Bahamas	CABI and EPPO (date unknown); Spencer (1973)
Barbados	CABI and EPPO (date unknown); Spencer (1973)
Belgium	CABI and EPPO (date unknown); EFSA Panel on Plant Health (2012)
Brazil	CABI and EPPO (date unknown); De Freitas Bueno et al., (2007)
Cambodia	Gao et al., (2017)
Canada	Broadbent et al., (1986); CABI and EPPO (date unknown); Parrella and Keil (1984); Černý and Von Tschirnhaus (2014); Spencer (1973)
China	Gao et al., (2011); Gao et al., (2017)
Colombia	CABI and EPPO (date unknown); Parrella and Keil (1984)
Costa Rica	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); Spencer (1983)
Cuba	Altieri et al., (1999); CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014)
Cyprus	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); EFSA Panel on Plant Health (2012)
Dominican Republic	CABI and EPPO (date unknown); Serra et al., (2003)
Egypt	Abd-Rabou (2006); CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014)
Ethiopia	Abate (1988); CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014)
Federated States of Micronesia	Schreiner and Nafus (1986)
France	CABI and EPPO (date unknown); EFSA Panel on Plant Health (2012)
French Guiana	CABI and EPPO (date unknown)
Greece	CABI and EPPO (date unknown); EFSA Panel on Plant Health (2012)
Guadeloupe	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); Spencer et a., (1992)
Guam	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); Schreiner and Nafus (1986)
Guatemala	CABI and EPPO (date unknown)
Guinea	Černý and Von Tschirnhaus (2014)

COUNTRY/REGION	REFERENCE
Guyana	CABI and EPPO (date unknown); Spencer (1973)
India	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); Gao et al., (2017); Srinivasan et al., (1995)
Indonesia	Baliadi and Tengkano et al., (2010); Gao et al., (2017)
Iran	Doust (2010); Gao et al., (2017)
Israel	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); Weintraub and Horowitz, (1995)
Italy	CABI and EPPO (date unknown); EFSA Panel on Plant Health (2012)
Japan	Arakaki and Kinjo (1998); CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); Gao et al., (2017)
Jordon	Al-Ghabeish and Allawi (2001); Gao et al., (2017)
Kenya	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); De Lima (1979)
Korea	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); Han et al., (1996); Gao et al., (2017)
Lebanon	CABI and EPPO (date unknown); Gao et al., (2017)
Madagascar	Černý and Von Tschirnhaus (2014)
Malta	CABI and EPPO (date unknown); EFSA Panel on Plant Health (2012)
Martinique	CABI and EPPO (date unknown); Etienne and Martinez (2013)
Mauritius	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); Dove (1983)
Mexico	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); Scheffer and Lewis (2006)
Micronesia	CABI and EPPO (date unknown); Suta and Esguerra (1993)
Nigeria	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); Umeh et al., (2002)
Northern Mariana Islands	CABI and EPPO (date unknown); Schreiner and Nafus (1986)
Oman	Gao et al., (2017); Černý and Von Tschirnhaus (2014); Deadman et al., (2000)
Peru	CABI and EPPO (date unknown)
Philippines	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); Gao et al., (2017); Scheffer et al., (2006)
Portugal	CABI and EPPO (date unknown); EFSA Panel on Plant Health (2012)

COUNTRY/REGION	REFERENCE
Republic of Benin	Černý and Von Tschirnhaus (2014)
Republic of Cote d'Ivoire	Černý and Von Tschirnhaus (2014)
Réunion	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); Vercambre (1980)
Romania	CABI and EPPO (date unknown); EFSA Panel on Plant Health (2012)
Samoa	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014)
Saudi Arabia	Al-Khateeb and Al-Jabr (2004); Gao et al., (2017)
Senegal	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); Diatte et al., (2018)
Serbia	Dobrosavljevic et al., (2017)
South Africa	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); Daiber (1985)
Spain (including Canary Islands)	CABI and EPPO (date unknown); EFSA Panel on Plant Health (2012)
Sri Lanka	Niranjana et al., (2005)
Sudan	Černý and Von Tschirnhaus (2014)
Switzerland	CABI and EPPO (date unknown)
Taiwan	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); Gao et al., (2017); Wang and Lin (1988)
Tanzania	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014)
Thailand	Gao et al., (2017)
Tonga	CABI and EPPO (date unknown)
Trinidad and Tobago	CABI and EPPO (date unknown)
Tunisia	Černý and Von Tschirnhaus (2014); CABI and EPPO (date unknown)
Turkey	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); Gao et al., (2017)
United Arab Emirates	Gao et al., (2017); Howarth (2006)
United States of America (including Hawaii)	CABI and EPPO (date unknown); Černý and Von Tschirnhaus (2014); De Freitas Bueno et al., (2007); Parrella and Keil (1984); Spencer (1973)
Venezuela	CABI and EPPO (date unknown); Spencer (1973)
Vietnam	Gao et al., (2017);
Yement	Černý and Von Tschirnhaus (2014); Gao et al., (2017)
Yugoslavia	CABI and EPPO (date unknown)

COUNTRY/REGION	REFERENCE
Zambia	Černý and Von Tschirnhaus (2014)
Zimbabwe	Černý and Von Tschirnhaus (2014)

2.7 Risk of establishment in Australia

CLIMEX models are provided in Jovicich (2009). These found that the American serpentine leafminer is most likely to establish along the northern, eastern, southern and southwestern coastline of Australia and Tasmania.

Refer to: https://ausveg.com.au/app/data/technical-insights/docs/VG06113.pdf for further details.

Cesar Australia has created a model of the potential geographic distribution of the American serpentine leafminer in Australia, the results of which are summarised below (Figure 3). A copy of the relevant reports and/or published manuscripts are available from Hort Innovation or from Cesar Australia (http://cesaraustralia.com/contact-us/).

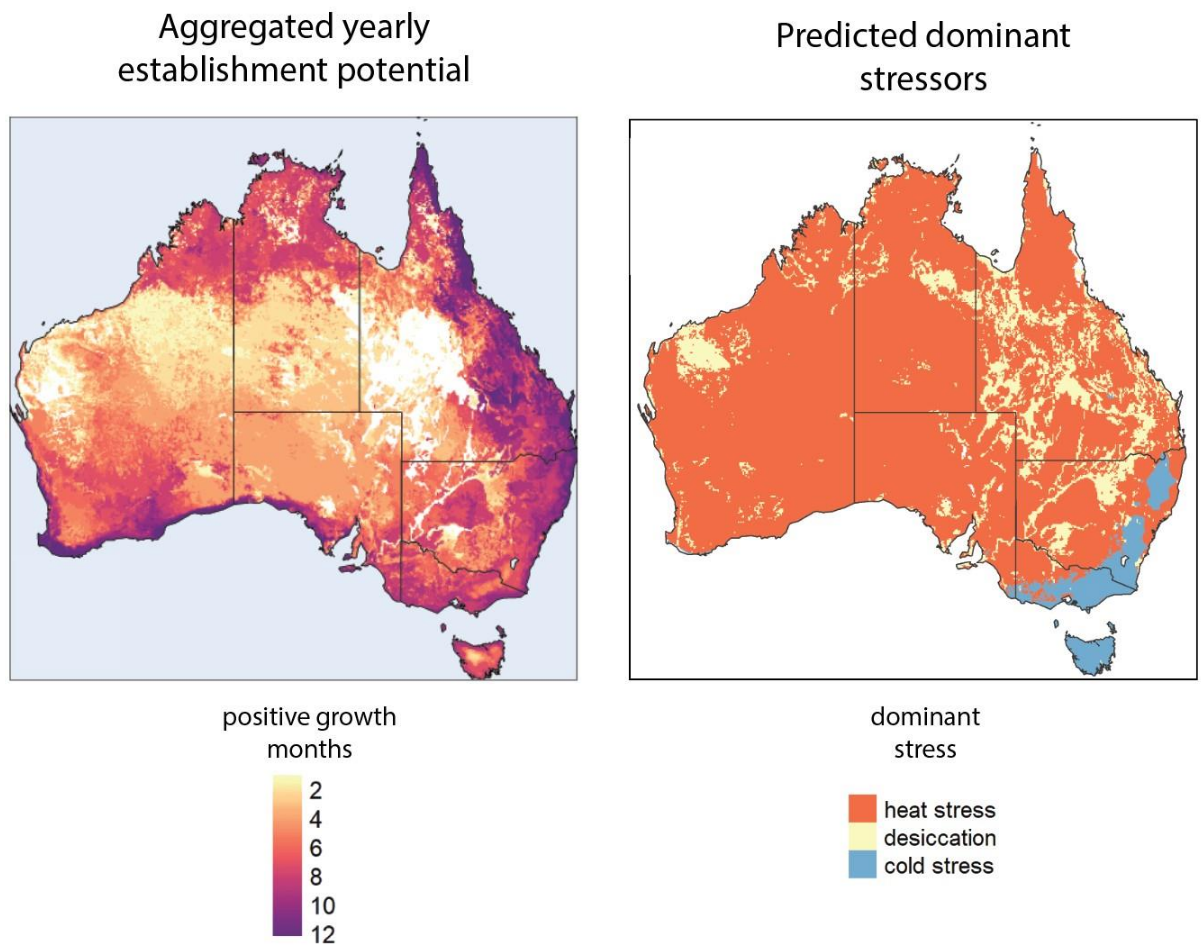

Figure 3 Aggregated yearly establishment potential of American serpentine leafminer as the number of months across the year with increasing population sizes) based on temperature and moisture constraints (left) and predicted dominant stressors based on the highest mortality rate from desiccation, cold, and heat stress across the year (right).

2.8 Risk of spread within Australia

2.8.1 Risk pathways – international and domestic

This species could potentially enter new areas by natural spread and by hitchhiking on goods, aircraft, vehicles, or through the movement of plant material (DAWR 2016).

Table 2 lists some of the potential international risk pathways and control measures in place. These are also be broadly applicable to other *Liriomyza* species.

Table 2 International risk pathways for the spread of the pest and control measures

RISK PATHWAY	DESCRIPTION	CONTROL MEASURES
Cut flowers on regulated imports	Infested cut flowers moved to residential dwellings that contain suitable hosts and the insect transfers to a host.	Border inspections
Infected plant material on passenger or mail pathways	Infested plant material moved to residential dwellings that contain suitable hosts and the insect transfers to a host.	Border inspections
Natural dispersal from Papua New Guinea (PNG)	Ongoing spread from PNG to Torres Strait and/or Far North Queensland via traditional movements, winds or flight.	Ongoing surveillance via the Northern Australia Quarantine Strategy Domestic quarantine
Infested plant material	Plant material or pupae in soil spread to new areas in baggage, vehicles or camping equipment.	Domestic quarantine

Additionally, as the larvae of *Liriomyza* spp. leave the plant to pupate, pupae may also be spread with crop debris or soil associated with infested areas. Table 3 lists some of the potential risk pathways and potential domestic control measures to reduce the spread of American serpentine leafminer. These will also be broadly applicable to other *Liriomyza* species.

Table 3. Risk pathways for the spread of the pest and potential domestic control measures

RISK PATHWAY	DESCRIPTION	POTENTIAL DOMESTIC CONTROL MEASURES
Cut flowers (host plants)	Cut flowers that are a host of American serpentine leafminer (see Appendix 1) pose a significant risk. The life of cut flowers is long enough to allow the completion of the pest's lifecycle (CABI and EPPO, date unknown). Eggs may be present within leaves but are never visible. Larvae may be present and visible within leaves. Hitchhiking adults and pupae may be transported on cut flowers.	The application of systemic insecticides may be required before allowing cut flowers grown in an infested area to be moved outside the infested area. Further information on chemical control is provided in Section 5.3. 3. All cut flowers leaving infested areas will also need to be visually inspected for signs of leafminers before leaving the area.
Cut flowers (non-host plants)	Cut flowers that are not a host of American serpentine leafminer poses significantly less risk for the spread of this pest, but is still a potential pathway, particularly if the non-host cut flowers are transported with or spent time in close proximity with host cut flowers. Eggs, larvae and pupae will not spread with non-host stock. Adults may potentially spread with non-host stock as a hitchhiker.	To reduce the risk of spread, cut flowers that are not a host plant for vegetable leafminer should be inspected and/or treated as a precaution if grown in an area known to be infested with American serpentine leafminer.
Nursery Stock (containerized host plants)	Nursery stock that is a host plant for American serpentine leafminer (see Appendix 1) poses a significant risk for the spread of this pest. Containerized nursery stock can carry all life stages of the pest. Eggs may be present within leaves but are never visible. Larvae may be present and visible within leaves. Pupae may also be present in the soil of containerized stock. Larvae emerge from the leaf and pupate in the soil under host plants meaning potting mix/soil can also potentially spread the pest. Larvae very occasionally attach to leaves or surrounding non-soil surfaces to pupate. Adults may potentially spread with containerized nursery stock as a hitchhiker.	Visual inspection of containerised nursery stock for the presence of adults resting on leaves, larvae creating leaf mines and pupae in the soil (see Figure 2, however pupae will be very hard to detect as they are mixed into the substrate) or attached to leaves and container surfaces. To reduce the risk of spread, containerised nursery stock that is a host plant for vegetable leafminer should not be moved from infested to non-infested areas without being treated with an appropriate systemic insecticide. Treatment of growing media using appropriate pesticides (eg Cyromazine-PER83506) should also be considered. Further information on chemical control is provided in Section 5.3.3.

RISK PATHWAY	DESCRIPTION	POTENTIAL DOMESTIC CONTROL MEASURES
Nursery Stock (bare rooted host plants)	Nursery stock that is a host plant for American serpentine leafminer (see Appendix 1) poses a significant risk for the spread of this pest. Bare rooted nursery stock can carry all life stages of the pest. Eggs may be present within leaves but are never visible. Larvae may be present and visible within leaves. Pupae are less likely to be present in bare rooted stock than containerized stock. However, upon emergence, if larvae are unable to find a substrate to bury into, they will attach to any surface available (including tray walls or plant leaves) meaning pupae can potentially still spread via bare rooted stock. Adults may potentially spread with bare rooted nursery stock as a hitchhiker.	Visual inspection of bare rooted nursery stock for the presence of adults resting on leaves, larvae creating leaf mines and pupae attached to leaves or surfaces surrounding the roots (see Figure 2). To reduce the risk of spread, bare rooted nursery stock that is a host plant for vegetable leafminer should not be moved from infested to non-infested areas without being treated with an appropriate systemic insecticide. Further information on chemical control is provided in Section 5.3.3.
Nursery Stock (non-host plants)	Nursery stock that is not a known host plant of American serpentine leafminer poses significantly less risk for the spread of this pest, but is still a potential pathway, particularly if the non-host stock spent time in close proximity with host stock. Eggs, larvae and pupae will not spread with non-host stock. Adults may potentially spread with non-host stock as a hitchhiker.	Visual inspection of nursery stock for the presence of adults resting on leaves. To reduce the risk of spread, nursery stock that is not a host plant for vegetable leafminer should be inspected and/or treated as a precaution if grown in an area known to be infested with American serpentine leafminer. Treatment of growing media using appropriate pesticides (eg Cyromazine-PER83506) may also be considered as a precaution to limit the potential for spread.

RISK PATHWAY	DESCRIPTION	POTENTIAL DOMESTIC CONTROL MEASURES
Non-commercially grown seedlings and plants	People and small businesses selling/trading seedlings at a local level (e.g. at farmers markets, school fetes, roadside stalls, etc.) pose similar threats to those posed by nursery stock, (i.e. plants can spread eggs, larvae, pupae and potentially adults via host plants to new areas). However, being less regulated this is a difficult pathway to control and therefore potentially poses a higher risk than commercial nursery businesses.	Should an incursion occur effort will be needed to identify those involved in the non-commercial trade of seedlings to reduce the risks that they pose. Similar to commercial nursery stock, host plants should not be moved from infested to non-infested areas without being inspected and treated with an appropriate systemic insecticide. Likewise, non-host crops grown in proximity to host plants should be inspected and/or treated as a precaution if grown in an area known to be infested with American serpentine leafminer, as there is a small risk that non-host crops could potentially spread adult leafminers as hitchhikers. Treatment of growing media using appropriate pesticides (eg Cyromazine-PER83506) may also be considered. Further information on chemical control is provided in Section 5.3.3.
Plant material including hay, plant debris and crop waste	Hay, plant debris and crop waste could potentially spread pupae and adults to new areas. Larvae are not expected to be able to survive long after plant debris and begins to wilt and rot (once it cannot feed on the plant, the larvae must vacate the leaf to begin pupation or die), however pupae will survive plant debris and crop waste. Adults may also hitchhike on hay, plant debris and crop waste.	Visual inspection for the presence of adults, larvae and pupae should be carried out. To reduce the potential risk of spread, plant material should not be moved from infested to non-infested areas without being treated with an appropriate insecticide. Further information on chemical control is provided in Section 5.3.3.
Soil	Larvae emerge from the leaf and pupate in the soil under host plants (Capinera 2014). Soil therefore poses a potential risk for moving the pest to new areas.	Minimise potential spread by reducing the spread of soil off infested sites (e.g. by cleaning down machinery between properties).

RISK PATHWAY	DESCRIPTION	POTENTIAL DOMESTIC CONTROL MEASURES
Tools, equipment, and machinery	Tools, equipment, and machinery used on farm in the vicinity of host plants pose a low risk of spreading the pest, however, may transport pupae via soil deposits, or may transport adults.	Clean tools, equipment and machinery before moving off infested sites.
Transport vehicles	Vehicles in the vicinity of host plants could allow the pest to hitchhike (in cabins etc.) to new areas (DAWR 2016).	Clean vehicles before moving off infested sites.
Conveyances (includes crates, boxes, bins, pallets)	Crates, bins, pallets, etc. that are clean of soil are unlikely to spread leafminers.	As a precaution, clean conveyances before moving between sites to reduce any risk of spread.
Seed	There are no expected pathways for leafminer spread by the movement of seed.	Not applicable.
Fruit (without leaves)	There are no expected pathways for leafminer spread by the movement of fruit (without leaves). It is expected the process of harvesting and cleaning fruit will remove leaf and soil material that could spread larvae and pupae and would cause adults to disperse rather than hitchhike with fruit to new areas.	Not applicable.
Fresh leafy or green vegetables (including peas and beans)	Mines can occur on leaves of a wide range of green vegetables. There is therefore a risk that leafminer eggs or larvae (and potentially pupae and hitchhiking adults) could be spread to a new area via the movement of infested leafy vegetables. Mines do not occur on fruiting structures, with the exception that Liriomyza huidobrensis can form mines in the pods of snow peas and disrupt market access (Gitonga et al. 2010). However, it is not clear if this risk extends to Liriomyza trifolii.	Visual inspection for the presence of adults, larvae and pupae should be carried out. To reduce the potential risk of spread, plant material should not be moved from infested to non-infested areas without undertaking suitable treatments to reduce the risk of pest spread.

2.8.2 Predicting spread potential

Cesar Australia has created a model of the potential rate of area invasion by the American serpentine leafminer at entry points across Australia, the results of which are summarised below (Figure 4). A copy of the relevant reports and/or published manuscripts are available from Hort Innovation or from Cesar Australia (http://cesaraustralia.com/contact-us/).

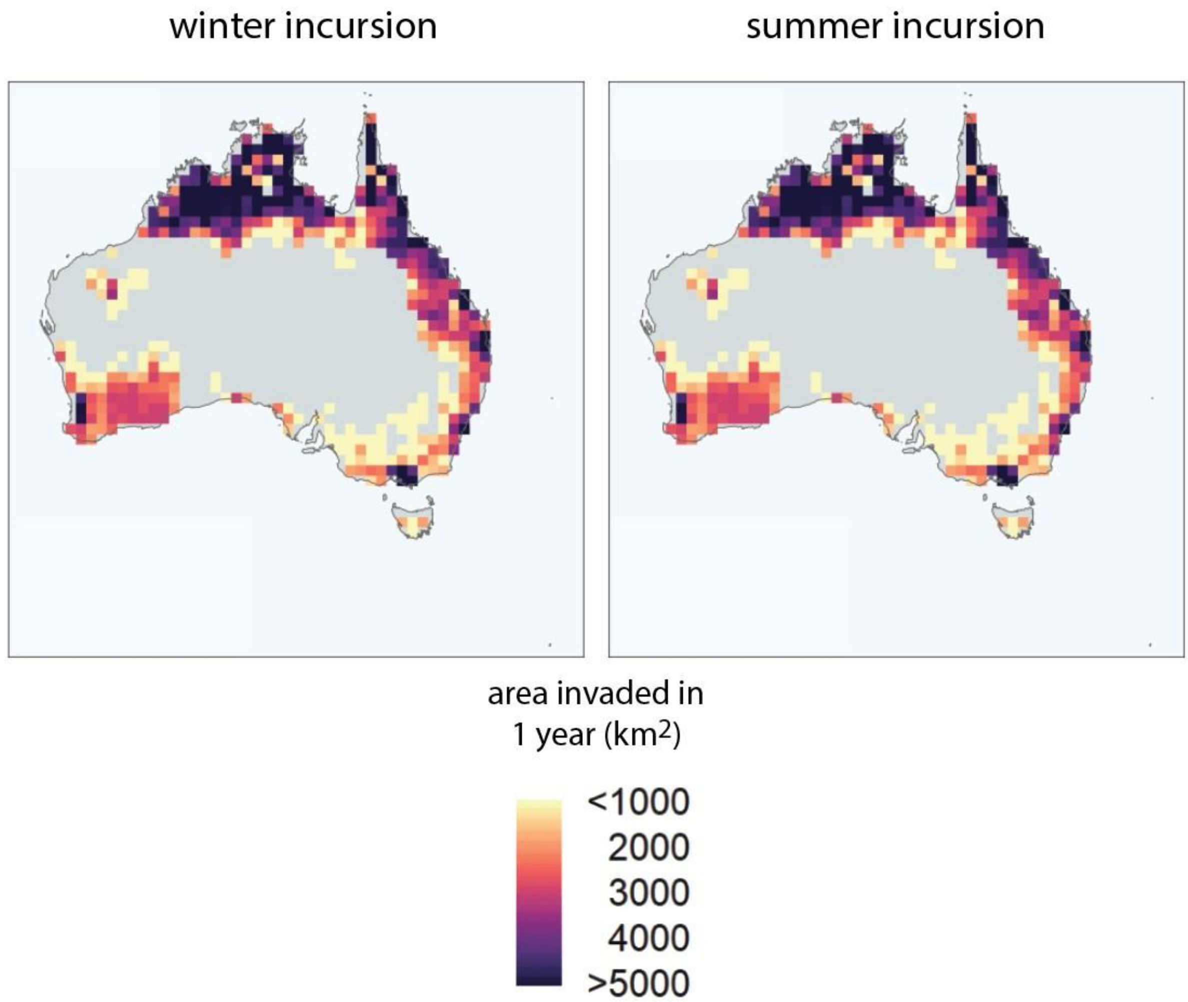

Figure 4 Rate of spread from locations across Australia. For each grid cell an incursion is simulated with the mean predicted area invaded by American serpentine leafminer in one year shown by the colour gradient. The mean predicted area is estimated from 10 replicated simulations. Incursions were commenced in July for a winter incursion and January for a summer incursion.

2.9 Risk of economic impact within Australia

Cesar Australia has created a model of the potential economic impacts of the American serpentine leafminer in Australia, the results of which are summarised below (Table 4, Table 5, and Figure 5). A copy of the relevant reports and/or published manuscripts are available from Hort Innovation or from Cesar Australia (http://cesaraustralia.com/contact-us/).

Table 4 Impact potential of American serpentine leafminer on affected commodities in terms of international collated reports of proportions crop value lost due to direct feeding damage.

Host	Proportion crop value lost			Sources
	Min	Max	Mean	
Beans	0.35	1.00	0.55	Schreiner et al 1986
Celery	0.01	1.00	0.27	Foster and Sanchez 1988
Tomatoes	0.28	1.00	0.32	Krishna Kumar 1998; Kotze et al 1996
Eggplant	0.01	1.00	0.07	Lim et al. 2007

Host	Proportion crop value lost			Sources
	Min	Max	Mean	
Watermelon	1.00	1.00	1.00	Palumbo 2020
Cotton	0.11	1.00	0.38	Nadagoudad et al. 2010
Cowpea	1.00	1.00	1.00	Jackai 1986

Table 5 Australia wide accumulated unmitigated impacts in millions of dollars after 3 years resulting from a spring (September) incursion of American serpentine leafminer at key entry points across Australia. Simulations were replicated 10 times with means and standard deviations shown in parentheses. The proportion crop impact was fixed at 10% in order to explore variability due to incursion location and the size and distribution of different industries. Thus, host preferences of the pests do not influence the predicted crop impacts, and impacts of low preferences hosts may be overestimated while impacts of high preference hosts may be underestimated. Predictions were made using ESIM framework and are the culmination of the establishment, spread and impact modules (with each level of risk building upon the previous). For impacts calculated at state levels, see Appendix 4, Table 20. All cells with a value of 0.00 represent unmitigated impacts less than $10,000.

	Incursion location					
Crop	**Bundaberg**	**Darwin**	**Devonport**	**Melbourne**	**Perth**	**Sydney**
Beans	9.87 (0.57)	3.08 (1.39)	1.49 (0.35)	0.39 (0.09)	0.03 (0.04)	1.28 (0.92)
Broccoli	6.87 (1.46)	3.09 (1.65)	3.84 (2.94)	8.63 (0.27)	2.24 (0.46)	1.57 (1.77)
Brussels	0.79 (0.38)	0.09 (0.11)	0.54 (0.30)	0.82 (0.39)	0.00 (0.00)	0.28 (0.46)
Cabbages	4.27 (0.34)	1.88 (0.55)	1.01 (0.66)	1.19 (0.47)	0.60 (0.08)	2.63 (0.40)
Capsicum	4.20 (0.25)	0.25 (0.22)	1.63 (0.11)	0.35 (0.15)	0.68 (0.11)	0.20 (0.08)
Carrots	6.67 (0.69)	3.20 (1.30)	3.88 (0.11)	0.31 (0.05)	5.82 (1.17)	1.46 (0.67)
Cauliflowers	3.09 (0.77)	1.45 (0.84)	2.79 (1.62)	4.41 (0.15)	0.91 (0.12)	0.94 (1.00)
Flowers	21.08 (1.84)	9.65 (2.06)	9.81 (4.59)	10.67 (2.94)	2.26 (0.87)	18.49 (2.01)
Lettuces	9.03 (1.14)	3.58 (1.67)	4.09 (3.83)	10.00 (0.60)	3.27 (0.39)	2.75 (1.57)
Melons	4.62 (0.20)	1.12 (0.93)	0.01 (0.01)	0.01 (0.01)	0.80 (0.31)	0.09 (0.06)
Nurseries	48.08 (2.05)	19.13 (4.51)	12.74 (6.40)	20.38 (3.70)	8.89 (1.11)	25.65 (4.06)
Onions	3.92 (0.32)	1.63 (0.57)	3.83 (0.10)	0.20 (0.02)	1.61 (0.68)	0.66 (0.41)
Peas	0.53 (0.07)	0.09 (0.12)	0.82 (0.25)	0.21 (0.06)	0.01 (0.00)	0.07 (0.06)
Potatoes	6.69 (0.30)	1.51 (0.73)	6.56 (0.51)	1.81 (0.34)	2.41 (0.74)	1.57 (0.45)
Pumpkins	3.08 (0.17)	1.11 (0.62)	0.20 (0.04)	0.04 (0.03)	0.25 (0.11)	0.51 (0.31)
Tomatoes	13.30 (0.44)	1.38 (0.44)	1.16 (0.52)	1.28 (0.71)	0.13 (0.09)	2.26 (0.65)
[illegible]	**146.09 (6.47)**	**52.23 (13.38)**	**54.41 (19.81)**	**60.70 (8.28)**	**29.91 (5.58)**	**60.40 (11.92)**

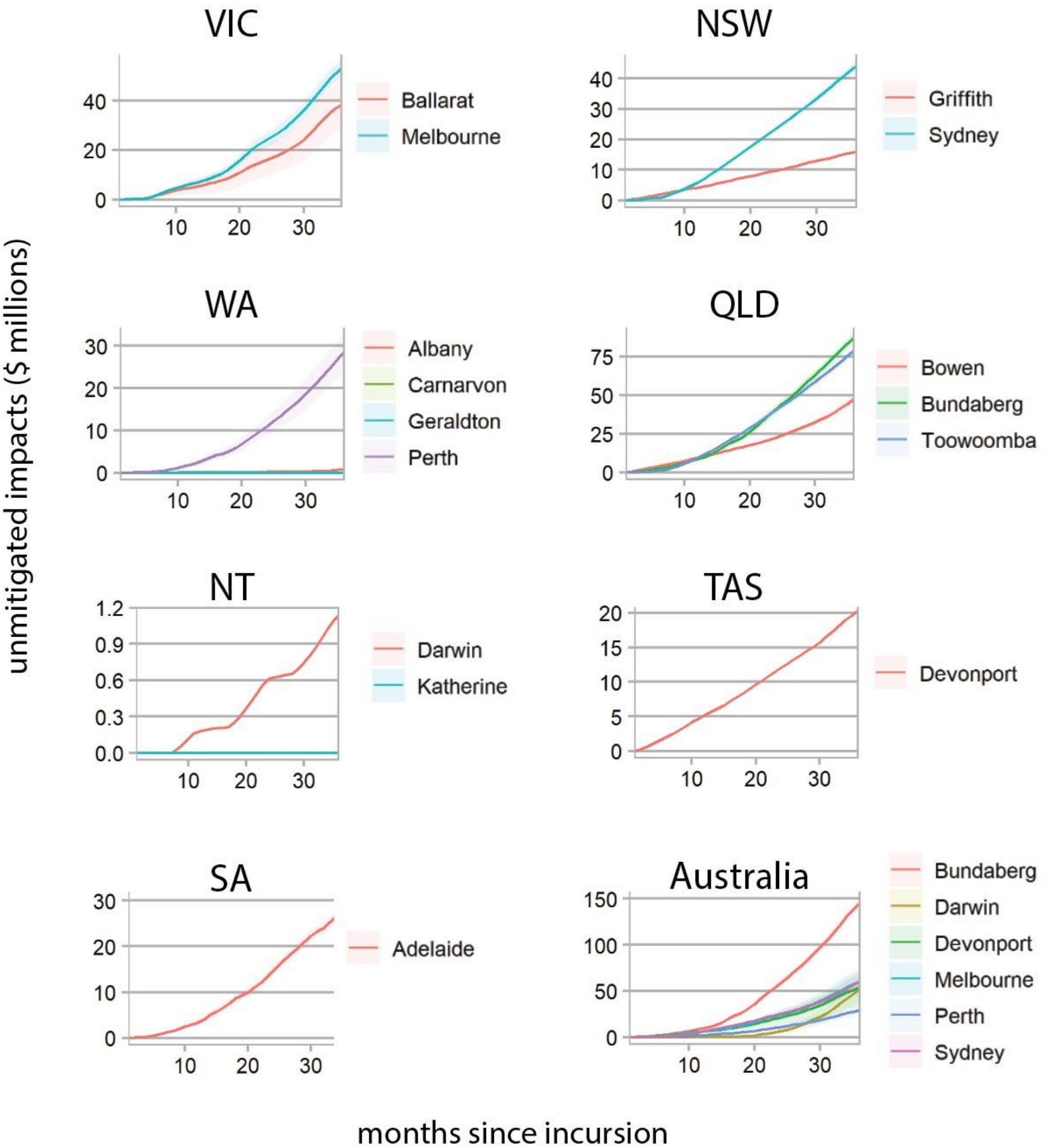

Figure 5 State level accumulating unmitigated impacts in millions of dollars across all host crops after 3 years resulting from a spring (September) incursion of American serpentine leafminer at key entry and establishment points. For state level impact accumulation by crop type, see Appendix 4 Figure 9 for additional information.

3. DIAGNOSTIC INFORMATION

Morphological diagnosis to a species level requires adult male flies. These can be collected by sweep netting, yellow sticky traps or collecting leaves with larvae in them and allowing the larvae to develop into adults. Alternatively, molecular tools can be used to identify larvae and adult flies.

Australia has a National Diagnostic Protocol covering American serpentine leafminer (SPHD 2016 – available from: http://www.plantbiosecuritydiagnostics.net.au/app/uploads/2018/11/NDP-27-American-serpentine-leaf-miner-Liriomyza-trifolii-V1.pdf). An International Plant Protection Convention (IPPC) Diagnostic Protocol (IPPC 2016) and an European and Mediterranean Plant Protection Organization (EPPO) diagnostic protocol for *Liriomyza* spp (EPPO 2005) are also available. These diagnostic protocols should be referred to for the diagnosis of suspected *Liriomyza* spp. It should be noted that these protocols do not include information on environmental DNA (eDNA). Additional information on the use of eDNA for vegetable leafminer diagnosis can be found at Pirtle et al., *in press*.

An information portal for polyphagous agromyzid leafminer identification is available at https://keys.lucidcentral.org/keys/v3/leafminers/index.htm, which includes species-specific fact sheets, and a pictorial Lucid3 key that allows users to make a preliminary identification of pest agromyzids and to be able to distinguish these species from non-pest endemic agromyzids. A factsheet for *Liriomyza sativae* is accessible here: https://keys.lucidcentral.org/keys/v3/leafminers/key/Polyphagous%20Agromyzid%20Leafminers/Media/Html/Liriomyza_trifolii.htm

3.1 Diagnostic considerations

Considerations when triaging samples of suspected American serpentine leafminer for diagnostics include:

- One of the greatest challenges in detection and subsequent management of *Liriomyza* species overseas has been the difficulty in correctly identifying the species (Reitz, Gao and Lei 2013), which can have considerable overlap in adult morphology, host range and damage symptoms left on a plant. In the presence of indigenous leafminer, it may be difficult to detect a new incursion, or determine the limits of an infestation (Powell 1981).
- There are also several difficult to distinguish Agromyzid species present within Australia that are morphologically indistinguishable from American serpentine leafminer to a non-expert (including *L. brassicae* and *L. chenopodii*). In many cases, specimens must be distinguished by expert taxonomists, or via molecular means.
- Within Australia, there at least 50 leafminer species (family Agromyzidae) (and presumably many more that have not yet been described) that create leaf mines that look similar to American serpentine leafminer and may appear on the same host plants. Some of the most common include *Liriomyza brassicae* (which shares several brassica hosts with American serpentine leafminer), *Liriomyza chenopodii* (which shares cultivated beets with American serpentine leafminer), and *Phytomyza syngenesiae (*which shares cultivated asters with American serpentine leafminer) (Appendix 2). Moreover, there are an unknown number of additional Dipteran and Lepidopteran species that share the leaf mining habit.
- Of these species that create similar leaf mining damage, some can be distinguished from American serpentine leafminer via their mine characteristics, and their pupal or adult forms. (see Appendix 2, IPCC 2016). However, the high degree of individual variation between each leaf mine means there can always be exceptions to these guidelines. For example, while American serpentine leafminer pupate outside the leaf, there are rare instances where a larvae will fail to emerge and complete pupation within the leaf mine.

- Due to the high degree of morphological overlap of adults and visual overlap of damage, sample collection (of flies of any life stage and/or leaf mines) will be paramount for identifying and delimiting potential American serpentine leafminer incursions.
- Surveyors should be familiar with the American serpentine leafminer host plant list (Appendix 1), as well as with commonly observed signs of indigenous leafminer damage and the extent of known overlap with indigenous Agromyzids for common host genera (Appendix 2) before conducting American serpentine leafminer surveillance. For example, damage caused by the closely related *L. brassicae* is essentially indistinguishable from American serpentine leafminer and is very common on brassica crops (Appendix 2). Crops such as tomato, cucumbers and melons, on the other hand, have little to no reported overlap with indigenous Agromyzids (Appendix 2). Mines detected on these crops during surveillance activities should be considered highly suspicious.

4. SURVEILLANCE AND COLLECTION OF SAMPLES

4.1 Surveillance

4.1.1 Technical information for planning surveys

Detection and delimiting surveys are required to determine the extent of outbreaks, ensure areas free of the pest retain market access, and ensure appropriate quarantine zones are established to contain outbreaks.

Initial surveillance priorities for American serpentine leafminer should consider the following:

- Visual surveillance for the leaf mines created by American serpentine leafminer is expected to be the most reliable way to detect new incursions. This is because the serpentine leaf mines created by leafminer larvae persist permanently on a leaf, extending the detection window beyond the lifespan of the fly itself. In comparison, sweep netting requires active populations, as do yellow sticky traps. While sticky traps can be left in place for extended periods to increase the chance of catching an adult, in open field settings, relying solely on sticky traps would be impractical due to the very large number of traps that would be needed to be placed and processed, to reach a statistically acceptable detection likelihood for small or isolated populations.
- In closed cropping systems, sticky traps become much more practical, but should still be accompanied by visual surveillance.
- Sticky traps will have a high level of bycatch (i.e. other insects will be caught in the trap), which can increase processing time for manual identifications. However, molecular diagnostic methods are also available for bulk invertebrate samples collected via a sticky trap (see Section 4.2.2.2).
- When undertaking visual surveillance in plant crops, the leaf mines are the most conspicuous symptoms to look for, though stippling from oviposition and feeding may also be apparent.
- Mines created by *Liriomyza* spp. are generally expected to be more common on the edges of fields and in the upper portions of the plant (Weintraub 2001).
- The American serpentine leafminer has an extensive list of weed hosts (see Section 2.3) and therefore surveillance in broadleaf weeds as well as cultivated crops should be undertaken.
- Larvae, pupae and adults can be identified using molecular methods (refer to Section 3).
- Only adult male leafminers can be identified using morphological methods.
    - Adults can be captured using yellow sticky traps, sweep netting (IPPC 2016), or rearing from infested material. The latter is the most practical and reliable method for collecting adult flies. Infested leaves can be placed into an insectarium to develop into adults (IPPC 2016). Techniques for rearing Agromyzids are described in Griffiths (1962) and Fisher et al. (2005).
- Collectors should be made aware of common signs of leafminers and note symptomatic plants when conducting surveillance for American serpentine leafminer.

- Australia is already home to several leafminer species, both native and naturalized, which can be confused for American serpentine leafminer. Surveyors should be made aware of the native and naturalized species they might expect to see in the particular region and crops they are surveying.
- Early detection surveillance will be most effective if timed when American serpentine leafminer population growth potential is greatest, such as during warm conditions. The seasonality of American serpentine leafminer activity at major centers is provided in Table 6.

Table 6 Major Australian growing regions showing risk seasonality for American serpentine leafminer activity across the year. Green means highest establishment risk (where the population growth potential was greater than 50% of the maximum predicted growth rate) yellow means lower establishment risk (where the population growth potential was between 1 and 50% of the maximum), and red means lowest establishment risk (where predicted growth rates are negative, meaning populations are predicted to decline).

State	**Incursion point**	**Seasonality**											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Western Australia	Perth	Red	Yellow	Red	Green	Green	Green	Yellow	Red	Yellow	Green	Yellow	Red
	Geraldton	Red	Red	Red	Red	Red	Green	Yellow	Yellow	Green	Green	Yellow	Red
	Carnarvon	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
	Bunbury	Red	Red	Yellow	Green	Red	Yellow	Yellow	Red	Yellow	Green	Green	Yellow
	Albany	Yellow	Yellow	Green	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green
Victoria	Thorpdale	Green	Green	Green	Yellow	Yellow	Red	Red	Red	Red	Yellow	Green	Green
	Melbourne	Green	Green	Green	Yellow	Yellow	Red	Red	Red	Yellow	Yellow	Green	Green
	Ballarat	Green	Green	Green	Yellow	Yellow	Red	Red	Red	Yellow	Yellow	Green	Green
Tasmania	Smithton	Yellow	Yellow	Green	Yellow	Yellow	Red	Red	Red	Yellow	Yellow	Yellow	Yellow
	Devonport	Green	Yellow	Green	Yellow	Yellow	Red	Red	Red	Yellow	Yellow	Yellow	Green
South Australia	Mt. Gambier	Green	Green	Yellow	Yellow	Yellow	Red	Red	Red	Yellow	Yellow	Green	Green
	Loxton	Red	Red	Red	Red	Green	Red	Red	Red	Red	Red	Red	Red
	Adelaide	Red	Red	Red	Red	Red	Red	Yellow	Yellow	Green	Green	Red	Red
Queensland	Toowoomba	Red	Red	Green	Green	Yellow	Yellow	Red	Yellow	Red	Red	Green	Green
	Bundaberg	Green	Red	Red	Green	Green	Yellow	Yellow	Yellow	Red	Red	Green	Green
	Bowen	Red	Green	Green	Green	Green	Green	Green	Green	Yellow	Red	Yellow	Red
	Atherton	Yellow	Green	Green	Green	Green	Yellow	Green	Yellow	Green	Green	Green	Yellow
Northern Territory	Katherine	Green	Red	Red	Green	Red	Green	Yellow	Red	Red	Red	Red	Red
	Darwin	Green	Green	Green	Green	Green	Green	Yellow	Red	Red	Red	Red	Red
New South Wales	Sydney	Red	Red	Green	Green	Yellow	Yellow	Red	Yellow	Yellow	Yellow	Red	Red
	Griffith	Red	Red	Red	Green	Green	Red	Red	Red	Green	Green	Green	Red

4.1.1.1 Surveillance tools

Yellow sticky traps and sweep netting can be used as supplementary methods to visual searches during delimiting surveillance activities, particularly when suspicious damage has been observed, or for monitoring existing outbreaks.

- Sweep netting is expected to be most effective when employed near recently active leaf mines, and is less effective near old leaf mines (which tend to be darker coloured than fresh mines, see Figure 6). Windy conditions can also reduce the effectiveness of sweep netting as adults tend to remain low in foliage during windy conditions (Foster 1986).

Figure 6 Younger leafminer mines (on the left) are more white-coloured with more distinct black trails of frass. Frass becomes less distinct as mines age, and mines develop a brown colour (right). Younger mines are expected to give the best sweep netting success. Images: Elia Pirtle, Cesar Australia *Pty Ltd*

- Agromyzid flies are attracted to the colour yellow (Chandler 1981), and can therefore be captured on yellow sticky traps. Yellow sticky traps are more effective for *Liriomyza* adults than other types of traps, such as funnel traps and yellow water pans (Chavez and Raman 1987). Vacuum sampling has also been shown to be a less effective means of sampling adult leafminer (Weintraub 2001).
- A great deal of effort overseas has been dedicated to improving the effectiveness of yellow sticky traps for *Liriomyza* adults (Heinz et al 1992) including the modifications of size, shape, adhesives, lures, height and orientation. For example, several studies report a strong effect of trap height on the number and species trapped (Trumble and Nakakihara 1983, Zehnder and Trumble 1984, Zoebisch and Schuster 1990), however these results do not always appear consistent and may be difficult to extrapolate across different crop types. Moreover, optimal height may vary considerably between *Liriomyza* species (Zehnder and Trumble 1984). General guidelines are:
- Some considerations when using yellow sticky traps for *Liriomyza* surveillance are provided below:
    - Traps should be placed (vertically oriented) at the edges of paddocks, preferably on the upwind side of paddocks, and near weed reservoirs if possible.
    - Optimal trap height may vary with crop type.
    - Traps should be placed in the afternoon, and left for a minimum of 24 hours, to ensure traps are active during the peak flight time for American serpentine leafminer
    - Traps may be left in place for up to one month, at which point they should be collected, to prevent excessive degradation of DNA and allow for molecular confirmation of American Serpentine leafminer caught on the trap. If traps are placed outdoors and exposed to the elements and/or high levels of bycatch they should be collected sooner than one month.

Experimental lures developed from the extracted volatiles of known plant hosts have been shown to be attractive to *Liriomyza*. However, none have yet been identified for American serpentine leafminer.

4.1.2 Delimiting surveys in the event of an incursion into new areas

Following a new detection of American serpentine leafminer, the following guidelines are recommended for delimiting surveillance:

- Surveillance to delimit a detection of American serpentine leafminer should take into account tracing information as outlined in Section 5.1 to determine potential pathways for the movement of material from the site of the initial detection
- Surveillance should be a combination of:
    - Visual inspection in high risk areas (e.g. areas with suitable hosts)
    - Sweep nets to collect adults around infested host plants
    - Yellow sticky traps, particularly in closed cropping systems and around infested plants/areas
- Surveillance should be accompanied with awareness material, signs and personal visits to households and businesses within the surveillance zone and any buffer zones

The suggested surveillance procedure for American serpentine leafminer is as follows:

1. Delimiting surveillance should be conducted immediately upon detection of any incursions within a radius within 1 km of the incursion site, based on natural spread dynamics of agromyzid leafminer. The Surveillance zone may be increased as deemed necessary for the individual response
2. At each site, chose a crop that is a known host plant of American serpentine leafminer (refer to Section 2.3)
3. Choose a survey path that preferences the following areas if possible:
    - Paddocks and weeds near transport routes and unloading areas. These are preferred, because a major long-distance pathway of leafminer spread is human assisted movement
    - Paddock edges should be included in the survey path, with the 'incoming wind side' preferred, since short distance movements of leafminer can be driven by wind.
    - Weeds along paddocks should be included in the survey path.
4. Leafminer damage may be patchy at low densities.
5. At low densities, leaf mines have a relatively low detectability, despite their characteristic appearance. Slower search speeds will improve detection likelihood, however, when time is limited, search speed trades off with the total area covered (reducing the number of possible encounters). This trade-off is important in realistic paddock monitoring scenarios.
    - When time is not limited: To achieve a detection probability of 20%, 50%, and 80% respectively, when leaf mine density is about 1% of plants affected, the mean (and 95% CI) search time required per metre is 11.2 (4.8, 20.5), 34.8 (15.0, 63.8), and 80.8 (34.9, 148.2) seconds spend 1 minute searching per 1 m^2 of area (based on data collected during vegetable leafminer survey effort trials).

- When time is limited: The optimal search speed, balancing area coverage with sensitivity, when leaf mine density is about 1% of plants, is about 10 seconds per 1 m^2 of area. Further benefits are not achieved by increasing search speed beyond this level to achieve greater area coverage.
- (These recommendations are based on data collected during Vegetable leafminer (*L. sativae*) survey effort trials – other *Liriomyza* leafminers are expected to require similar effort)).

6. A survey plan should take into consideration any variables regarding the environment or surveyor that might reduce detectability and increase the effort spent accordingly. These variables might include:
    - *Plant type*
        i. *Leaf density:* leafminer damage may be harder to spot in plants that are very dense and leafy, than in plants with larger, sparser or flatter leaves.
        ii. *Plant age:* it may be easier to spot leaf mines in young plants with few leaves and more open space between plants than in larger mature, overlapping plants.
        iii. *Colour:* leafminer damage may be harder to spot against light coloured leaves than against darker leaves.
        iv. *Height*: Leafminer damage in plants that are at eye level may be easier to spot than crops that are low to the ground.
        v. *Time of day/direction of survey relative to the sun*: Survey success may be higher when surveyors are walking with their back to the sun, rather than walking into the sun.
    - *Residues on plants:* Chemical residue on plants may reduce the contrast between the mine and the leaf, or obscure mine patterns with background residue patterns.
    - *Damage from other pests/disease on plants:* damage caused by other pests or disease may obscure leaf mines, or lead to false positive detections.
    - *Surveyor experience:* Inexperienced surveyors may have a learning curve.
    - *Weather conditions:* Surveys during poor weather should be avoided when possible.
7. If suspicious damage is detected, samples should be collected (see Section 4.2), and yellow sticky traps should be placed around the affected area, in an attempt to capture adults and diagnose the fly responsible for the damage.
    a. If American serpentine leafminer are confirmed, visual surveillance along with sticky traps should be used to monitor the edges of the outbreak area.
8. If no suspicious damage is detected, the initial round of delimiting surveillance should be followed with a second round occurring after one week.
    a. This second round is necessary as leafminer eggs are undetectable in the leaf, and hatch after about 2-5 days. A crop that appears clean during the initial survey may still develop symptoms within a week.
    b. After the first revisit, any further revisits should occur on a monthly basis. One lifecycle of the American serpentine leafminer is estimated to take approximately 2 to 4 weeks, dependent on host and temperature.

4.1.3 Activities for general surveillance immediately following a detection

Given the wide host range of this pest and its noticeable impact it may be a suitable target for general surveillance programs that request submission of images and/or samples from the public.

To establish a general surveillance program, the following will be required:

- Use of online or app reporting tools such as MyPestGuide to promote the submission of reports of suspected detections.
- Factsheets to provide information on the pest, symptoms, impacts and reporting mechanisms.
- Media releases to describe the impact of the pest, surveillance programs and activities within the response program.
- Information for industry communication channels including articles for industry newsletters, magazines and websites, information for Twitter feeds and Facebook, and presentations for industry talks.
- A website to provide information for the public and for commercial businesses and links to other relevant sites.
- Release and promotion of information on details for physical sample collection and submission, as well as information on how to take and submit images of flies/leaf mines.
- Broader awareness campaigns should consider literature (brochures and factsheets) in several languages.
- A non-expert friendly surveillance and sample collection guide for vegetable leafminer, which also has relevance for the pea leafminer, as well as other useful information, can be found here.

4.2 Collection and treatment of samples

4.2.1 If collecting for morphological diagnosis

Of the four life stages (egg, larva, pupae and adult) only adult males are identifiable to a species level using morphological features.

4.2.1.1 Collection of adult male specimens

Adult flies can be collected with a vacuum sampler or sweep net. Adult flies are normally found on the foliage. However, the most practical and reliable method is the collection of leaves with mines containing pupae or mature larvae which can then be reared until adult flies emerge (refer to Section 4.2.1.3).

4.2.1.2 How to collect sticky traps for identification

Sticky traps should be left in the field for up to one month (but preferably 2 weeks or less), to allow morphological identifications. Upon collection, sticky traps should be folded lightly in half sticky side inwards (not pressed shut), and placed in a sealed, padded plastic bag. Traps should be sent within a week of collection (and kept in cool, dry place in the meantime, but not frozen).

4.2.1.3 How to collect plant samples for rearing

For rearing of adult flies, mined leaves containing pupae or mature larvae can be collected into an insectarium and kept in a constant temperature room for regular checking. Simple insectariums include sealed partially inflated ziplock bags, or sealed rigid plastic containers or jars. A piece of paper towel should be placed into the insectarium along with the infested leaves to regulate humidity. Once pupae emerge from the leaves, they should be transferred carefully with a wet paintbrush to a new rigid container, which contains a layer of damp sand but no leaf material. Pupae can be placed directly onto the damp sand. Techniques for rearing agromyzids are described in the IPCC diagnostic protocol for *Liriomyza* (IPPC 2016, available from here).

4.2.1.4 How to preserve plant samples for identification

Identifying the plant species affected by suspected American serpentine leafminer damage can aid diagnoses, particularly when surveying in weeds. To preserve a plant for identification, leaves can be stored between sheets of dry newspaper. However, if plant material with suspected leaf mines is pressed and dried, there will be no chance of rearing out adult flies from those leaf mines. Therefore, whenever plant identity is in question, infested material should be stored in an insectarium for rearing, and an accompanying pressed sample of uninfested leaves should be taken to facilitate identification of the host.

4.2.1.5 How to preserve leafminers

Adults caught in sweep nets or reared in insectariums can be placed in 70% ethanol and stored indefinitely for morphological purposes. For adults reared in insectariums, it is advised to collect these adults in the afternoon, as emergences tend to occur in the morning, and enough time should be given for wings to fully expand before collection.

4.2.1.6 How to transport leafminers

Vials of ethanol should be sealed to avoid leakage and packed with cushioning material in a strong box.

For information on what can or cannot be sent by post refer to the Australia Post website: https://auspost.com.au/content/dam/auspost_corp/media/documents/dangerous-and-prohibited-goods-guide.pdf.

4.2.1.7 How to transport plant samples

Plant samples may be collected if the host needs to be identified. Queensland Herbarium (2016) provides information on how to collect and preserve herbarium specimens. Samples should then be taken to state herbaria for identification.

For information on what can or cannot be sent by post refer to the Australia Post website: https://auspost.com.au/content/dam/auspost_corp/media/documents/dangerous-and-prohibited-goods-guide.pdf.

4.2.2 If collecting for molecular diagnosis

All life stages can potentially be diagnosed using molecular methods, including empty leaf mines.

4.2.2.1 Collection of specimens

Adult flies can be collected with a vacuum sampler or sweep net. Adult flies are normally found on the foliage. However, as other life stages can be diagnosed using molecular methods leaves with mines containing pupae or mature larvae should also be collected for analysis. Rearing these life stages in an insectarium is not necessary for molecular diagnostics.

4.2.2.2 How to collect sticky traps

Upon collection, sticky traps should be either:

- Placed inside a plastic sleeve that has been cut along one long side and along the bottom, the trap and sleeve can then be sealed in a plastic zip lock bag.
- Folded in half, sticky side inwards, and placed in a sealed plastic bag.

Traps should be sent within a week of collection (and kept in a cool, dry place in the meantime, but never frozen).

4.2.2.3 How to collect plant samples

Plant samples with suspected American serpentine leafminer damage should be collected for molecular confirmation. If it is possible to discern a live larvae inside a leaf mine (which can be spotted through the leaf mine as a small yellow maggot, either by eye or with a hand lens, see Figure 7), these samples are always preferable. However, mined leaves that appear empty can also be collected. Empty mine samples that look youngest should be preferred, as they have the greatest chance of containing a live larva (see Figure 6).

Figure 7 A larva inside a leaf mine. Larvae are visible to the eye in later stages of development. Images: Elia Pirtle, Cesar Australia *Pty Ltd*

4.2.2.4 How to preserve plant samples

Mined leaves containing pupae or mature larvae, or mined leaves that appear empty can all be placed straight into 100% Ethanol. Small mined leaves should be rolled and placed into the tube of absolute ethanol. For larger leaves, the mine should be cut out, with care taken to avoid cutting across the mine, and the cut out should be rolled and placed into the tube of absolute ethanol. These samples should be frozen and mailed within a week of collection for diagnostics.

Due to the very small amounts of DNA within leaf mines, the odds of sample contamination is much higher than when working with whole flies. Careful hygiene must be employed when collecting and preserving suspicious leaf mine samples. Mines from different host plants or different locations should never be stored in the same container. Samples should either be immediately preserved into on site, or should be placed into unused, clean, sealed plastic bags on site and preserved within the day. If samples from multiple hosts or sites are being processed together at a field lab location, all equipment must be sterilised between each host/location (i.e. cleaning counter tops, sterilizing tweezers and other tools).

Leaf mines may also be preserved onto FTA cards, however DNA quality is somewhat lower than for preservation into 100% ethanol (Pirtle et al., *in press*). To preserve leaf mines onto FTA cards, remove the mined leaf from plant and push the leaf mine face down onto the FTA card. Smear the mine thoroughly on the FTA card, for about 30 seconds, and then close the card and place in small sealed plastic bag. Do not rub mines from different host plants/sites onto the same FTA card, and do not store FTA cards from different host plants/sites in the same sealed bag. Store the FTA cards in a cool, dark, dry place and send for analysis within a week of collection

4.2.2.5 How to preserve leafminers

Specimens required for molecular diagnostic work, including larvae, pupae or adults, should be killed and preserved in absolute ethanol, frozen at -80°C , or preserved on an FTA card.

4.2.2.6 How to transport leafminers and plant samples

Vials of ethanol should be sealed to avoid leakage and packed with cushioning material in a strong box.

For information on what can or cannot be sent by post refer to the Australia Post website: https://auspost.com.au/content/dam/auspost_corp/media/documents/dangerous-and-prohibited-goods-guide.pdf.

5. IMMEDIATE RESPONSE TO DETECTION

5.1 Tracing

Detection and delimiting surveys are required to delimit the extent of the outbreak, ensure areas free of the pest retain market access, and ensure that appropriate quarantine zones are established.

Extensive tracing (trace forward and trace back) may be feasible as *Liriomyza* spp. can be readily dispersed by the movement of infested plant material, soil and crop debris. The focus should be on high risk linkages including premises linked directly with the initial detection, particularly where movements of plant material (such as nursery plants and seedlings), or soil have occurred as these pathways may move American serpentine leafminers over long distances.

Further information on possible risk pathways are presented in Section 2.8 and in Table 3.

5.2 Quarantine and movement controls

If Restricted or Quarantine Areas are practical, no plant material should be moved from the infested to uninfested areas without first being inspected and appropriately treated. The size of the Restricted or Quarantine Area will be dependent on the type and scale of the incursion. However, a zone 1 km in radius should be considered for initial delimiting surveillance activities (Section 4.3). This zone can then be expanded as needed depending on the specific situation.

Voluntary movement control should be considered for urban/residential detections. Voluntary controls would involve negotiation with residents to undertake inspection and treatment of goods prior to movement from infested areas. Residents should be advised on measures to minimise the inadvertent transport of the pest from the infested area to unaffected areas. Voluntary compliance is likely to be implemented for urban areas using awareness campaigns to highlight high risk goods/situations and appropriate treatments.

5.3 Destruction strategy

5.3.1 Priorities and considerations

If eradication of an outbreak is considered feasible, the priority will involve the destruction of the pest. Adult leafminers may be present around host plants; eggs, larvae and pupae may be present in the leaves of host plants, and pupae may be present within the first 5 cm of soil under host plants.

Considerations include:

- The infested plants may need to be sprayed with a suitable insecticide (refer to Section 5.3.3), then bagged and then buried (or tilled/ploughed directly into the soil if a large area is affected).
- Other host plants in the immediate area should be inspected and treated as needed.
- Soil and plant media in greenhouses should be treated (heat or chemically) to destroy any pupae that may be present in the soil.

- Machinery and equipment used on site should be washed down to minimise the potential risk of spreading the pest between sites.

5.3.2 Decontamination of tools and equipment

Machinery, equipment, tools and clothes should be cleaned and disinfected between sites to minimise the potential to spread leafminers, and other pests and diseases that may be present on the site, to new areas.

For points to consider when decontaminating, refer to the PLANTPLAN Guideline document: Disinfection and Decontamination (PHA, 2015[1]). which includes guidelines for the destruction and decontamination of tools used when working with emergency plant pests.

Several state agriculture departments have also produced publications on cleaning down machinery and vehicles and should be referred to if decontamination is required, examples include:

- www.dpi.nsw.gov.au/__data/assets/pdf_file/0010/545554/procedure-decontamination-vehicles-and-equipment.pdf.
- www.daf.qld.gov.au/__data/assets/pdf_file/0011/58178/cleandown-procedures.pdf
- http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/weeds/weedstop-vehicle-hygiene-program/machinery-hygiene.

5.3.3 Chemical control

Overseas *Liriomyza* leafminers are most damaging when parasitoids are removed due to the use of non-selective insecticides (Cesar Australia 2018; Murphy and LaSalle 1999). For the ongoing management of leafminers it will therefore be important that chemicals are selected that are reasonably selective and have low toxicity towards key parasitoids.

The European and Mediterranean Plant Protection Organization (EPPO) provides guidance (EPPO 2009) on how to manage and eradicate Vegetable leafminer infestations in Europe, which are broadly applicable to other *Liriomyza* spp., such as the American serpentine leafminer. For Vegetable leafminer, the EPPO recommends that foliar sprays are applied at weekly intervals until control has been achieved. Importantly the EPPO suggests rotating chemicals and modes of action (where possible) each treatment (Table 7). In greenhouse environments the use of a suitable space treatment is also suggested (EPPO 2009). Based on this it would be ideal if pesticides from different mode of action groups are available for each host crop, as this would allow pesticides to be rotated rather than relying on a single product being continuously used to manage/treat the pest.

[1] www.planthealthaustralia.com.au/biosecurity/incursion-management/plantplan/

Table 7 An ideal chemical rotation schedule used for eradication of Liriomyza leafminers in Europe (refer to EPPO 2009)

WEEK	PESTICIDE USED TO TREAT INFESTED AREA
Week 1	Chemical A
Week 2	Chemical B
Week 3	Chemical C
Week 4 onwards	Repeat above sequence

Pesticides registered for the control of American serpentine leafminer overseas include the following actives:

- Abamectin
- Azadirachtin
- Chlorantraniliprole
- Cyantraniliprole
- Cyromazine
- Diazinon
- Emamectin benzoate
- Indoxacarb
- Permethrin
- Spinetoram
- Spinosad
- Spirotetramat

It should be noted that Australian Pesticides and Veterinary Medicines Authority (APVMA) permits will need to be put in place before these pesticides can be used for the control of American serpentine leafminers. Permits are being applied for as part of Horticulture Innovation Australia Project MT16004 (RD&E program for control, eradication and preparedness for Vegetable leafminer), and these are noted in Table 8.

As the American serpentine leafminer can affect many plant species (including agricultural and ornamental species) (refer to Section 2.3), it is important that all potential hosts are covered by at least one, but preferably multiple, pesticide permits. Appendix 3 provides a summary of the pesticides that can be used on each crop type and host and should be used as a guide when treating new American serpentine leafminer outbreaks, or if eradication is unsuccessful, managing the pest. As new permits are approved by the APVMA, they will be made publicly available on the APVMA permit database: https://portal.apvma.gov.au/permits.

Table 8 Insecticide permits that have been applied for or granted by the APVMA for the control of American serpentine leafminer in Australia (as of July 2020)

CHEMICAL	CHEMICAL ACTIVITY	LIFECYCLE STAGES CONTROLLED	CROPS COVERED[2]	PROPOSED RATE	PERMIT NUMBER	EXPIRATION DATE
Cyromazine (MOA 17)	Contact and translaminar activity	Not effective against adults but being an insect growth regulator is very effective against larval stages (Cesar Australia 2018b). Experiments on the American serpentine leafminer found that Cyromazine was very effective against first and second instar but less effective against late instar larvae (Yathom et al., 1986).	Nursery stock (non-food)	333 g in 20 L water/10 tonne potting mix	PER83506	31 October 2022
			Fruit trees (non-bearing)	950 g/ha or 95 g/100 L applied in 1,000 L/ha.		
Dimethoate (MOA 1B)	Contact and systemic activity	Dimethoate is reported to control *Liriomyza* spp. adults and larvae however resistance is known overseas (Tran and Takagi 2005)	Pulse crop (grains)	75ml (400 g a.i/L products)/100L water	PER89184	31/3/2025
Emamectin benzoate (MOA 6)	Contact and translaminar activity	Same mode of action as abamectin. Reported efficacy against larvae, adults and eggs (Cesar Australia 2018b)	Brassica vegetables (including broccoli, Brussels sprouts, cabbage, cauliflower)	250 to 300 g/ha (44 g a.i/kg products); or 650 to 780 mL/h (17 g a.i/L products) (suppression only)	PER87563	30 June 2024

[2] Refer to Appendix 4 for detailed information on chemical control options.

CHEMICAL	CHEMICAL ACTIVITY	LIFECYCLE STAGES CONTROLLED	CROPS COVERED[2]	PROPOSED RATE	PERMIT NUMBER	EXPIRATION DATE
Spinetoram (MOA 5)	Contact, systemic and translaminar activity	Spinetoram has shown efficacy against *L. sativae* adults and larvae (Shimokawatoko et al., 2012)	Vegetable legumes (peas and beans)	400 ml (48 g a.i)/ha	PER87878	28/2/2023
Spirotetramat (MOA 23)	Contact, systemic and translaminar activity	Affects the development of larvae and has little impact on adults (Ring 2019)	Capsicum	400ml (96 g a.i)/ha	PER88640	31/5/2023
			Celery			
			Chili			
			Eggplant			
			Green beans			
			Lettuce (head and leafy)			
			Parsley			
			Rhubarb			
			Snow & sugar snap peas			
			Tomato			

Research undertaken as part of the Hort Innovation project MT16004 has identified the suitability of the following as potential control options for *Liriomyza* spp.:

- Azadirachtin (a systemic insecticide that acts as an insect growth regulator, MOA unknown) on ornamental and floriculture plants.
- Abamectin (an insecticide with contact and translaminar activity, MOA 6) on fruiting vegetables, cucurbits, leafy vegetables, legume vegetables, bulb vegetables, cabbage, celery, and rhubarb.
- Cyantraniliprole (a systemic insecticide, MOA 28) on bulb vegetables, fruiting vegetables, cucurbits, melons, and potatoes (note residue data will be required to support this use pattern).
- Diazinon (a contact insecticide, MOA 1B) on beans, melons, beetroot, lettuce, parsnips, tomatoes, and potatoes. Note can have significant impact on beneficial insects meaning it would likely be more suited to use in eradication programs than ongoing management of the pest.
- Dimethoate (a systemic insecticide, MOA 1B) on green beans, peas, tomatoes, capsicums, and potatoes. Note can have significant impact on beneficial insects and not fit well with IPM systems.
- Emamectin Benzoate (an insecticide with contact and translaminar activity, MOA 6) on brassicas, leafy vegetables, fruiting vegetables, cucurbits, and melons.

- Indoxocarb (an insecticide with contact and some translaminar activity, MOA 22A) on tomatoes.
- Permethrin (an insecticide with contact activity, MOA 3A) on tomatoes. Note can have significant impact on beneficial insects meaning it would likely be more suited to use in eradication programs than ongoing management of the pest.
- Pyrethrins (an insecticide with contact activity but very limited residual activity, MOA 3A) on brassicas, leafy vegetables, lettuce, fruiting vegetables, and legume vegetables.
- Spinetoram (an insecticide with contact, systemic and translaminar activity, MOA 5) on cotton.

Permits for these use patterns have not been applied to date. However, in the event of an incursion, emergency permits for these use patterns could be developed if required.

5.3.4 Physical control options

Destruction of host plants and deep ploughing of crop residues can assist with leafminer control as adult leafminers have difficulty emerging from pupae buried deeply in soil.

Removal of weed hosts of the leafminer and planting susceptible crops away from weed hosts can also assist with the ongoing management of the pest by removing potential leafminer reservoirs.

5.3.5 Biological control

Although not specifically for eradication, biological controls will assist in lowering leafminer populations and will be an important part of the management of American serpentine leafminers should eradication not be possible in the event of an outbreak.

Parasitoids often provide effective suppression of leafminers in the field when non-selective insecticides are not used (Cesar Australia 2018). History has also shown that invading *Liriomyza* populations are rapidly exploited by endemic Agromyzid parasitoids (Cesar Australia 2018). For these reasons it will be important that any pesticides used for the ongoing management of leafminers are compatible with Integrated Pest Management (IPM) systems.

Minkenberg and Lenteren (1986) identified 28 species of parasitoids that are reported to affect American serpentine leafminer (Table 9). Agromyzid parasitoids tend not to be very host-specific and Australia already has several endemic species that would likely be effective against the American serpentine leafminer. *Diglyphus isaea* is an example of a parasitoid that occurs in Australia and is mass reared overseas for the biological control of *Liriomyza* species including American serpentine leafminers.

The importation of biological control agents is not warranted at this time as the adventive parasitoids such as *D. isaea*, already occur in Australia and would likely be suitable for the management of leafminers assuming pesticides are selected appropriately and are compatible with IPM systems.

Table 9 Parasites and parasitoids of American serpentine leafminer noted in Minkenberg and Lenteren (1986)

PARASITE NAME	PARASITE NAME	PARASITE NAME	PARASITE NAME
Chorebus misella	*Diglyphus intermedus*	*Halticoptera circulus*	*Diglyphus crassinervis*
Dacnusa maculipes	*Diglyphus pulchripes*	*Halticoptera patellana*	*Ratzeburgiola incompleta*
Oenonogastra microrhopalae	*Diglyphus websteri*	*Diaulinopsis callichroma*	*Hemiptarsenus dropion*
Opius dimidiatus	*Chrysocharis parksi*	*Chrysocharis caribea*	*Pnigalio soemius*
Opius dissitus	*Chrysonotomyia formosa*	*Closterocerus purpureus*	*Chrysocharis pentheus*
Mirzagrammosoma lineaticeps	*Chrysonotomyia punctiventris*	*Hemiptarsenus semialbiclava*	*Dacnusa sibirica*
Diglyphus begini	*Closterocerus cinctipennis*	*Diglyphus isaea*	*Halticoptera crius*

5.4 Decision support for eradication

A summary of key activities associated with different detection scenarios for American serpentine leafminer is provided in Table 10. Differing physical detection scenarios have been chosen to highlight operational differences in urban compared with agricultural and horticultural environments.

A summary of factors to be considered for eradication or alternative action is provided in Table 11.

Table 10 Recommended responses and considerations for differing scenarios of detection of American serpentine leafminer

DETECTION SCENARIO	RECOMMENDED ERADICATION/ CONTROL TREATMENTS – SEE SECTION 5.3	RECOMMENDED MOVEMENT CONTROLS – SEE SECTION 5.2	RECOMMENDED SURVEILLANCE OPTIONS – SEE SECTION 4
Commercial glasshouse/ protected cropping setting	➢ Destruction of hosts within glasshouses could be considered to limit food sources or refuges (see Section 5.3.4). ➢ Chemical sprays to eradicate larvae and adults (see Section 5.3.3). ➢ Surveillance within 1 km radius of the detection and in glasshouses managed by the same business as the infested glasshouse (use visual inspections, sweep netting and yellow sticky traps for	➢ No movement of equipment or produce without permit. ➢ Permits to include information on inspection, decontamination or destruction requirements.	➢ Minimum 1 km surveillance zone around the Infected Premises (IP). ➢ Focus on known hosts. ➢ Surveillance at linked properties. ➢ See Section 4 for points to consider when establishing a surveillance program. Key points for glasshouses are: • Undertake visual surveillance of all host plants. • Consider using visual surveys, sweep nets and yellow sticky traps.
Open agricultural/ horticultural setting	➢ Spray infested area using appropriate insecticide (see Section 5.3.3). ➢ Surveillance within 1 km radius of the detection and survey jointly managed properties (use visual inspections, sweep netting and yellow sticky traps for surveillance).	➢ No movement of equipment or produce without permit. ➢ Permits to include information on inspection, decontamination or destruction requirements.	➢ Minimum 1 km surveillance zone around each IP. ➢ Yellow sticky traps, visual inspections and sweep netting should be undertaken in the 1 km zone. ➢ General surveillance awareness campaigns may be beneficial. ➢ Surveillance at linked properties should occur.

DETECTION SCENARIO	RECOMMENDED ERADICATION/ CONTROL TREATMENTS – SEE SECTION 5.3	RECOMMENDED MOVEMENT CONTROLS – SEE SECTION 5.2	RECOMMENDED SURVEILLANCE OPTIONS – SEE SECTION 4
Urban environment	➢ Chemical sprays to eradicate larvae and adults. ➢ Surveillance within 1 km radius of the detection (use visual inspections, sweep netting and yellow sticky traps for surveillance).	➢ Movement controls in infested areas could be undertaken by permit or as voluntary movement controls (coupled with awareness campaign for urban areas).	➢ Surveillance on host plants within 1 km area around IP (noting leaf mines, feeding and oviposition punctures are the most easily seen plant symptoms). ➢ Surveillance to be undertaken in conjunction with awareness campaigns for households providing information on the pest and symptoms. ➢ Yellow sticky traps, visual inspections and sweep netting should be undertaken in the 1 km zone. ➢ Surveillance at linked properties.
Open natural environment (e.g. detection on roadsides or national park)	➢ Treatment of detections in a 1km zone pending delimiting surveillance. ➢ Surveillance within 1 km radius of the detection (use visual inspections, sweep netting and yellow sticky traps for surveillance).	➢ Movement controls in infested areas could be undertaken by permit or as voluntary movement controls. ➢ Movement restrictions may be considered pending outcomes of delimiting surveillance.	➢ Surveillance on host plants within 1 km area around IP (noting leaf mines, feeding and oviposition punctures are the most easily seen plant symptoms). ➢ Yellow sticky traps, visual inspections and sweep netting should be undertaken in the 1 km zone. ➢ General surveillance and awareness campaigns should be considered. ➢ Surveillance should be

Table 11 Summary of factors to be considered in determining whether eradication or alternative action will be taken for an incursion of a American serpentine leafminer

FACTORS TO CONSIDER REGARDING THE TECHNICAL FEASIBILITY OF ERADICATION
• **The population size and population structure associated with the initial detection.** • **The cost effectiveness of recommended control technique options.** - Multiple applications of several different pesticides over a period of time (weeks/months) may be required to successfully eradicate American serpentine leafminer populations. • **The ability to remove or destroy all American serpentine leafminers by the recommended control techniques.** - Permission to enter private premises for surveillance and treatment must be considered. - Determination of whether treatments can effectively eradicate populations within premises or environments. • **The recommended control techniques are publicly acceptable.** - Chemical treatments in residences or backyards may not be acceptable or will require negotiation with residents. • **Whether emergency containment measures can effectively be put in place to contain the outbreak.** • **Whether there are control methods, commonly employed for endemic pests, that may prevent the establishment of, or be impacted by the treatment, for American serpentine leafminer.** • **Legislative impediments to undertaking an eradication response.** - If not a prescribed pest, confirmatory diagnosis will be required under legislation in some jurisdictions before powers to enter premises and undertake treatments can be enacted. - Delimiting surveillance in urban environments may be restricted to front yards and environs rather than entry into premises (unless permission from the resident can be negotiated). - Emergency permits will be required for chemical treatments. Amendments to chemical labels will be required for longer term management of the pest if eradication is not possible. • **The ability to delimit the known area of infestation.** - Determination of linked properties in an urban detection may be unfeasible given the ability of adult leafminers to disperse at a local level. High risk linkages such as the recent purchase of seedlings, cut flowers or other commodities that could vector the pest should be investigated. • **The ability to identify and close the pathway for entry of the pest into Australia.** - Pathways into Australia such as on nursery plants from overseas are managed via Post Entry Quarantine. - Natural dispersal is a possible pathway from neighbouring countries into northern Australia. Northern Australia Quarantine Strategy (NAQS) surveys offer an early detection mechanism to detect natural introductions from the north. If an outbreak is detected the pathway will need to be identified and closed, where possible. • **The dispersal ability of the pest.** - American serpentine leafminer has the ability to naturally spread over short distances through flight or wind assisted dispersal. - Nursery material that is a host of American serpentine leafminer (including containerized plants, seedlings, bare rooted plants, etc.; see Appendix 1 for host list) and cut flowers that are host plants are the most likely means of spread to new areas. They may carry all life stages of the pest and will need to be managed to reduce the spread of the pest to new areas. Nursery material and cut flowers that are not a host of American serpentine leafminer are at significantly lower risk (but may still transport adults across short periods if they have been in close proximity with host plants).

- Plant material (potentially including fresh hay and crop debris) and soil could also facilitate the spread of the pest (via adults and pupae) to new areas. Tools, equipment, machinery and vehicles are lower risk but may still transport hitchhiking adults or pupae via soil deposits.
- American serpentine leafminer is considered unlikely to travel with harvested fruit (without leaves) as the process of harvesting or moving produce is likely to cause adults to disperse and provided soil and leaf material is absent it is unlikely to spread larvae and pupae. Leafminer are also not expected to travel via the movement of seed.
- Fresh green or leafy vegetables or fresh legume vegetables (e.g. snow peas) may allow the spread of eggs and larvae and potentially adults and pupae. Therefore, movement restrictions or mandatory treatments may be needed for some vegetable crops.
- See Table 3 for further details on possible dispersal pathways

- **The capability to detect *Liriomyza* leafminers at very low densities for the purpose of declaring freedom, and that all sites affected by the pest have or can be found.**
- Surveillance typically relies on visual inspection of host plants for mining activity as well as the use of yellow sticky traps and sweep netting.
- **The ability to put into place surveillance to confirm proof of freedom.**
- Surveillance options are available for American serpentine leafminer and include visual inspection of host plants for mines, yellow sticky traps and sweep netting.
- **Whether community consultation activities have or will be undertaken.**
- In an urban environment, community consultation will be critical to assist in securing public support for delimiting surveillance and an eradication program.
- Given the symptoms caused by this pest on a wide range of plants, general surveillance activities should be implemented comprising of awareness material, media releases, web-based reporting tools and the Exotic Plant Pest Hotline (1800 084 881).

6. EMERGENCY PLANT PEST RESPONSE DEED AND PLANTPLAN

The Emergency Plant Pest Response Deed (EPPRD) and PLANTPLAN should be referred to, in conjunction with this contingency plan when developing a Response Plan in the event of an American serpentine leafminer detection in Australia.

6.1 Emergency Plant Pest Response Deed

PHA is the custodian of the EPPRD. This is a formal legally binding agreement between PHA, the Australian Government, all state and territory governments and national plant industry body signatories.

It covers the management and funding of responses to Emergency Plant Pest (EPP) incidents, including the potential for Owner Reimbursement Costs (ORCs) for growers. It also formalises the role of plant industries' participation in decision making, as well as their contribution towards the costs related to approved responses.

Under the EPPRD an EPP is defined as a pest that meets one or more of the following criteria:

a) It is a known exotic Plant Pest the economic consequences of an occurrence of which would be economically or otherwise harmful for Australia, and for which it is considered to be in the regional and national interest to be free of the Plant Pest.
b) It is a variant form of an established Plant Pest which can be distinguished by appropriate investigative and diagnostic methods and which, if established in Australia, would have a regional and national impact.
c) It is a serious Plant Pest of unknown or uncertain origin which may, on the evidence available at the time, be an entirely new Plant Pest or one not listed in Schedule 13 and which if established in Australia is considered likely to have an adverse economic impact regionally and nationally.
d) It is a Plant Pest already found in Australia that:
    (i) is restricted to a defined area through the use of regulatory measures intended to prevent further spread of the pest out of the defined area or into an endangered area; and
    (ii) has been detected outside the defined area; and
    (iii) is not a native of Australia; and
    (iv) is not the subject of any instrument for management which is agreed to be effective risk mitigation and management at a national level; and
    (v) is considered likely to have an adverse economic impact such that an emergency response is required to prevent an incident of regional and national importance.

See: www.planthealthaustralia.com.au/biosecurity/emergency-plant-pest-response-deed/ for more information and the most recent version of the EPPRD.

6.2 PLANTPLAN

Underpinning the EPPRD is PLANTPLAN, the agreed technical response plan for an EPP incident. It provides nationally consistent guidelines for response procedures, outlining the phases of an incursion, as well as the key roles and responsibilities of industry and government during each of the phases.

See: www.planthealthaustralia.com.au/biosecurity/emergency-plant-pest-response-deed/ for more information and the most recent version of PLANTPLAN.

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Addendum:

Gitonga ZM, Chabi-Olaye A, Mithöfer D, Okello JJ & Ritho CN. 2010. Control of invasive *Liriomyza* leafminer species and compliance with food safety standards by small scale snow pea farmers in Kenya. *Crop Protection* 298: 1472-1477.

8. APPENDICES

Appendix 1: Known hosts of American serpentine leafminer

The American serpentine leafminer (*Liriomyza trifolii)* is highly polyphagous, with a wide host range across at least 15 families (Table 12). In order to facilitate trade and market access decisions, a thorough review was conducted as part of the Horticulture Innovation Australia funded Project MT16004 (R&E program for control, eradication and preparedness for vegetable leafminer), with a focus on evidence for lifecycle completion in the field. The results of this review, including commercial, ornamental and non-cultivated hosts of the American serpentine leafminer (*L. trifolii*), are presented in Table 13, Table 14 and Table 15 below. No guarantee can be made that these lists are exhaustive. Each record was scrutinized based on evidence provided showing completion of lifecycle within the field, and then included within the appropriate table. It is important to note that non-cultivated plants often serve as important reservoirs for *Liriomyza* pests (e.g. Schuster et al. 1991), and upon incursion into a new region, host ranges may expand to include native plant species. Moreover, host preferences may vary considerably across populations. For example, although chili (*Capsicum* spp.) is widely reported internationally as a favoured host of the closely related agromyzid *Liriomyza sativae*, the population of *L. sativae* which has established within the Torres Strait (IPPC 2017) has very rarely been observed to attack chili (despite it being an abundant garden host in the region) (Elia Pirtle pers. comm).

Number of host records for the American serpentine leafminer (*Liriomyza trifolii*) within plant families

Only records with either comprehensive or partial evidence of lifecycle completion in the field are included (see Table 13 and Table 14). Multiple records of the same species are included. Thus, the number of records does not indicate total number of affected species within each family. *Liriomyza trifolii* is highly polyphagous and no guarantee can be made that this list is exhaustive.

Table 12 Number of host records for the American serpentine leafminer (Liriomyza trifolii) within plant families.

Family	Number of records
Asteraceae	77
Fabaceae	38
Solanaceae	26
Cucurbitaceae	22
Brassicaceae	15
Amaranthaceae	12
Caryophyllaceae	9
Malvaceae	8
Apiaceae	6
Amaryllidaceae	5
Lamiaceae	4
Oxalidaceae	3
Plantaginaceae	3
Gentianaceae	2
Convolvulaceae	2

Family	Number of records
Verbenaceae	2
Zygophyllaceae	2
Apocynaceae	1
Araliaceae	1
Boranginaceae	1
Campanulaceae	1
Cleomaceae	1
Commelinaceae	1
Euphorbiaceae	1
Polemoniaceae	1
Polygalaceae	1
Primulaceae	1
Ranunculaceae	1
Rosaceae	1
Sapindaceae	1
Tropaeolaceae	1
Turneraceae	1

Commercial, ornamental and non-cultivated plants for which comprehensive evidence of lifecycle completion in the field for the American serpentine leafminer (*Liriomyza trifolii*) has been provided within the scientific literature

This includes all records where the following conditions were met:

(1) Adults were reared from plant material infested with eggs or from larvae collected in the field; and

(2) Emerging adults were subsequently identified via morphology or molecular diagnostics; and

(3) Scientific names of hosts are reported

In addition, all records from Kenneth Spencer, the foremost authority on leafminer taxonomy, are included. Records for plants identified only to the genus level (sp. or spp.) that did not meet the above conditions are included only if there are other records for species within this genus that met both conditions. Records for specific varieties within a species that did not meet the above conditions are included only if there are other records confirming lifecycle completion for that same species that met both conditions. Scientific names in the table appear as they were originally cited. A number of these names are now recognised as synonyms, however for brevity, we are not reporting the currently accepted names for these taxa (refer to WorldFloraOnline.org, Australian Plant Census, or Catalogue of Life for current taxonomic decisions). All common names associated with each scientific name, across all reports, are included. Additionally, many plants labelled as commercial and ornamental have escaped cultivation and naturalised in Australia. Records that report only partial confirmations of lifecycle completion are included in Table 14, while unverified records are included in Table 15. *Liriomyza trifolii* is highly polyphagous and no guarantee can be made that this list is exhaustive.

Table 13 Commercial, ornamental and non-cultivated plants for which comprehensive evidence of lifecycle completion in the field for the American serpentine leafminer (Liriomyza trifolii) has been provided within the scientific literature.

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Commercial	Beet; Chard; Beetroot	*Beta vulgaris*		Amaranthaceae	Stegmaier (1966); Spencer (1973); Srinivasan et al., (1995)	Stegmaier (1968); Fagoonee and Toory (1984); Capinera (2014); SPHD (2016); CABI (2019); EPPO (2020)
Commercial	Sugarbeet	*Beta vulgaris*	*saccharifera*	Amaranthaceae		CABI (2019)

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Commercial	Quinoa	*Chenopodium quinoa*		Amaranthaceae	Srinivasan et al., (1995)	
Commercial	Fat hen	*Chenopodium* spp.		Amaranthaceae		SPHD (2016)
Commercial	Spinach; Silverbeet	*Spinacia oleracea*		Amaranthaceae	Stegmaier (1966); Spencer (1973); Srinivasan et al., (1995)	Stegmaier (1968); SPHD (2016); CABI (2019); EPPO (2020)
Commercial	Onion; Shallot; Multiplier onion	*Allium cepa*		Amaryllidaceae	Stegmaier (1966); Spencer (1973); Spencer (1983)	Stegmaier (1968); Fagoonee and Toory (1984); Scheffer and Lewis (2005); Andersen et al. (2008); Capinera (2014); SPHD (2016); CABI (2019); EPPO (2020)
Commercial	Japanese bunching onion; Scallion; Welsh onion	*Allium fistulosum*		Amaryllidaceae	Chirinos et al. (2014)	EPPO (2020)
Commercial	Chive	*Allium schoenoprasum*		Amaryllidaceae	Spencer (1973)	SPHD (2016); Sooda et al. (2017)

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Commercial	Celery	*Apium graveolens*		Apiaceae	Stegmaier (1966); Spencer (1973)	Fagoonee and Toory (1984); Foster (1986); Altieri et al. (1999); Weintraub (1999); Scheffer and Lewis (2005); Andersen et al. (2008); Capinera (2014); SPHD (2016); CABI (2019); EPPO (2020); Andersen and Hofsvang (2010)
Commercial	Celery	*Apium graveolens*	*dulce*	Apiaceae		Stegmaier (1968); CABI (2019)
Commercial	Carrot	*Daucus carota*		Apiaceae	Stegmaier (1966); Spencer (1973)	Stegmaier (1968); Scheffer and Lewis (2005); Capinera (2014); SPHD (2016)
Commercial	Carrot	*Daucus carota*	*sativus*	Apiaceae		Scheffer et al. (2006)
Commercial	Carthamum; Safflower	*Carthamus tinctorius*		Asteraceae	Srinivasan et al., (1995)	

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Commercial	Lettuce; Garden lettuce	*Lactuca sativa*		Asteraceae	Stegmaier (1966); Spencer (1973); Masetti et al. (2006)	Stegmaier (1968); Fagoonee and Toory (1984); Olivera and Bordat (1996); Scheffer and Lewis (2005); Andersen et al. (2008); Capinera (2014); SPHD (2016); CABI (2019); EPPO (2020)
Commercial		*Lactuca* sp.		Asteraceae		Stegmaier (1968)
Commercial	Gai lan; Cabbage; Broccoli; Caisin; Cabbage; Cauliflower; Field cabbage	*Brassica oleracea*		Brassicaceae		Scheffer and Lewis (2005)
Commercial	Kale	*Brassica oleracea*	*acephala*	Brassicaceae	Foba et al. (2015)	
Commercial	Cauliflower	*Brassica oleracea*	*botrytis*	Brassicaceae		Fagoonee and Toory (1984)
Commercial	Cabbage	*Brassica oleracea*	*capitata*	Brassicaceae		Fagoonee and Toory (1984); Scheffer et al. (2006)A barcoding…)
Commercial	Brussels sprout	*Brassica oleracea*	*gemmiferae*	Brassicaceae		Fagoonee and Toory (1984)
Commercial		*Cleome gynandra*		Cleomaceae	Srinivasan et al., (1995)	

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Commercial	Wax gourd; White goard; Chinese melon; China squash; Ash gourd	*Benincasa hispida*		Cucurbitaceae	Srinivasan et al., (1995)	
Commercial	Watermelon	*Citrullus lanatus*		Cucurbitaceae	Foba et al. (2015)	Scheffer and Lewis (2005); SPHD (2016); CABI (2019); EPPO (2020)
Commercial	Watermelon	*Citrullus vulgaris*		Cucurbitaceae	Srinivasan et al., (1995)	
Commercial	Coccinia	*Coccinia indica*		Cucurbitaceae	Srinivasan et al., (1995)	
Commercial	Snake gourd	*Cucumis anguina*		Cucurbitaceae	Srinivasan et al., (1995)	
Commercial	Melon; Cantaloupe; Muskmelon; Honey melon; Cassaba melon	*Cucumis melo*		Cucurbitaceae	Stegmaier (1966); Spencer (1973)	Stegmaier (1968); Scheffer and Lewis (2005); Guimarães et al. (2009); Capinera (2014); SPHD (2016); CABI (2019); EPPO (2020)
Commercial	Cucumber	*Cucumis sativus*		Cucurbitaceae	Stegmaier (1966); Spencer (1973); Srinivasan et al., (1995)	Stegmaier (1968); Capinera (2014); Gao (2014); SPHD (2016); CABI (2019); EPPO (2020)
Commercial		*Cucumis* sp./spp.		Cucurbitaceae	Stegmaier (1966)	Stegmaier (1968)

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Commercial	Butternut squash; Pumpkin; Crookneck squash	*Cucurbita moschata*		Cucurbitaceae	Srinivasan et al., (1995)	
Commercial	Courgette; Zucchini; Pumpkin	*Cucurbita pepo*		Cucurbitaceae	Stegmaier (1966); Spencer (1973); Foba et al. (2015)	Stegmaier (1968); Olivera and Bordat (1996); Scheffer and Lewis (2005); SPHD (2016); CABI (2019); EPPO (2020)
Commercial	Squash	*Cucurbita* sp./spp.		Cucurbitaceae	Stegmaier (1966)	Stegmaier (1968)
Commercial	Sponge gourd; Ridge gourd	*Luffa aegyptiaca*		Cucurbitaceae	Srinivasan et al., (1995)	
Commercial	Towel gourd	*Luffa cylindrica*		Cucurbitaceae	Gao (2014)	
Commercial	Bitter gourd; Balsam pear	*Momordica charantia*		Cucurbitaceae	Srinivasan et al., (1995)	
Commercial	Smooth gourd	*Trichosanthes dioica*		Cucurbitaceae	Srinivasan et al., (1995)	
Commercial	Pidgeon pea	*Cajanus cajan*		Fabaceae	Srinivasan et al., (1995)	Fagoonee and Toory (1984)
Commercial	Sword bean	*Canavalia gladiata*		Fabaceae	Srinivasan et al., (1995)	

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Commercial	Sunn hemp	*Crotalaria juncea*		Fabaceae	Srinivasan et al., (1995)	SPHD (2016)
Commercial	Cluster beans	*Cyamopsis tetragonolobus*		Fabaceae	Srinivasan et al., (1995)	
Commercial	Creeper bean	*Dolichos lablab*		Fabaceae	Srinivasan et al., (1995)	
Commercial	Soybean; Soya bean	*Glycine max*		Fabaceae	Srinivasan et al., (1995)	Fagoonee and Toory (1984); SPHD (2016)
Commercial	Sweet Dolichos; Field bean	*Lablab purpureus*		Fabaceae	Srinivasan et al., (1995)	
Commercial	Mung bean	*Phaseolus aureus*		Fabaceae	Stegmaier (1966)	Stegmaier (1968)
Commercial	Sieva; Lima bean; Lima bean	*Phaseolus lunatus*		Fabaceae	Spencer (1973)	Fagoonee and Toory (1984); SPHD (2016); CABI (2019); EPPO (2020)
Commercial	String bean	*Phaseolus* sp./spp.		Fabaceae	Stegmaier (1966)	Stegmaier (1968); Scheffer et al. (2006); Scheffer and Lewis (2005)
Commercial		*Phaseolus tribulus*		Fabaceae	Srinivasan et al., (1995)	

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Commercial	Green bean; French bean; Kidney bean; Bean; Common bean; Snap bean	*Phaseolus vulgaris*		Fabaceae	Spencer (1983); de souza (1986); Srinivasan et al., (1995); Masetti et al. (2006); Foba et al. (2015)	Fagoonee and Toory (1984); Olivera and Bordat (1996); Altieri et al. (1999); Kox et al (2005); Andersen et al. (2008); Musundire et al. (2012); Capinera (2014); SPHD (2016); CABI (2019); EPPO (2020)
Commercial	Garden pea; Pea; Snow pea; Sugar snap	*Pisum sativum*		Fabaceae	Spencer (1973); Srinivasan et al., (1995); Foba et al. (2015)	Stegmaier (1968); Fagoonee and Toory (1984); Scheffer and Lewis (2005); Capinera (2014); SPHD (2016); CABI (2019); EPPO (2020)
Commercial		*Pisum* sp./spp.		Fabaceae	Stegmaier (1966)	Stegmaier (1968); Scheffer et al. (2006)
Commercial	White clover	*Trifolium repens*		Fabaceae	Stegmaier (1966); Spencer (1973)	Stegmaier (1968); Andrade et al. (1989); SPHD (2016)

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Commercial	Fenugreek	*Trigonella foenum-graecum*		Fabaceae	Srinivasan et al., (1995)	
Commercial	Fenugreek	*Trigonella* spp.		Fabaceae		SPHD (2016)
Commercial	Black gram	*Vigna mungo*		Fabaceae	Srinivasan et al., (1995)	
Commercial	Mungbean; Green gram	*Vigna radiata*		Fabaceae	Srinivasan et al., (1995)	Andersen et al. (2008)
Commercial	Red bean; Black eyed pea; Cowpea	*Vigna sinensis*		Fabaceae	Stegmaier (1966); Gao (2014)	Stegmaier (1968); Fagoonee and Toory (1984); SPHD (2016)
Commercial	Bean, gram	*Vigna* sp./spp.		Fabaceae		Stegmaier (1968); CABI (2019); EPPO (2020)
Commercial	Walp Cowpea; Yard-long bean; Long bean; Snakebean; Cowpea	*Vigna unguiculata*		Fabaceae	Srinivasan et al., (1995); Foba et al. (2015)	
Commercial	Okra	*Abelmoschus esculentus*		Malvaceae	Stegmaier (1966); Spencer (1973); Srinivasan et al., (1995); Foba et al. (2015)	SPHD (2016)

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Commercial		*Corchorus olitorius*		Malvaceae	Srinivasan et al., (1995)	
Commercial	Cotton	*Gossypium arboreum*		Malvaceae	Srinivasan et al., (1995)	
Commercial	Cotton	*Gossypium barbadense*		Malvaceae	Srinivasan et al., (1995)	
Commercial	Upland cotton; Cotton	*Gossypium hirsutum*		Malvaceae	Srinivasan et al., (1995)	SPHD (2016); CABI (2019); EPPO (2020)
Commercial	Pepper; Sweet pepper; Green pepper; Chili; Capsicum	*Capsicum annuum*		Solanaceae	Spencer (1973); Srinivasan et al., (1995)	Kox et al (2005); Capinera (2014); SPHD (2016); CABI (2019); EPPO (2020)
Commercial	Bell pepper	*Capsicum frutescens*		Solanaceae	Srinivasan et al., (1995)	Altieri et al. (1999)
Commercial	Pepper	*Capsicum sp./spp.*		Solanaceae	Stegmaier (1966)	Stegmaier (1968); Scheffer and Lewis (2005)
Commercial	Tomato	*Lycopersicum esculentum*		Solanaceae	Stegmaier (1966); Spencer (1973); Spencer (1983); Srinivasan et al., (1995)	Stegmaier (1968); Fagoonee and Toory (1984); Olivera and Bordat (1996); Kox et al (2005); Scheffer et al. (2006); Capinera (2014); SPHD (2016);

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
						CABI (2019); EPPO (2020)
Commercial	Tomato	*Solanum lycopersicum*		Solanaceae	Foba et al. (2015)	Altieri et al. (1999); Macdonald et al. (2002); Hanafi (2005); Scheffer et al. (2006); Andersen et al. (2008); Musundire et al. (2011); Musundire et al. (2012)
Commercial	Brinjal eggplant; Eggplant; common eggplant; Pickling eggplant	*Solanum melongena*		Solanaceae	Stegmaier (1966); Spencer (1973); Srinivasan et al., (1995)	Stegmaier (1968); Fagoonee and Toory (1984); Capinera (2014); SPHD (2016)
Commercial		*Solanum* sp.		Solanaceae		Stegmaier (1968)

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Commercial	Potato	*Solanum tuberosum*		Solanaceae	Stegmaier (1966); Spencer (1973); de souza (1986); Srinivasan et al., (1995); Foba et al. (2015)	Stegmaier (1968); Fagoonee and Toory (1984); Macdonald et al. (2002); Scheffer and Lewis (2005); De Freitas Bueno et al., (2007); Andersen et al. (2008); Capinera (2014); SPHD (2016); CABI (2019); EPPO (2020)
Ornamental	Cock's comb	*Celosia argentea*		Amaranthaceae	Srinivasan et al., (1995)	
Ornamental	Aster	*Aster* sp./spp.		Asteraceae	Stegmaier (1966)	Stegmaier (1968); SPHD (2016); CABI (2019); EPPO (2020); Andersen and Hofsvang (2010)
Ornamental	Pot marigold	*Calendula officinalis*		Asteraceae	Srinivasan et al., (1995)	
Ornamental	Chinese aster	*Callistephus chinensis*		Asteraceae	Stegmaier (1966); Srinivasan et al., (1995)	Stegmaier (1968); SPHD (2016)
Ornamental	Garland chrysanthemum; Chrysanthemum	*Chrysanthemum sp.*		Asteraceae	Nakamura et al. (2013)	Bartlett and Powell (1981); Andersen et al. (2008); Musundire et al. (2011); Andersen and Hofsvang (2010)

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Ornamental	Chrysanthemum	*Chrysanthemum sp.*	*Flamenca*	Asteraceae	Spencer (1983)	
Ornamental	Chrysanthemum	*Chrysanthemum spp.*		Asteraceae	Spencer (1983)	Capinera (2014); SPHD (2016); CABI (2019); EPPO (2020)
Ornamental	Dahlia	*Dahlia* sp./spp.		Asteraceae	Stegmaier (1966)	Fagoonee and Toory (1984); Stegmaier (1968); SPHD (2016); CABI (2019); EPPO (2020)
Ornamental	Dahlia	*Dahlia variabilis*		Asteraceae	Srinivasan et al., (1995)	
Ornamental	Blue mistflower; Mistflower	*Eupatorium coelestinum*		Asteraceae	Stegmaier (1966)	Stegmaier (1968)
Ornamental		*Flaveria* sp.		Asteraceae		Stegmaier (1968); Srinivasan et al., (1995)
Ornamental	Clustered yellowtops	*Flaveria trinervia*		Asteraceae	Stegmaier (1966)	Stegmaier (1968)
Ornamental	Gaillardia; Maroon blanketflower	*Gaillardia amblyodon*		Asteraceae	Srinivasan et al., (1995)	SPHD (2016)
Ornamental	Common blanketflower	*Gaillardia aristata*		Asteraceae	Stegmaier (1966)	

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Ornamental	Gerbera; Barberton daisy; Transvaal daisy	*Gerbera jamesonii*		Asteraceae	Stegmaier (1966); Srinivasan et al., (1995)	Stegmaier (1968)
Ornamental	Gerbera	*Gerbera* sp./spp.		Asteraceae	Stegmaier (1966); Nakamura et al. (2013)	Stegmaier (1968); Fagoonee and Toory (1984); Kox et al (2005); Capinera (2014); SPHD (2016); CABI (2019); EPPO (2020)
Ornamental	Sunflower; Common sunflower	*Helianthus annuus*		Asteraceae	Stegmaier (1966); Srinivasan et al., (1995)	Stegmaier (1968); Fagoonee and Toory (1984); SPHD (2016)
Ornamental	Ragwort	*Senecio sp./spp.*		Asteraceae	Stegmaier (1966)	SPHD (2016)
Ornamental	Marigold; Aztec marigold	*Tagetes erecta*		Asteraceae	Stegmaier (1966); Srinivasan et al., (1995)	Stegmaier (1968); SPHD (2016)
Ornamental	Marigold; French marigold	*Tagetes patula*		Asteraceae	Stegmaier (1966)	Stegmaier (1968); Capinera (2014); SPHD (2016)
Ornamental	Marigold	*Tagetes spp.*		Asteraceae		Stegmaier (1968); Fagoonee and Toory (1984)
Ornamental		*Zinnia sp./spp.*		Asteraceae	Stegmaier (1966)	Stegmaier (1968); Fagoonee and Toory

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
						(1983); SPHD (2016); CABI (2019); EPPO (2020)
Ornamental	Indian pink; China pink	*Dianthus chinensis*		Caryophyllaceae	Srinivasan et al., (1995)	SPHD (2016)
Ornamental	Dianthus	*Dianthus* spp.		Caryophyllaceae		SPHD (2016); CABI (2019); EPPO (2020)
Ornamental	Gypsophila; Bbaby's breath	*Gypsophila* sp./spp.		Caryophyllaceae	Stegmaier (1966)	Stegmaier (1968); Andersen and Hofsvang (2010); Capinera (2014); SPHD (2016); CABI (2019); EPPO (2020)
Ornamental	Salvia; Azure blue sage	*Salvia azurea*		Lamiaceae	Srinivasan et al., (1995)	SPHD (2016)
Ornamental	Yellow hibiscus	*Hibiscus panduraeformis*		Malvaceae	Srinivasan et al., (1995)	
Ornamental	Indian hemp	*Hibiscus subdarifa*		Malvaceae	Srinivasan et al., (1995)	
Ornamental		*Gerbera sp.*		Primulaceae		Bartlett and Powell (1981)
Ornamental	Petunia; Large white petunia	*Petunia axillaris*		Solanaceae	Srinivasan et al., (1995)	
Ornamental	Petunia	*Petunia* sp./spp.		Solanaceae	Stegmaier (1966)	Stegmaier (1968)

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Non Cultivated		*Alternanthera ficoidea*		Amaranthaceae	Srinivasan et al., (1995)	
Non Cultivated		*Amaranthus spinosus*		Amaranthaceae	Srinivasan et al., (1995)	
Non Cultivated		*Amaranthus* spp.		Amaranthaceae		Fagoonee and Toory (1984)
Non Cultivated	Elephant-head amaranth	*Amaranthus tricolor*		Amaranthaceae	Srinivasan et al., (1995)	
Non Cultivated	Goosefoot; Lamb's quarters; Fat hen	*Chenopodium album*		Amaranthaceae	Stegmaier (1966)	Stegmaier (1968)
Non Cultivated	Mugwort	*Artemisia vulgaris*		Asteraceae	Masetti et al. (2004)	SPHD (2016)
Non Cultivated	Sea myrtle; Groundsel tree	*Baccharis halimifolia*		Asteraceae	Stegmaier (1966)	Stegmaier (1968); Hudson and Stiling (1997); SPHD (2016)
Non Cultivated	Groundsel tree	*Baccharis* sp.		Asteraceae		Stegmaier (1968)
Non Cultivated	Shepherd's needles; Spanish needles	*Bidens alba*		Asteraceae	Schuster et al. (1991)	Capinera (2014); CABI (2019); EPPO (2020)

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Non Cultivated	Black jack; Spanish needle; hairy beggarticks	*Bidens pilosa*		Asteraceae	Stegmaier (1966); Srinivasan et al., (1995)	Stegmaier (1968); Fagoonee and Toory (1984); SPHD (2016)
Non Cultivated	Bidens	*Bidens* sp.		Asteraceae		Stegmaier (1968); Scheffer and Lewis (2005)
Non Cultivated	Distaff thistle	*Carthamus* spp.		Asteraceae		SPHD (2016)
Non Cultivated		*Cirsium arvense*		Asteraceae	Masetti et al. (2004)	
Non Cultivated	American burnweed; Pilewort; Fireweed	*Erechtites hieracifolia*		Asteraceae	Stegmaier (1966)	Stegmaier (1968); Capinera (2014)
Non Cultivated	Fireweed	*Erechtites* sp.		Asteraceae		Stegmaier (1968)
Non Cultivated	Blue mistflower; Mistflower	*Eupatorium coelestinum*		Asteraceae		SPHD (2016)
Non Cultivated	Late boneset	*Eupatorium serotinum*		Asteraceae	Stegmaier (1966)	SPHD (2016)
Non Cultivated	Quickweed; Shaggy soldier	*Galinsoga ciliata*		Asteraceae	Stegmaier (1966)	Stegmaier (1968); SPHD (2016)

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Non Cultivated	Cudweed	*Gnaphalium spathalium*		Asteraceae	Stegmaier (1966)	Stegmaier (1968)
Non Cultivated	Carolina woollywhite	*Hymenopappus scabiosaeus*		Asteraceae	Stegmaier (1966)	Stegmaier (1968)
Non Cultivated	Canada lettuce; Canada wild lettuce	*Lactuca canadensis*		Asteraceae	Stegmaier (1966)	Stegmaier (1968)
Non Cultivated		*Lactuca serriola*		Asteraceae	Masetti et al. (2004)	
Non Cultivated	Melanthera	*Melanthera deltoidea*		Asteraceae	Stegmaier (1966)	Stegmaier (1968)
Non Cultivated		*Parthenium hysterophorus*		Asteraceae	Srinivasan et al., (1995)	
Non Cultivated		*Picris echioides*		Asteraceae	Masetti et al. (2004)	
Non Cultivated		*Picris hieracioides*		Asteraceae	Masetti et al. (2004)	
Non Cultivated	Butterweed	*Senecio glabellus*		Asteraceae	Stegmaier (1966)	

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Non Cultivated	Perennial sow thistle	*Sonchus arvensis*		Asteraceae	Srinivasan et al., (1995)	SPHD (2016)
Non Cultivated	Spiny sow thistle; Prickly sow thistle	*Sonchus asper*		Asteraceae	Stegmaier (1966); Masetti et al. (2004)	Stegmaier (1968)
Non Cultivated	Common sow thistle	*Sonchus oleraceus*		Asteraceae	Stegmaier (1966); Srinivasan et al., (1995); Masetti et al. (2004)	Fagoonee and Toory (1984); SPHD (2016)
Non Cultivated	Cinderella weed; Nodeweed	*Synedrella nodiflora*		Asteraceae	Stegmaier (1966); Srinivasan et al., (1995)	Stegmaier (1968)
Non Cultivated	Dandelion	*Taraxacum* sp./spp.		Asteraceae	Masetti et al. (2004)	SPHD (2016)
Non Cultivated	Coat buttons; Tridax	*Tridax procumbens*		Asteraceae	Stegmaier (1966)	Stegmaier (1968)
Non Cultivated	Cocklebur	*Xanthium sp./spp.*		Asteraceae	Stegmaier (1966)	Stegmaier (1968); SPHD (2016)
Non Cultivated		*Commelina benghalensis*		Commelinaceae	Srinivasan et al., (1995)	

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Non Cultivated		*Convolvulus arvensis*		Convolvulaceae	Srinivasan et al., (1995)	
Non Cultivated		*Blastania garcinia*		Cucurbitaceae	Srinivasan et al., (1995)	
Non Cultivated		*Momordica tuberosa*		Cucurbitaceae	Srinivasan et al., (1995)	
Non Cultivated	Castor bean; Castor oil bush	*Ricinus communis*		Euphorbiaceae	Srinivasan et al., (1995)	SPHD (2016)
Non Cultivated	Desert cassia	*Cassia biflora*		Fabaceae	Srinivasan et al., (1995)	SPHD (2016)
Non Cultivated	Rattlepod; Rattlebox	*Crotalaria incana*		Fabaceae	Stegmaier (1966)	Stegmaier (1968)
Non Cultivated	Black medic	*Medicago lupulina*		Fabaceae	Stegmaier (1966)	Stegmaier (1968)
Non Cultivated	Pongamia	*Pongamia pinnata*		Fabaceae	Srinivasan et al., (1995)	
Non Cultivated	Corkwood tree	*Sesbania grandiflora*		Fabaceae	Srinivasan et al., (1995)	
Non Cultivated	Berseem	*Trifolium alexandricum*		Fabaceae	Srinivasan et al., (1995)	
Non Cultivated	Carolina Pirqueta	*Piriqueta cistoides*	*caroliniana*	Passifloraceae	Stegmaier (1968)	
Non Cultivated		*Polygala persicariifolia*		Polygalaceae	Srinivasan et al., (1995)	

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Non Cultivated		*Cardiospermum halicacabum*		Sapindaceae	Srinivasan et al., (1995)	
Non Cultivated		*Datura spp.*		Solanaceae	Srinivasan et al., (1995)	
Non Cultivated	Manyflower tobacoo	*Nicotiana acuminata*		Solanaceae	Srinivasan et al., (1995)	
Non Cultivated	Wild tobacco	*Nicotiana goodspeedi*		Solanaceae	Srinivasan et al., (1995)	
Non Cultivated	Wild tobacco	*Nicotiana paniculata*		Solanaceae	Srinivasan et al., (1995)	
Non Cultivated	Wild tobacco	*Nicotiana simusslands*		Solanaceae	Srinivasan et al., (1995)	
Non Cultivated	Wild tobacco	*Nicotiana velutina*		Solanaceae	Srinivasan et al., (1995)	
Non Cultivated	Ground cherry	*Physalis* sp./spp.		Solanaceae	Stegmaier (1966)	Stegmaier (1968); SPHD (2016)
Non Cultivated	American black nightshade	*Solanum americanum*		Solanaceae	Schuster et al. (1991)	Capinera (2014)
Non Cultivated	Black nightshade	*Solanum nigrum*		Solanaceae	Stegmaier (1966); Srinivasan et al., (1995)	Stegmaier (1968); Fagoonee and Toory (1984)

Host type	Common names	Scientific name	Variety	Family	Records with comprehensive evidence	All other records (partial and unverified records)
Non Cultivated	Big caltrop; Caltrop	*Kallstroemia maxima*		Zygophyllaceae	Stegmaier (1966)	Stegmaier (1968)
Non Cultivated	Bindii; Caltrop	*Tribulus terrestris*		Zygophyllaceae	Stegmaier (1966)	Stegmaier (1968); SPHD (2016)

Commercial, ornamental and non-cultivated plants for which only partial evidence of lifecycle completion in the field for the American serpentine leafminer (*Liriomyza trifolii*) has been provided within the scientific literature

This includes all records where:

(1) Adults were reared from field collected plant material infested with larvae, but no subsequent identification via morphology or molecular diagnostics was reported; or

(2) Laboratory feeding and oviposition preference experiments were conducted that did not confirm lifecycle completion; or

(3) Identification via morphology or molecular diagnostics was reported, but collection methods in the field were not reported. Lifestyle completion cannot be confirmed in these instances due to the potential use of non-specific collection methods (e.g. sticky traps or sweep nets); or

(4) Laboratory cultures confirmed lifecycle completion, but evidence of lifecycle completion in the field was not provided; or

(5) Only common names of plant were given, but the scientific name could be confidently inferred; or

(6) The record reports presence of *L. trifolii* on imported material detected at the border.

Records for plants identified only to the genus level (sp. or spp.) that did not meet the above conditions are included here only if there are other records for species within this genus that met one of these conditions outlined above. Records for specific varieties within a species that did not meet the above conditions are included only if there are other records for that same species that meet one of the conditions outlined above. Scientific names in the table appear as they were originally cited. A number of these names are now recognised as synonyms, however for brevity, we are not reporting the currently accepted names for these taxa (refer to WorldFloraOnline.org, Australian Plant Census, or Catalogue of Life for current taxonomic decisions). All common names associated with each scientific name, across all reports, are included. Additionally, many plants labelled as commercial and ornamental have escaped cultivation and naturalised in Australia. Records that report comprehensive confirmations of lifecycle completion are included in Table 13, while unverified records are included in Table 15. *Liriomyza trifolii* is highly polyphagous and no guarantee can be made that this list is exhaustive.

Table 14 Commercial, ornamental and non-cultivated plants for which only partial evidence of lifecycle completion in the field for the American serpentine leafminer (Liriomyza trifolii) has been provided within the scientific literature

Host type	Common names	Scientific name	Variety	Family	All records (including any unverified records)
Commercial	Leek	*Allium porrum*		Amaryllidaceae	Fagoonee and Toory (1984)

Host type	Common names	Scientific name	Variety	Family	All records (including any unverified records)
Commercial	Garlic	*Allium sativum*		Amaryllidaceae	Fagoonee and Toory (1984); Ortega et al. (2014); SPHD (2016); CABI (2019); EPPO (2020)
Commercial	Coriander	*Coriandrum sativum*		Apiaceae	Fagoonee and Toory (1984)
Commercial	Parsley	*Petroselinum crispum*		Apiaceae	Fagoonee and Toory (1984)
Commercial		*Anthemis nobilis*		Asteraceae	Andrade et al. (1989)
Commercial	Turnip	*Brassica campestris*	*rapa*	Brassicaceae	Fagoonee and Toory (1984)
Commercial	Chinese cabbage	*Brassica chinensis*	*chinensis*	Brassicaceae	Fagoonee and Toory (1984)
Commercial	Leaf mustard; Mustard greens; Radish; Chinese mustard; Indian mustard; Mustard	*Brassica juncea*		Brassicaceae	Fagoonee and Toory (1984); Scheffer et al. (2006); Scheffer and Lewis (2005); Andersen et al. (2008)
Commercial	Turnip; Rinsho; Chinese cabbage; Bokchoy	*Brassica rapa*		Brassicaceae	Scheffer et al. (2006)

Host type	Common names	Scientific name	Variety	Family	All records (including any unverified records)
Commercial	Pak choi; Pechay; Chinese cabbage	*Brassica rapa*	*chinensis*	Brassicaceae	Scheffer and Lewis (2005); Andersen et al. (2008); SPHD (2016); CABI (2019); EPPO (2020)
Commercial	Chinese mustard	*Brassica rapa*	*pekinensis*	Brassicaceae	Andersen et al. (2008)
Commercial	Radish; Chinese radish (Daikon); Wild radish; Garden radish; White radish	*Raphanus sativus*		Brassicaceae	Fagoonee and Toory (1984)
Commercial	White radish	*Raphanus sativus*	*longipinnatus*	Brassicaceae	Andersen et al. (2008)
Commercial	Sweet potato	*Ipomoea batatas*		Convolvulaceae	Fagoonee and Toory (1984)
Commercial	Pumpkin; Winter squash; Squash	*Cucurbita maxima*		Cucurbitaceae	Fagoonee and Toory (1984)
Commercial	Bottle gourd	*Lagenaria siceraria*		Cucurbitaceae	Fagoonee and Toory (1984)
Commercial	Snake gourd	*Lagenaria vulgaris*		Cucurbitaceae	Fagoonee and Toory (1984)
Commercial	Groundnut; Peanut	*Arachis hypogaea*		Fabaceae	Fagoonee and Toory (1984); SPHD (2016)
Commercial	Chickpea	*Cicer arietinum*		Fabaceae	Fagoonee and Toory (1984)
Commercial	Alfalfa; Lucerne	*Medicago sativa*		Fabaceae	Stegmaier (1968); Fagoonee and Toory (1984); SPHD (2016); CABI (2019); EPPO (2020)

Host type	Common names	Scientific name	Variety	Family	All records (including any unverified records)
Commercial	Fenugreek	*Trigonella foingraecum*		Fabaceae	Fagoonee and Toory (1984)
Commercial	Broad bean; Faba bean; Fava bean	*Vicia faba*		Fabaceae	Fagoonee and Toory (1984); Shahein and El-Maghraby (1988); Musundire et al. (2012)
Commercial	Broad bean; Vetch	*Vicia* spp.		Fabaceae	Fagoonee and Toory (1984); SPHD (2016)
Commercial	Basil; Sweet basil; Thai basil	*Ocimum basilicum*		Lamiaceae	Andersen et al. (2008)
Commercial		*Ocimum americanum*		Lamiaceae	Andersen and Hofsvang (2010)
Commercial	Okra	*Hibiscus esculentus*		Malvaceae	Stegmaier (1968); Fagoonee and Toory (1984)
Ornamental		*Asclepias* sp.		Apocynaceae	Andersen and Hofsvang (2010)
Ornamental	Daisy	*Bellis perennis*		Asteraceae	Fagoonee and Toory (1984)
Ornamental	Chrysanthemum; Florists' chrysanthemum	*Chrysanthemum morifolium*		Asteraceae	Fagoonee and Toory (1984); Andrade et al. (1989); CABI (2019)
Ornamental	Coreopsis	*Coreopsis sp.*		Asteraceae	Scheffer and Lewis (2005)

Host type	Common names	Scientific name	Variety	Family	All records (including any unverified records)
Ornamental		*Dendranthema sp.*		Asteraceae	Miller et al. (1985); Andersen and Hofsvang (2010)
Ornamental		*Dimorphotheca aurantiaca*		Asteraceae	Kox et al (2005)
Ornamental		*Echinacea* sp.		Asteraceae	Andersen and Hofsvang (2010)
Ornamental		*Leucanthemum* sp.		Asteraceae	Kox et al (2005)
Ornamental		*Solidago hybrida*		Asteraceae	Andersen and Hofsvang (2010)
Ornamental	Goldenrod	*Solidago sp.*		Asteraceae	Andersen and Hofsvang (2010)
Ornamental	Marigold	*Tagetes indica*		Asteraceae	Fagoonee and Toory (1984)
Ornamental		*Trachelium* sp.		Campanulaceae	Andersen and Hofsvang (2010)
Ornamental	Gypsophila; Baby's breath	*Gypsophila paniculata*		Caryophyllaceae	Andersen and Hofsvang (2010)
Ornamental		*Eustoma sp.*		Gentianaceae	Andersen and Hofsvang (2010)
Ornamental		*Lisianthus sp.*		Gentianaceae	Andersen and Hofsvang (2010)
Ornamental		*Salvia splendens*		Lamiaceae	Fagoonee and Toory (1984)
Ornamental	Snapdragon	*Antirrhinum majus*		Plantaginaceae	Fagoonee and Toory (1984)
Ornamental	Phlox	*Phlox drummondii*		Polemoniaceae	Fagoonee and Toory (1984)

Host type	Common names	Scientific name	Variety	Family	All records (including any unverified records)
Ornamental	Buttercup	*Ranunculus sp.*		Ranunculaceae	Andersen and Hofsvang (2010)
Ornamental		*Rosa sp.*		Rosaceae	Andersen and Hofsvang (2010)
Ornamental	Nasturtium	*Tropaeolum* sp.		Tropaeolaceae	Fagoonee and Toory (1984)
Ornamental		*Lantana camara*		Verbenaceae	Fagoonee and Toory (1984)
Ornamental	Vervain	*Verbena officinalis*		Verbenaceae	Fagoonee and Toory (1984)
Non cultivated	Rough pigweed	*Amaranthus retroflexus*		Amaranthaceae	Fagoonee and Toory (1984)
Non cultivated		*Hydrocotyle bonariensis*		Araliaceae	Fagoonee and Toory (1984)
Non cultivated	Chick weed; Goatweed	*Ageratum conyzoides*		Asteraceae	Fagoonee and Toory (1984)
Non cultivated		*Eclipta prostrata*		Asteraceae	Fagoonee and Toory (1984)
Non cultivated		*Erigeron canadensis*		Asteraceae	Fagoonee and Toory (1984)
Non cultivated		*Galinsoga caracasana*		Asteraceae	Andrade et al. (1989)

Host type	Common names	Scientific name	Variety	Family	All records (including any unverified records)
Non cultivated		*Cordia myxa*		Boranginaceae	Fagoonee and Toory (1984)
Non cultivated		*Silene gallica*		Caryophyllaceae	Andrade et al. (1989)
Non cultivated		*Spergula arvensis*		Caryophyllaceae	Andrade et al. (1989)
Non cultivated		*Oxalis debilis*	*corymbosa*	Oxalidaceae	Fagoonee and Toory (1984)
Non cultivated		*Oxalis latifolia*		Oxalidaceae	Fagoonee and Toory (1984)
Non cultivated		*Oxalis repens*		Oxalidaceae	Fagoonee and Toory (1984)
Non cultivated	Blue toadflax	*Linaria canadensis*		Plantaginaceae	Fagoonee and Toory (1984)
Non cultivated		*Plantago lanceolata*		Plantaginaceae	Fagoonee and Toory (1984)
Non cultivated		*Solanum auriculatum*		Solanaceae	Fagoonee and Toory (1984)
Non cultivated		*Solanum indicum*		Solanaceae	Fagoonee and Toory (1984)

Commercial, ornamental and non-cultivated plants with unverified records of lifecycle completion in the field for the American serpentine leafminer (*Liriomyza trifolii*)

This includes all records for which no evidence was presented within the record for lifecycle completion and no evidence was shown for confident species identification, or evidence could not suitably be accessed for verification. We are not disputing the veracity of these records - we simply did not have enough information available to verify if these hosts support lifecycle completion in the field. This includes all records where:

(1) Adults were collected by sweep netting the presumed host, but neither larval activity nor lifecycle completion was confirmed; or

(2) A scientific name could not reliably be assumed from a reported common name; or

(3) Collection and identification methodology were unclear or unreported; or

(4) The record could not be accessed or suitably translated to confirm collection and identification methodology.

For some unverified species within this table, there may be other congeneric species that have been either comprehensively or partially confirmed as a host plant, and thus these would appear within Table 13 and Table 14. Scientific names in the table appear as they were originally cited. A number of these names are now recognised as synonyms, however for brevity, we are not reporting the currently accepted names for these taxa (refer to WorldFloraOnline.org, Australian Plant Census, or Catalogue of Life for current taxonomic decisions). All common names associated with each scientific name, across all reports, are included. Additionally, many plants labelled as commercial and ornamental have escaped cultivation and naturalised in Australia. Records that report comprehensive confirmations of lifecycle completion are included in Table 13, while records that report only partial confirmations of lifecycle completion are included in Table 14. *Liriomyza trifolii* is highly polyphagous and no guarantee can be made that this list is exhaustive.

Table 15 Commercial, ornamental and non-cultivated plants with unverified records of lifecycle completion in the field for the American serpentine leafminer (Liriomyza trifolii)

Host type	Common names	Scientific name	Variety	Family	Records
commercial	Leek; Leeks	*Allium ampeloprasum*		Amaryllidaceae	CABI (2019); EPPO (2020)
commercial	Malabar spinach	*Basella*		Basellaceae	SPHD (2016)
commercial	Angled luffa; Sing kwa; Towelsponge; Angled luffa	*Luffa acutangula*		Cucurbitaceae	CABI (2019)
commercial	Ground bean	*Macrotyloma* sp./spp.		Fabaceae	CABI (2019); SPHD (2016)
commercial	Runner bean	*Phaseolus coccineus*		Fabaceae	EPPO (2020)
commercial	Passionfruit	*Passiflora* sp.		Passifloraceae	Kahinga et al. (2017)

Host type	Common names	Scientific name	Variety	Family	Records
commercial	Oats	*Avena sativa*		Poaceae	SPHD (2016); CABI (2019)
commercial	Barley	*Hordeum spp.*		Poaceae	SPHD (2016); CABI (2019)
commercial	Arabica coffee	*Coffea arabica*		Rubiceae	CABI (2019)
commercial	Robusta coffee	*Coffea canephora*		Rubiceae	CABI (2019)
commercial		*Capsicum chinense*		Solanaceae	Holhuin-Pena et al (2019); EPPO (2020)
ornamental		*Alstroemeria* sp.		Alstroemeriaceae	Bartlett and Powell (1981)
ornamental		*Argyranthemum frutescens*		Asteraceae	EPPO (2020)
ornamental	Knapweed	*Centaurea* spp.		Asteraceae	SPHD (2016); CABI (2019)
ornamental		*Chrysanthemum indicum*		Asteraceae	CABI (2019)
ornamental		*Dahlia hybrids*		Asteraceae	EPPO (2020)
ornamental		*Dendranthema indicum*		Asteraceae	EPPO (2020)
ornamental		*Dendranthema x grandiflorum*		Asteraceae	EPPO (2020)

Host type	Common names	Scientific name	Variety	Family	Records
ornamental	Gazania; Treasure-flower	*Gazania* spp.		Asteraceae	SPHD (2016); CABI (2019)
ornamental		*Leucanthemum vulgare*		Asteraceae	EPPO (2020)
ornamental		*Leucanthemum x superbum*		Asteraceae	EPPO (2020)
ornamental		*Pericallis x hybrida*		Asteraceae	EPPO (2020)
ornamental	Butterweed	*Senecio cruentus*		Asteraceae	Stegmaier (1968)
ornamental		*Tanacetum parthenium*		Asteraceae	EPPO (2020)
ornamental		*Tanacetum vulgare*		Asteraceae	EPPO (2020)
ornamental	Carnation	*Dianthus caryophyllus*		Caryophyllaceae	EPPO (2020)
ornamental	Gypsophila; Baby's breath	*Gypsophila paniculata*		Caryophyllaceae	EPPO (2020)
ornamental	Vetchling	*Lathyrus* spp.		Fabaceae	SPHD (2016); CABI (2019); EPPO (2020)
ornamental	Sword lily	*Gladiolus hybridus*		Iridaceae	CABI (2019)
ornamental	Gladioli	*Gladiolus* spp.		Iridaceae	SPHD (2016)

Host type	Common names	Scientific name	Variety	Family	Records
ornamental	Shell flower	*Moluccella* sp./spp.		Lamiaceae	SPHD (2016); CABI (2019)
ornamental	Primrose	*Primula* sp./spp.		Primulaceae	Bartlett and Powell (1981); SPHD (2016); CABI (2019)
ornamental	Hawthorn	*Crataegus* spp.		Rosaceae	SPHD (2016); CABI (2019)
ornamental	Garden nasturtium	*Tropaeolum majus*		Tropaeolaceae	EPPO (2020)
non cultivated	Lilly of the Incas; Inca lily	*Alstroemeria* spp.		Alstroemeriaceae	Malipatil and Wainer (2005); SPHD (2016); CABI (2019)
non cultivated	Rag weed	*Ambrosia* spp.		Asteraceae	Malipatil and Wainer (2005); SPHD (2016); CABI (2019)
non cultivated		*Symphyotrichum novi-belgii*		Asteraceae	EPPO (2020)
non cultivated	Tree marigold	*Tithonia* spp.		Asteraceae	SPHD (2016); CABI (2019)
non cultivated	Yellow salsify; Goat's-beard	*Tragopogon* spp.		Asteraceae	SPHD (2016); CABI (2019)
non cultivated	Malabar spinach	*Basella* spp.		Basellaceae	SPHD (2016); CABI (2019)
non cultivated	Melilots; Sweet clover	*Melilotus* sp./spp.		Fabaceae	SPHD (2016); CABI (2019)
non cultivated	Mallow	*Malva* sp./spp.		Malvaceae	SPHD (2016); CABI (2019)

Host type	Common names	Scientific name	Variety	Family	Records
non cultivated	Cestrums; Jassamine	*Cestrum* spp.		Solanaceae	SPHD (2016); CABI (2019)
non cultivated	Bulrush; Reedmace	*Typha* spp.		Typhaceae	SPHD (2016); CABI (2019)

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Appendix 2: Leaf mining damage caused by established species

Table 16 provides a summary of established (native or naturalised) leaf mining species, their host overlap with American serpentine leafminer and features that can be used to differentiate between American serpentine leafminer and established leafminers.

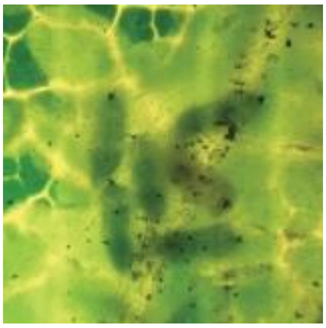
It should be noted that because host plant records are poor for many native or naturalised species, there could be many more affected hosts than included here. The host overlap between American serpentine leafminer and several native leafminer underscores the importance of sample collection and molecular diagnostics.

Figure 8 provides some general guidelines for differentiating between Dipteran and Lepidopteran leafminer larvae.

Table 16 Leaf mining damage caused by Australian dipterans or lepidopterans on leaves of cultivated crops and common weeds of cultivated crops

LEAFMINER	DISTINGUISHING FEATURES FROM L. *TRIFOLII* DAMAGE	HOSTS (THOSE SHARED WITH L. *TRIFOLII* ARE UNDERLINED)	PHOTO OF LEAF MINE
Liriomyza brassicae	None (all life stages are morphologically indistinguishable in appearance, without dissection, and behaviour from American serpentine leafminer)	<u>Brassicaceae</u> Capparaceae <u>Tropaeolaceae</u> <u>Fabaceae</u>	
Liriomyza chenopodii	None (all life stages are morphologically indistinguishable in appearance, without dissection, and behaviour from American serpentine leafminer)	<u>Amaranthaceae</u> <u>Caryophyllaceae</u> Any native hosts are as yet unrecorded (*L. chenopodii* is a native species)	

LEAFMINER	DISTINGUISHING FEATURES FROM L. *TRIFOLII* DAMAGE	HOSTS (THOSE SHARED WITH L. *TRIFOLII* ARE UNDERLINED)	PHOTO OF LEAF MINE
Phytomyza syngenesiae	Pupation occurs inside the leaf mine.  Adults easily distinguishable from American serpentine leafminer	Apiaceae Asteraceae Fabaceae	
Tropicomyia polyphtya	Larvae are upper surface epidermal feeders (deeper parenchymatous tissues is not eaten). As such, mines have a silvery, film like appearance. Pupation occurs inside the mine and pupa is noticeably flattened.  Adults easily distinguishable from American serpentine leafminer	Highly polyphagous Common hosts include plants in the Passifloraceae, Euphorbiaceae, Fabaceae, Rubiaceae, Ruaceae, and Solanaceae	
Ophiomyia solanicola	Pupation occurs inside the leaf mine.  Adults easily distinguishable from American serpentine leafminer	Solanaceae (incl. egg plant)	

LEAFMINER	DISTINGUISHING FEATURES FROM L. *TRIFOLII* DAMAGE	HOSTS (THOSE SHARED WITH L. *TRIFOLII* ARE UNDERLINED)	PHOTO OF LEAF MINE
Ophiomyia alysicarpi	Mint green pupae can be found inside mines  Adults easily distinguishable from American serpentine leafminer	*Alysicarpus* sp. *Desmodium* sp.	
Ophiomyia cornuta	Adults easily distinguishable from American serpentine leafminer	*Scaevola* sp. *Goodenia* sp.	
Lepidopteran leafminer	Lepidopteran larvae can be distinguished from dipteran larvae on the spot, via a hand lens (Figure 10). For some lepidopteran species, when the larva is in its final stages, it forms a large blister at the end of the mine (see images on the right). American serpentine leafminer larvae do not create such blisters.	Polyphagous (incl. <u>Fabaceae</u>, Eucalypts, native trees, etc)	 

LEAFMINER	DISTINGUISHING FEATURES FROM L. *TRIFOLII* DAMAGE	HOSTS (THOSE SHARED WITH L. *TRIFOLII* ARE UNDERLINED)	PHOTO OF LEAF MINE
			

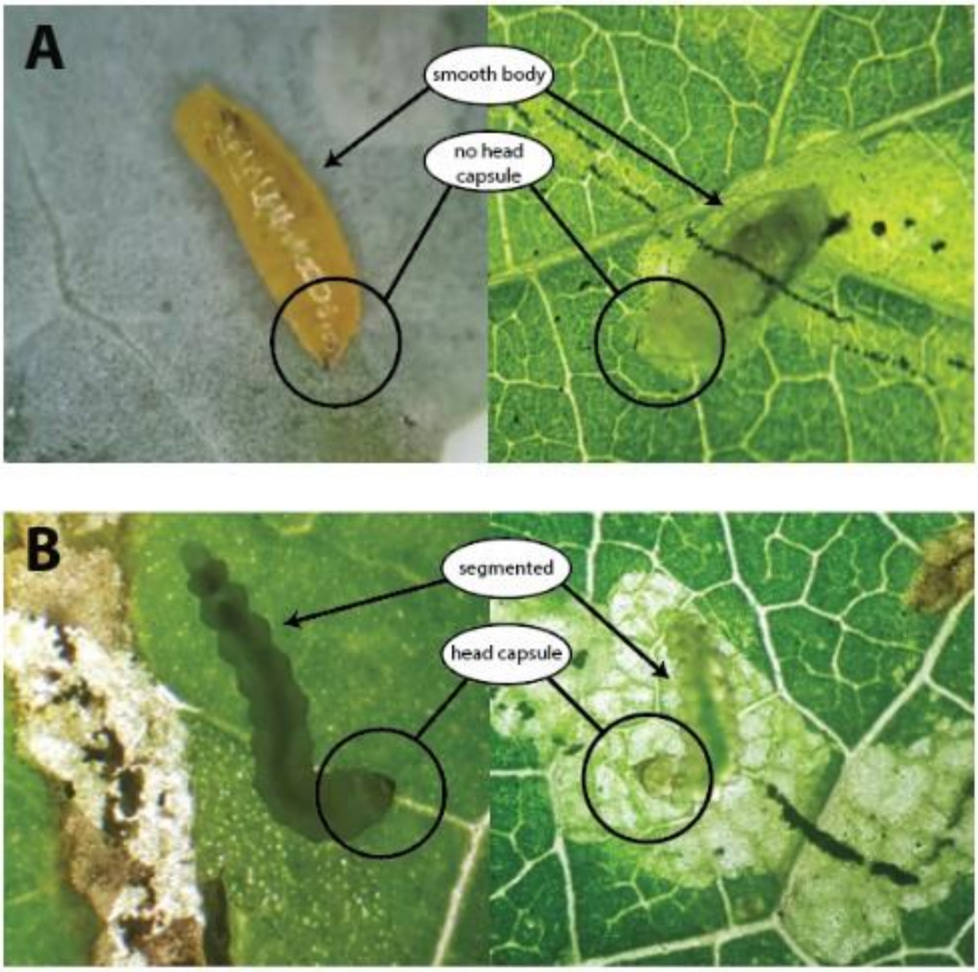


Figure 8 General guidelines for distinguishing dipteran vs lepidopteran leafminer larvae. Dipteran leafminer larvae (A) lack a head capsule and have a smooth body without clear segments. Lepidopteran leafminer larvae (B) have a distinct head capsule and are more visibly segmented. When attempting to distinguish a dipteran from lepidopteran leafminer larva on the spot, it is helpful to backlight the leaf as it is viewed under a hand lens, or to carefully excise the larva. Images: Elia Pirtle, Cesar Australia *Pty Ltd*

Surveillance for *L. trifolii* in Australia will be confounded by the presence of other leafmining insects already present in Australia, many of which create mines that are indistinguishable to a casual observer, and even in some cases indistinguishable to experts.

Table 17 lists genera that include hosts of *L. trifolii* but do not appear to contain of other agromyzids within Australasia. It is important to note that host plant records for non-pest leafminer flies are highly incomplete, and some of the genera included herein could host leafminer flies that have not yet been reported. Host records for weeds and native plants are expected to be more incomplete than for cultivated crops and ornamentals, and despite poor host records for native leafminers. We can be more confident that native leafminers are not currently a notable presence within the genera containing cultivated crops and ornamentals, where sampling effort is expected to be higher. As such, leafmining damage detected within the genera included in these tables should be regarded as highly suspicious.

Table 18 indicates where known overlap exists between hosts of *L. huidobrensis, L. trifolii* or *L. sativae* and native or naturalised agromyzids in Australia and Australasia.

Table 17 Host genera of L. huidobrensis, L. sativae or L trifolii (including only records with comprehensive or partial evidence for lifecycle completion in the field, see Appendix 1) without any reported overlap with native or naturalised agromyzids already present in Australia or Australasia (see Table 18 for known overlap). For each host, preferences of the three exotic Liriomyza are indicated (LH = L. huidobrensis; LT = L. trifolii; LS = L. sativae).

Genus	Family	Exotic *Liriomyza*	Host type
Allium	Amaryllidaceae	LH; LT; LS	commercial
Coriandrum	Apiaceae	LH; LT; LS	commercial
Eryngium	Apiaceae	LH	commercial
Petroselinum	Apiaceae	LT	commercial
Colocasia	Araceae	LH	commercial
Cichorium	Asteraceae	LH	commercial
Crassocephalum	Asteraceae	LH	commercial
Basella	Basellaceae	LH	commercial
Eruca	Brassicaceae	LH	commercial
Spinacea	Chenopodiaceae	LH	commercial
Benincasa	Cucurbitaceae	LH; LT; LS	commercial
Coccinia	Cucurbitaceae	LT	commercial
Lagenaria	Cucurbitaceae	LH; LT; LS	commercial
Luffa	Cucurbitaceae	LH; LT; LS	commercial
Momordica	Cucurbitaceae	LH; LT; LS	commercial
Sechium	Cucurbitaceae	LH	commercial
Trichosanthes	Cucurbitaceae	LT	commercial
Arachis	Fabaceae	LT	commercial
Cicer	Fabaceae	LH; LT; LS	commercial
Cyamopsis	Fabaceae	LT	commercial
Lens	Fabaceae	LS	commercial
Lotus	Fabaceae	LH	commercial
Lupin	Fabaceae	LH	commercial
Medicago	Fabaceae	LH; LT; LS	commercial
Trigonella	Fabaceae	LH; LT	commercial
Vicia	Fabaceae	LH; LT; LS	commercial
Mentha	Lamiaceae	LH; LS	commercial
Origanum	Lamiaceae	LS	commercial
Linum	Linaceae	LH	commercial

Genus	Family	Exotic *Liriomyza*	Host type
Abelmoschus	Malvaceae	LH; LT; LS	commercial
Corchorus	Malvaceae	LT	commercial
Gossypium	Malvaceae	LT; LS	commercial
Hibiscus	Malvaceae	LH; LT	commercial
Zizania	Poaceae	LH	commercial
Lycium	Solanaceae	LH	commercial
Thurnbergia	Acanthaceae	LH	ornamental
Celosia	Amaranthaceae	LH; LT	ornamental
Bupleurum	Apiaceae	LH	ornamental
Centella	Apiaceae	LH	ornamental
Oenanthe	Apiaceae	LH	ornamental
Catharanthus	Apocynaceae	LH	ornamental
Asclepias	Asclepiadaceae	LT	ornamental
Chionodoxa	Asparagaceae	LH	ornamental
Hemerocallis	Asphodelaceae	LH	ornamental
Argyranthemum	Asteraceae	LH	ornamental
Calendula	Asteraceae	LH; LT; LS	ornamental
Centaurea	Asteraceae	LH	ornamental
Conoclinium	Asteraceae	LH	ornamental
Cosmos	Asteraceae	LH	ornamental
Dimorphotheca	Asteraceae	LT	ornamental
Echinacea	Asteraceae	LT	ornamental
Eupatorium	Asteraceae	LT	ornamental
Felicia	Asteraceae	LS	ornamental
Flaveria	Asteraceae	LT	ornamental
Kalimeris	Asteraceae	LH	ornamental
Osteospermum	Asteraceae	LH	ornamental
Pyrethrum	Asteraceae	LH	ornamental
Tanacetum	Asteraceae	LH	ornamental
Zinnia	Asteraceae	LH; LT; LS	ornamental
Impatiens	Balsaminaceae	LH	ornamental
Nasturtium	Brassicaceae	LH; LS	ornamental
Calceolaria	Calceolariaceae	LH	ornamental
Campanula	Campanulaceae	LH	ornamental
Platycodon	Campanulaceae	LH	ornamental
Trachelium	Campanulaceae	LH; LT	ornamental
Dianthus	Caryophyllaceae	LH; LT	ornamental
Gypsophila	Caryophyllaceae	LH; LT; LS	ornamental
Bauhinia	Fabaceae	LS	ornamental
Lathyrus	Fabaceae	LH	ornamental
Lupinus	Fabaceae	LH; LS	ornamental
Eustoma	Gentianaceae	LH; LT	ornamental
Exacum	Gentianaceae	LH	ornamental
Lisianthus	Gentianaceae	LH; LT; LS	ornamental
Freesia	Iridaceae	LH	ornamental
Gladiolus	Iridaceae	LH	ornamental
Salvia	Lamiaceae	LH; LT	ornamental
Lilium	Liliaceae	LH	ornamental

Genus	Family	Exotic *Liriomyza*	Host type
Torenia	Linderniaceae	LH	ornamental
Althaea	Malvaceae	LH	ornamental
Moringa	Moringaceae	LS	ornamental
Godetia	Onagraceae	LH	ornamental
Oenothera	Onagroideae	LH	ornamental
Dendrobium	Orchidaceae	LS	ornamental
Papaver	Papaveraceae	LH	ornamental
Antirrhinum	Plantaginaceae	LH; LT; LS	ornamental
Myosotis	Plumbaginaceae	LH	ornamental
Lagurus	Poaceae	LH	ornamental
Phlox	Polemoniaceae	LH; LT; LS	ornamental
Primula	Primulaceae	LH	ornamental
Aquilegia	Ranunculaceae	LS	ornamental
Delphinium	Ranunculaceae	LH	ornamental
Nigella	Ranunculaceae	LH	ornamental
Prunus	Rosaceae	LS	ornamental
Rosa	Rosaceae	LH; LT	ornamental
Diascia	Scrophulariaceae	LH	ornamental
Viola	Violaceae	LH	ornamental
Sagittaria	Alismataceae	LH	non cultivated
Alternanthera	Amaranthaceae	LT	non cultivated
Amaranthus	Amaranthaceae	LH; LT; LS	non cultivated
Deeringia	Amaranthaceae	LH	non cultivated
Gomphrena	Amaranthaceae	LH	non cultivated
Iresine	Amaranthaceae	LH	non cultivated
Alocasia	Araceae	LH	non cultivated
Hydrocotyle	Araliaceae	LH; LT; LS	non cultivated
Artemisia	Asteraceae	LH; LT	non cultivated
Baccharis	Asteraceae	LT	non cultivated
Carduus	Asteraceae	LH	non cultivated
Dichrocephala	Asteraceae	LH	non cultivated
Echinops	Asteraceae	LH	non cultivated
Eclipta	Asteraceae	LT	non cultivated
Emilia	Asteraceae	LH	non cultivated
Erechtites	Asteraceae	LH; LT	non cultivated
Galinsoga	Asteraceae	LH; LT; LS	non cultivated
Helipterum	Asteraceae	LH	non cultivated
Hemistepta	Asteraceae	LH	non cultivated
Hymenopappus	Asteraceae	LT	non cultivated
Lipochaeta	Asteraceae	LS	non cultivated
Melanthera	Asteraceae	LT	non cultivated
Parthenium	Asteraceae	LT	non cultivated
Synedrella	Asteraceae	LH; LT	non cultivated
Tridax	Asteraceae	LT	non cultivated
Verbesina	Asteraceae	LS	non cultivated
Xanthium	Asteraceae	LT	non cultivated
Cordia	Boranginaceae	LT	non cultivated
Capsella	Brassicaceae	LH	non cultivated

Genus	Family	Exotic *Liriomyza*	Host type
Rorippa	Brassicaceae	LH	non cultivated
Silene	Caryophillaceae	LH; LT	non cultivated
Malachium	Caryophyllaceae	LH	non cultivated
Spergula	Caryophyllaceae	LT	non cultivated
Commelina	Commelinaceae	LT	non cultivated
Calystegia	Convolvulaceae	LH	non cultivated
Convolvulus	Convolvulaceae	LT	non cultivated
Pharbitis	Convolvulaceae	LH	non cultivated
Ceratosanthes	Cucurbitaceae	LS	non cultivated
Melothria	Cucurbitaceae	LH	non cultivated
Melilotus	Fabaceae	LH; LS	non cultivated
Poissonia	Fabaceae	LS	non cultivated
Lamium	Lamiaceae	LH	non cultivated
Leonurus	Lamiaceae	LH	non cultivated
Melissa	Lamiaceae	LS	non cultivated
Anoda	Malvaceae	LS	non cultivated
Malva	Malvaceae	LH; LS	non cultivated
Sida	Malvaceae	LH; LS	non cultivated
Oxalis	Oxalidaceae	LH; LT	non cultivated
Piriqueta	Passifloraceae	LT	non cultivated
Linaria	Plantaginaceae	LT	non cultivated
Veronica	Plantaginaceae	LH	non cultivated
Limonium	Plumbaginaceae	LH	non cultivated
Polygala	Polygalaceae	LT	non cultivated
Rumex	Polygonaceae	LH	non cultivated
Cardiospermum	Sapindaceae	LT	non cultivated
Nemesia	Scrophulariaceae	LH	non cultivated
Datura	Solanaceae	LH; LT; LS	non cultivated
Nicotiana	Solanaceae	LH; LT	non cultivated
Kallstroemia	Zygophyllaceae	LT	non cultivated
Tribulus	Zygophyllaceae	LT	non cultivated

Table 18 Host genera of either L. huidobrensis, L. sativae or L trifolii with known overlap with native or naturalised agromyzids already present in Australia or Australasia. Some of these species are stem miner, which should be straightforward to distinguish from the leaf mining damage caused by L. huidobrensis, L. sativae or L trifolii. Records of L. sativae host plants within the Torres Strait Islands (TSI) and on the Cape York Peninsula (CYP) are included.

Host genus	Host family	Australasian Agromyzid genera	Sources
Beta	Amaranthaceae	*Liriomyza*	Benavent Corai et al. (2005); Spencer (1973); Spencer (1977); Spencer (1990)
Chenopodium	Amaranthaceae	*Liriomyza*	Benavent Corai et al. (2005); Spencer (1977); Spencer (1990)
Spinacia	Amaranthaceae	*Liriomyza*	Benavent Corai et al. (2005); Spencer (1973); Spencer (1977)
Apium	Apiaceae	*Melanagromyza*	Benavent Corai et al. (2005); Spencer (1973); Spencer (1977)
Daucus	Apiaceae	*Phytomyza*	Spencer (1973)
Asparagus	Asparagaceae	*Hexomyza*	Benavent Corai et al. (2005)
Ageratum	Asteraceae	*Melanagromyza*	Spencer (1977)
Arctium	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005)
Aster	Asteraceae	*Calycomyza, Phytomyza*	Benavent Corai et al. (2005); Spencer (1977)
Bellis	Asteraceae	*Calycomyza, Phytomyza*	Benavent Corai et al. (2005)
Bidens	Asteraceae	*Melanagromyza*	Spencer (1977)
Callistephus	Asteraceae	*Calycomyza, Phytomyza*	Benavent Corai et al. (2005)
Carthamus	Asteraceae	*Melanagromyza*	Benavent Corai et al. (2005)
Chrysanthemum	Asteraceae	*Ophiomyia, Phytomyza, Melanagromyza*	Benavent Corai et al. (2005); Spencer (1977)
Cineraria	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005)
Cirsium	Asteraceae	*Phytomyza*	Spencer (1977)
Conyza	Asteraceae	*Calycomyza, Phytomyza*	Benavent Corai et al. (2005)
Coreopsis	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005); Spencer (1977)
Craspedia	Asteraceae	*Liriomyza*	Benavent Corai et al. (2005)
Crepis	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005)
Cynara	Asteraceae	*Phytomyza*	Spencer (1973)
Dahlia	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005)
Erigeron	Asteraceae	*Calycomyza*	Benavent Corai et al. (2005); Spencer (1977)
Gaillardia	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005)
Gerbera	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005)
Gnaphalium	Asteraceae	*Melanagromyza, Malanagromyza*	Benavent Corai et al. (2005); Spencer (1977)
Helianthus	Asteraceae	*Calycomyza, Phytomyza*	Benavent Corai et al. (2005)
Helichrysum	Asteraceae	*Liriomyza, Melanagromyza, Phytomyza*	Benavent Corai et al. (2005); Spencer (1977)
Lactuca	Asteraceae	*Liriomyza*, Phytomyza*	Benavent Corai et al. (2005); Present in TSI/CYP; Spencer (1973)
Leucanthemum	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005)
Picris	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005)
Senecio	Asteraceae	*Melanagromyza, Phytomyza*	Benavent Corai et al. (2005); Spencer (1977); Spencer (1977)
Solidago	Asteraceae	*Calycomyza*	Benavent Corai et al. (2005)
Sonchus	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005); Spencer (1977)
Tagetes	Asteraceae	*Liriomyza**	Present in TSI/CYP

Host genus	Host family	Australasian Agromyzid genera	Sources
Taraxacum	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005)
Tecoma	Bignoniaceae	*Liriomyza**	Present in TSI/CYP
Barbarea	Brassicaceae	*Liriomyza*	Benavent Corai et al. (2005)
Brassica	Brassicaceae	*Liriomyza**	Benavent Corai et al. (2005); Present in TSI/CYP; Spencer (1977)
Cardamine	Brassicaceae	*Liriomyza*	Spencer (1977)
Diplotaxis	Brassicaceae	*Liriomyza*	Spencer (1977)
Hirschfeldia	Brassicaceae	*Liriomyza*	Benavent Corai et al. (2005)
Matthiola	Brassicaceae	*Liriomyza*	Benavent Corai et al. (2005); Spencer (1977)
Raphanus	Brassicaceae	*Liriomyza*	Benavent Corai et al. (2005); Present in TSI/CYP; Spencer (1977)
Silene	Caryophyllaceae	*Liriomyza*	Benavent Corai et al. (2005); Spencer (1977); Spencer (1990)
Stellaria	Caryophyllaceae	*Liriomyza*	Benavent Corai et al. (2005); Spencer (1977); Spencer (1990)
Cleome	Cleomaceae	*Liriomyza**	Benavent Corai et al. (2005); Present in TSI/CYP
Ipomoea	Convolvulaceae	*Melanagromyza*	Benavent Corai et al. (2005)
Citrullus	Cucurbitaceae	*Liriomyza**	Present in TSI/CYP
Cucumis	Cucurbitaceae	*Liriomyza**	Present in TSI/CYP
Cucurbita	Cucurbitaceae	*Liriomyza**	Present in TSI/CYP
Euphorbia	Euphorbiaceae	*Tropicomyia*	Spencer (1977)
Ricinus	Euphorbiaceae	*Liriomyza**	Present in TSI/CYP
Cajanus	Fabaceae	*Melanagromyza, Ophiomyia*	Spencer (1973); Spencer (1977)
Canavalia	Fabaceae	*Ophiomyia*	Spencer (1973)
Cassia	Fabaceae	*Tropicomyia, Ophiomyia*	Spencer (1977); Spencer (1990)
Crotalaria	Fabaceae	*Liriomyza*, Ophiomyia*	Present in TSI/CYP; Spencer (1973); Spencer (1977)
Dolichos	Fabaceae	*Ophiomyia*	Spencer (1973); Spencer (1977)
Glycine	Fabaceae	*Melanagromyza, Ophiomyia*	Benavent Corai et al. (2005); Spencer (1973); Spencer (1977)
Indigofera	Fabaceae	*Liriomyza*, Ophiomyia*	Benavent Corai et al. (2005); Present in TSI/CYP; Spencer (1977); Spencer (1990)
Lablab	Fabaceae	*Ophiomyia*	Spencer (1973)
Macroptilium	Fabaceae	*Liriomyza*, Tropicomyia*	Present in TSI/CYP; Spencer (1977)
Millettia	Fabaceae	*Unknown*	Pirtle pers. comm.
unknown	Fabaceae	*Melanagromyza*	Spencer (1977)
Phaseolus	Fabaceae	*Ophiomyia, Tropicomyia, Melanagromyza, Ophiomyla*	Spencer (1973); Spencer (1977)
Pisum	Fabaceae	*Liriomyza, Phytomyza, Tropicomyia, Ophiomyia*	Benavent Corai et al. (2005); Spencer (1973); Spencer (1977)
Senna	Fabaceae	*Tropicomyia*	Spencer (1977)
Sesbania	Fabaceae	*Liriomyza**	Present in TSI/CYP
Trifolium	Fabaceae	*Ophiomyia*	Benavent Corai et al. (2005); Spencer (1977)
Vigna	Fabaceae	*Liriomyza*, Melanagromyza, Tropicomyia, Ophiomyia*	Present in TSI/CYP; Pirtle et al. (2020); Spencer (1973); Spencer (1977); Spencer 1977
Scaevola	Goodeniaceae	*Liriomyza, Ophiomyia*	Benavent Corai et al. (2005); Pirtle pers.

Host genus	Host family	Australasian Agromyzid genera	Sources
			comm.; Spencer (1977)
Hydrangea	Hydrangeaceae	*Tropicomyia*	Spencer (1977)
Ocimum	Lamiaceae	*Liriomyza**	Pirtle et al. (2020)
Stephania	Menispermaceae	*Tropicomyia*	Spencer (1977); Spencer (1990)
Passiflora	Passifloraceae	*Tropicomyia, Liriomyza**	Pirtle et al. (2020); Spencer (1977); Spencer (1990)
Turnera	Passifloraceae	*Liriomyza**	Pirtle et al. (2020)
Plantago	Plantaginaceae	*Liriomyza, Phytomyza*	Benavent Corai et al. (2005); Spencer (1977);
Hordeum	Poaceae	*Ceradontha, Pseudonapomyza*	Benavent Corai et al. (2005); Spencer (1973)
unknown	Poaceae	*Agromyza, Cerodontha*	Spencer (1973)
Setaria	Poaceae	*Agromyza*	Benavent Corai et al. (2005)
Triticum	Poaceae	*Ceradontha, Pseudonapomyza*	Benavent Corai et al. (2005); Spencer (1973)
Zea	Poaceae	*Pseudonapomyza*	Spencer (1973)
Portulaca	Portulacaceae	*Liriomyza*	Benavent Corai et al. (2005)
Ranunculus	Ranunculaceae	*Phytomyza, Napomyza*	Spencer (1977); Spencer (1990)
Passiflora	Resedaceae	*Tropicomyia*	Spencer (1990)
Coffea	Rubiaceae	*Tropicomyia*	Spencer (1973); Spencer (1977)
Citrus	Rutaceae	*Tropicomyia*	Spencer (1973); Spencer (1977)
Capsicum	Solanaceae	*Tropicomyia, Liriomyza**	Pirtle et al. (2020); Spencer (1977)
Cestrum	Solanaceae	*Tropicomyia*	Spencer (1977)
Lycopersicum	Solanaceae	*Liriomyza**	Present in TSI/CYP
Petunia	Solanaceae	*Liriomyza**	Present in TSI/CYP
Physalis	Solanaceae	*Liriomyza**	Present in TSI/CYP; Pirtle et al. (2020)
Solanum	Solanaceae	*Ophiomyia, Liriomyza**	Pirtle pers. comm.; Present in TSI/CYP; Spencer (1977)
Tropaeolum	Tropaeolaceae	*Liriomyza*	Benavent Corai et al. (2005); Spencer (1977); Spencer (1990)
Lantana	Verbenaceae	*Calycomyza, Tropicomyia, Ophiomyia*	Benavent Corai et al. (2005); Spencer (1977)
Stachytarpheta	Verbenaceae	*Liriomyza**	Pirtle et al. (2020)
Verbena	Verbenaceae	*Calycomyza*	Benavent Corai et al. (2005)

* Includes *Liriomyza sativae* within TSI/CYP

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Appendix 3: Permits for the control of American serpentine leafminer and other *Liriomyza* spp. on different host crops

Table 19 lists the commercial hosts of American serpentine leafminer (refer to Appendix 1) and notes where suitable pesticides are available and approved by the APVMA for control on each host crop. Blank cells denote where suitable pesticides have not yet been approved or identified. Refer to the APVMA permit database (https://portal.apvma.gov.au/permits) or the most up to date information on current leafminer permits.

Table 19 Insecticides control options for different crop groups

Relevant Crop group	Crop/host plant	Pesticide	Permit number(s)/ status	Target pest (as per permit)	Expiration date	Withholding information/notes	Suitable for management or eradication[3]
Brassica vegetables	Bok choy; pak-choy; turnip	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	**Treated crop must be destroyed.** Treated crops must not be made available for human consumption Do not graze or cut for stock food	**Eradication only**
Brassica vegetables	Broccoli	Emamectin benzoate	PER87563	*Liriomyza* spp. (including*: L. sativae*)	30 June 2024	3 days (harvest) Do not graze or cut for stock food	Management or eradication
Brassica vegetables	Broccoli	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication

[3] Some pesticides will be more suitable for eradication than for the ongoing management of the pest. This is because either they will need to be used at high rates to be effective, there are potential resistance issues, or the pesticide is not likely to fit into existing IPM systems as well as alternative pesticides. Other chemicals provide good control of the pest and are also compatible with IPM systems and will be more suitable for the ongoing management of the pest. To highlight this, pesticides are noted for either eradication, or for management and eradication.

Brassica vegetables	Brussels sprouts	Emamectin benzoate	PER87563	*Liriomyza* spp. (including*: L. sativae*)	30 June 2024	3 days (harvest) Do not graze or cut for stock food	Management or eradication
Brassica vegetables	Brussels sprouts	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	**Treated crop must be destroyed.** Treated crops must not be made available for human consumption Do not graze or cut for stock food	**Eradication only**
Brassica vegetables	Cabbage	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Brassica vegetables	Cabbage	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	**Treated crop must be destroyed.** Treated crops must not be made available for human consumption Do not graze or cut for stock food	**Eradication only**
Brassica vegetables	Cabbage	Emamectin benzoate	PER87563	*Liriomyza* spp. (including*: L. sativae*)	30 June 2024	3 days (harvest) Do not graze or cut for stock food	Management or eradication
Brassica vegetables	Cauliflower	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	**Treated crop must be destroyed.** Treated crops must not be made available for human consumption Do not graze or cut for stock food	**Eradication only**
Brassica vegetables	Cauliflower	Emamectin benzoate	PER87563	*Liriomyza* spp. (including*: L.*	30 June 2024	3 days (harvest) Do not graze or cut for	Management or eradication

				sativae)		stock food	
Brassica vegetables	Indian mustard	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	**Treated crop must be destroyed.** Treated crops must not be made available for human consumption Do not graze or cut for stock food	**Eradication only**
Bulb vegetables	Garlic	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	14 days (harvest) Do not graze or cut for stock food	Management or eradication
Bulb vegetables	Garlic	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Bulb vegetables	Leek	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	14 days (harvest) Do not graze or cut for stock food	Management or eradication
Bulb vegetables	Leek	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Bulb vegetables	Onions	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	30 days (harvest) Do not graze or cut for stock food	Management or eradication
Bulb vegetables	Onions	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication

Bulb vegetables	Shallots	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	14 days (harvest) Do not graze or cut for stock food	Management or eradication
Bulb vegetables	Shallots	Cyantraniliprole	PER90387	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Bulb vegetables	Spring onion	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	14 days (harvest) Do not graze or cut for stock food	Management or eradication
Bulb vegetables	Spring onion	Cyantraniliprole	PER90387	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Cereal grains	Barley	No suitable pesticides identified					
Fruit trees (non-bearing)	Any trees that will not bear fruit for the next 12 months	Cyromazine	PER83506	Larvae of leafminers	31 October 2022	Do not ship within 7 days of treatment	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Angled luffa, sing-kwa	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Angled luffa, sing-kwa	Cyantraniliprole	PER90387	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication

Fruiting vegetables (Cucurbits – including melons)	Angled luffa, sing-kwa	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Bottle gourd	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Bottle gourd	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae,* *L trifolii,* *L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Bottle gourd	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Cucumber	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Cucumber	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae,* *L trifolii,* *L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting	Cucumber	Cyromazine	PER81867	*Liriomyza*	30 November	7 days (harvest)	Management or

vegetables (Cucurbits – including melons)				*sativae* and *L. huidobrensis*	2023	Do not graze or cut for stock food	eradication
Fruiting vegetables (Cucurbits – including melons)	Melon (including honeydew, rock melon)	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Melon (including honeydew, rock melon)	Cyantraniliprole	PER90387	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Melon (including honeydew, rock melon)	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Pumpkin (e.g. butternut)	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Pumpkin (e.g. butternut)	Cyantraniliprole	PER90387	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits –	Bottle gourd	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication

including melons)							
Fruiting vegetables (Cucurbits – including melons)	Pumpkin (e.g. Queensland blue)	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Pumpkin (e.g. Queensland blue)	Cyantraniliprole	PER90387	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Pumpkin (e.g. Queensland blue)	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Smooth luffa, sponge gourd	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Smooth luffa, sponge gourd	Cyantraniliprole	PER90387	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Smooth luffa, sponge gourd	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting	Watermelon	Abamectin	PER81876	*Liriomyza*	30 April 2024	7 days (harvest)	Management or

vegetables (Cucurbits – including melons)				*sativae* and *L. huidobrensis*		Do not graze or cut for stock food	eradication
Fruiting vegetables (Cucurbits – including melons)	Watermelon	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*: L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Watermelon	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Wax gourd	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Wax gourd	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*: L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Wax gourd	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication

Fruiting vegetables (Cucurbits – including melons)	Zucchini	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Zucchini	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Zucchini	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Bell pepper	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Bell pepper	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Bell pepper	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Capsicum, chili*	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables	Capsicum, chili*	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:*	31 December 2023	1 day (harvest) Do not graze or cut for	Management or eradication

(other than cucurbits)				*L. sativae,* *L trifolii,* *L. huidobrensis*)		stock food	
Fruiting vegetables (other than cucurbits)	Capsicum, chili*	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Capsicum, chili*	Spirotetramat	PER88640	*Liriomyza* spp. (including: *L. sativae,* *L trifolii,* *L. huidobrensis*)	31 May 2023	1 day (harvest) Do not graze or cut for stock food	Management
Fruiting vegetables (other than cucurbits)	Eggplant	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Eggplant	Cyantraniliprole	PER90387	*Liriomyza* spp. (including: *L. sativae,* *L trifolii,* *L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Eggplant	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Eggplant	Spirotetramat	PER88640	*Liriomyza* spp. (including: *L. sativae,* *L trifolii,* *L. huidobrensis*)	31 May 2023	1 day (harvest) Do not graze or cut for stock food	Management
Fruiting vegetables (other than cucurbits)	Okra*	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication

Fruiting vegetables (other than cucurbits)	Okra*	Cyantraniliprole	PER90387	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Okra*	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Tomato	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Tomato	Cyantraniliprole	PER90387	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Tomato	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Tomato	Spirotetramat	PER88640	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 May 2023	1 day (harvest) Do not graze or cut for stock food	Management
Herbs	Basil	No suitable pesticides identified					
Herbs	Oregano	No suitable pesticides identified					

Herbs	Parsley[4]	Spirotetramat	PER88640	*Liriomyza* spp. (including*:* *L. sativae,* *L trifolii,* *L. huidobrensis*)	31 May 2023	3 days (harvest) Do not graze or cut for stock food	Management
Head lettuce	Lettuce (Head type only)	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Leafy vegetables (including brassica leafy vegetables)	Lettuce	Spirotetramat	PER88640	*Liriomyza* spp. (including*:* *L. sativae,* *L trifolii,* *L. huidobrensis*)	31 May 2023	1 day (harvest) Do not graze or cut for stock food	Management
Leafy vegetables (including brassica leafy vegetables)	Spinach	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	14 days (harvest) Do not graze or cut for stock food	Management or eradication
Leafy vegetables (including brassica leafy vegetables)	Spinach	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	**Treated crop must be destroyed.** Treated crops must not be made available for human consumption Do not graze or cut for stock food	**Eradication only**
Leafy vegetables	Spinach and silverbeet	Chlorantraniliprole	PER87631	*Liriomyza* spp. (including*:*	30 June 2024	3 days (harvest) 7 days (grazing or	Management or eradication

[4] Note: Parsley is not a recorded host for *L. sativae* but may be a host of other *Liriomyza* spp. and is listed as one of the crops that the permit covers.

(including brassica leafy vegetables)				*L. sativae, L brassicae, L. huidobrensis*)		cutting for stock food)	
Legume vegetables	Common bean; French beans, kidney beans	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Common bean; French beans, kidney beans	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Common bean; French beans, kidney beans	Spirotetramat	PER88640	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 May 2023	7 days (harvest) 7 days (grazing and hay)	Management
Legume vegetables	Faba bean, broad bean	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Faba bean, broad bean	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Mung bean	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Mung bean	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Pea, snow peas, sugar snap peas, field pea	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Pea, snow peas, sugar snap peas, field pea	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Pea, snow peas, sugar snap peas,	Spinetoram	PER87878	*Liriomyza* spp.	28 February 2023	3 days (harvest); 14 days (grazing and	Management or eradication

	field pea					hay) Do not allow dairy cattle to graze treated forage	
Legume vegetables	Pea, snow peas, sugar snap peas, field pea	Spirotetramat	PER88640	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 May 2023	3 days (harvest); 3 days (grazing and hay)	Management
Legume vegetables	Red bean	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Red bean	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Snake bean	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Snake bean	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Not classified	Field mustard	No suitable pesticides identified					
Not classified	Lucerne	No suitable pesticides identified					
Nursery stock (non-food)	Various non-food nursery plants (e.g. chrysanthemum etc.)	Cyromazine	PER83506	Larvae of leafminers	31 October 2022	Do not ship within 7 days of treatment	Management or eradication
Nursery stock	Seedlings, tubes	Abamectin	PER88977	Leafminers	30	Not required when	Management or

(non-food)	and plugs, potted colour, trees and shrubs, foliage plants, palms, grasses, fruiting plants (non-bearing), cut flowers and ornamentals.	Azadirachtin Cyromazine Emamectin Chlorantraniliprole + thiamethoxam Cyantraniliprole Indoxacarb Spinetoram		(*Liriomyza* spp.) including Vegetable leafminer (*Liriomyza sativae*)	November, 2022	used as directed	eradication
Oilseeds	<u>Cotton</u>	Spinetoram has been identified as suitable for the control of Vegetable leafminer and other *Liriomyza* spp. on cotton as overseas and Australian use patterns are comparable. However, no permit has been applied for this use to date					
Pulses	<u>Pulses</u>	Dimethoate	PER89184	*Liriomyza sativae, Liriomyza trifolii, Liriomyza huidobrensis*	31 March 2025	Harvest: Do not harvest for 14 days after application. Grazing: Do not graze or cut for stock food for 14 days after application.	Management
Root and tuber vegetables	<u>Beets (beetroot, silver beet, sugar beets)</u>	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	14 days (harvest) Do not graze or cut for stock food	Management or eradication
Stalk and stem vegetables	<u>Beets (beetroot, silver beet, sugar beets)</u>	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Root and tuber vegetables	<u>Carrot</u>	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	14 days (harvest) Do not graze or cut for stock food	Management or eradication
Stalk and stem vegetables	<u>Carrot</u>	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Root and tuber	<u>Potato</u>	Abamectin	PER81876	*Liriomyza sativae* and	30 April 2024	14 days (harvest) Do not graze or cut for	Management or eradication

vegetables				*L. huidobrensis*		stock food	
Root and tuber vegetables	Potato	Cyantraniliprole	PER90387	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Stalk and stem vegetables	Potato	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Root and tuber vegetables	Radish	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	14 days (harvest) Do not graze or cut for stock food	Management or eradication
Stalk and stem vegetables	Radish	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Stalk and stem vegetables	Celery	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest); do not graze	Management or eradication
Stalk and stem vegetables	Celery	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Stalk and stem vegetables	Celery	Spirotetramat	PER88640	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 May 2023	3 days (harvest) Do not graze or cut for stock food	Management or eradication
Stalk and stem vegetables	Rhubarb[5]	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest); do not graze	Management or eradication

[5] Note: Rhubarb is not a recorded host for *L. sativae or L. huidobrensis* but may be a host of other *Liriomyza* spp. and is part of the 'Stalk and Stem Vegetable Crop Group' that the permit covers.

Stalk and stem vegetables	Rhubarb[3]	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Stalk and stem vegetables	Rhubarb[3]	Spirotetramat	PER88640	*Liriomyza* spp. (including*: L. sativae, L trifolii, L. huidobrensis*)	31 May 2023	3 days (harvest) Do not graze or cut for stock food	Management or eradication

Appendix 4: Additional impact prediction outputs

Table 20 State level accumulated unmitigated impacts in millions of dollars after 3 years resulting from a spring (September) incursion of L. trifolii *at key entry points across Australia. Simulations were replicated 10 times with means and standard deviations shown in parentheses. The proportion crop impact was fixed at 10% in order to explore variability due to incursion location and the size and distribution of different industries. Thus, host preferences of the pests do not influence the predicted crop impacts, and impacts of low preference hosts may be overestimated while impacts of high preference hosts may be underestimated. All cells with a value of 0.00 represent unmitigated impacts less than $10,000.*

INCURSION LOCATION															
	NSW		**NT**		**QLD**			**SA**	**TAS**	**VIC**		**WA**			
Crop	**Griffith**	**Sydney**	**Darwin**	**Katherine**	**Bowen**	**Bundaberg**	**Toowoomba**	**Adelaide**	**Devonport**	**Ballarat**	**Melbourne**	**Albany**	**Carnarvon**	**Geraldton**	**Perth**
Beans	0.00 (0.00)	0.05 (0.00)	0.06 (0.00)	0.00 (0.00)	7.56 (0.66)	9.62 (0.56)	9.23 (0.31)	0.00 (0.00)	1.18 (0.00)	0.31 (0.15)	0.39 (0.09)	0.01 (0.00)	0.00 (0.00)	0.00 (0.00)	0.02 (0.00)
Broccoli	0.11 (0.00)	0.10 (0.00)	0.00 (0.00)	0.00 (0.00)	0.34 (0.30)	4.33 (0.41)	6.34 (0.22)	0.38 (0.05)	0.38 (0.00)	6.86 (1.80)	8.62 (0.27)	0.07 (0.02)	0.00 (0.00)	0.00 (0.00)	2.24 (0.46)
Brussels sprouts	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.05 (0.02)	0.07 (0.03)	5.01 (0.05)	0.31 (0.00)	0.38 (0.23)	0.82 (0.39)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Cabbages	0.00 (0.00)	2.19 (0.11)	0.00 (0.00)	0.00 (0.00)	0.23 (0.19)	2.66 (0.26)	3.91 (0.04)	0.26 (0.01)	0.12 (0.00)	0.70 (0.16)	0.87 (0.03)	0.00 (0.01)	0.00 (0.00)	0.00 (0.00)	0.58 (0.07)
Capsicum	0.14 (0.00)	0.14 (0.01)	0.00 (0.00)	0.00 (0.00)	9.24 (0.03)	3.87 (0.16)	0.76 (0.21)	2.59 (0.40)	1.47 (0.00)	0.19 (0.14)	0.33 (0.15)	0.08 (0.05)	0.00 (0.00)	0.00 (0.00)	0.68 (0.11)
Carrots	0.07 (0.00)	0.18 (0.03)	0.00 (0.00)	0.00 (0.00)	1.05 (0.87)	6.14 (0.46)	7.12 (0.60)	3.45 (0.20)	3.75 (0.00)	0.21 (0.09)	0.29 (0.03)	0.04 (0.06)	0.00 (0.00)	0.00 (0.01)	5.75 (1.17)
Cauliflowers	0.00 (0.00)	0.40 (0.03)	0.00 (0.00)	0.00 (0.00)	0.08 (0.09)	1.56 (0.15)	2.45 (0.07)	0.56 (0.06)	0.97 (0.00)	3.56 (1.00)	4.35 (0.13)	0.05 (0.01)	0.00 (0.00)	0.00 (0.00)	0.90 (0.11)
Flowers	0.00 (0.00)	16.57 (0.62)	0.18 (0.00)	0.00 (0.00)	0.51 (0.31)	4.91 (0.16)	4.17 (0.24)	2.04 (0.14)	0.63 (0.00)	4.18 (2.23)	7.59 (1.07)	0.24 (0.08)	0.00 (0.00)	0.00 (0.01)	1.84 (0.23)
Lettuces	0.00 (0.00)	1.18 (0.06)	0.00 (0.00)	0.00 (0.00)	0.38 (0.32)	5.96 (0.52)	8.30 (0.09)	0.93 (0.08)	0.01 (0.00)	7.38 (2.31)	9.85 (0.45)	0.04 (0.06)	0.00 (0.00)	0.00 (0.01)	3.26 (0.39)
Melons	3.03 (0.00)	0.04 (0.00)	0.61 (0.02)	0.00 (0.00)	4.55 (0.03)	4.50 (0.04)	0.73 (0.16)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.80 (0.30)

INCURSION LOCATION															
Nurseries	2.39 (0.00)	20.32 (1.26)	0.28 (0.00)	0.00 (0.00)	3.45 (1.50)	19.88 (0.99)	21.13 (1.37)	5.85 (0.10)	0.70 (0.02)	10.83 (3.42)	17.10 (1.64)	0.18 (0.27)	0.00 (0.00)	0.01 (0.04)	8.31 (0.58)
Onions	0.29 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.49 (0.34)	3.77 (0.26)	4.86 (0.25)	3.92 (0.41)	3.74 (0.00)	0.11 (0.06)	0.19 (0.02)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.60 (0.68)
Peas	0.00 (0.00)	0.02 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.45 (0.01)	0.06 (0.01)	0.00 (0.00)	0.64 (0.00)	0.17 (0.12)	0.20 (0.06)	0.02 (0.00)	0.00 (0.00)	0.00 (0.00)	0.01 (0.00)
Potatoes	7.18 (0.00)	1.17 (0.08)	0.00 (0.00)	0.00 (0.00)	0.24 (0.13)	5.25 (0.20)	3.25 (0.24)	3.46 (0.20)	5.99 (0.00)	3.19 (0.36)	1.66 (0.28)	0.02 (0.03)	0.00 (0.00)	0.00 (0.00)	2.39 (0.73)
Pumpkins	2.03 (0.00)	0.16 (0.01)	0.00 (0.00)	0.00 (0.00)	1.86 (0.17)	2.90 (0.17)	3.33 (0.20)	0.00 (0.00)	0.14 (0.00)	0.01 (0.00)	0.01 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.24 (0.11)
Tomatoes	0.83 (0.00)	1.81 (0.06)	0.01 (0.00)	0.00 (0.00)	17.76 (0.14)	11.68 (0.35)	3.34 (0.41)	1.10 (0.28)	0.34 (0.00)	0.54 (0.38)	0.98 (0.66)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.09 (0.06)
Total	**16.07 (0.00)**	**44.35 (1.85)**	**1.14 (0.02)**	**0.00 (0.00)**	**47.75 (4.55)**	**87.54 (3.67)**	**79.05 (3.32)**	**29.55 (1.24)**	**20.36 (0.02)**	**38.61 (10.25)**	**53.24 (3.81)**	**0.76 (0.54)**	**0.00 (0.00)**	**0.02 (0.07)**	**28.71 (4.59)**

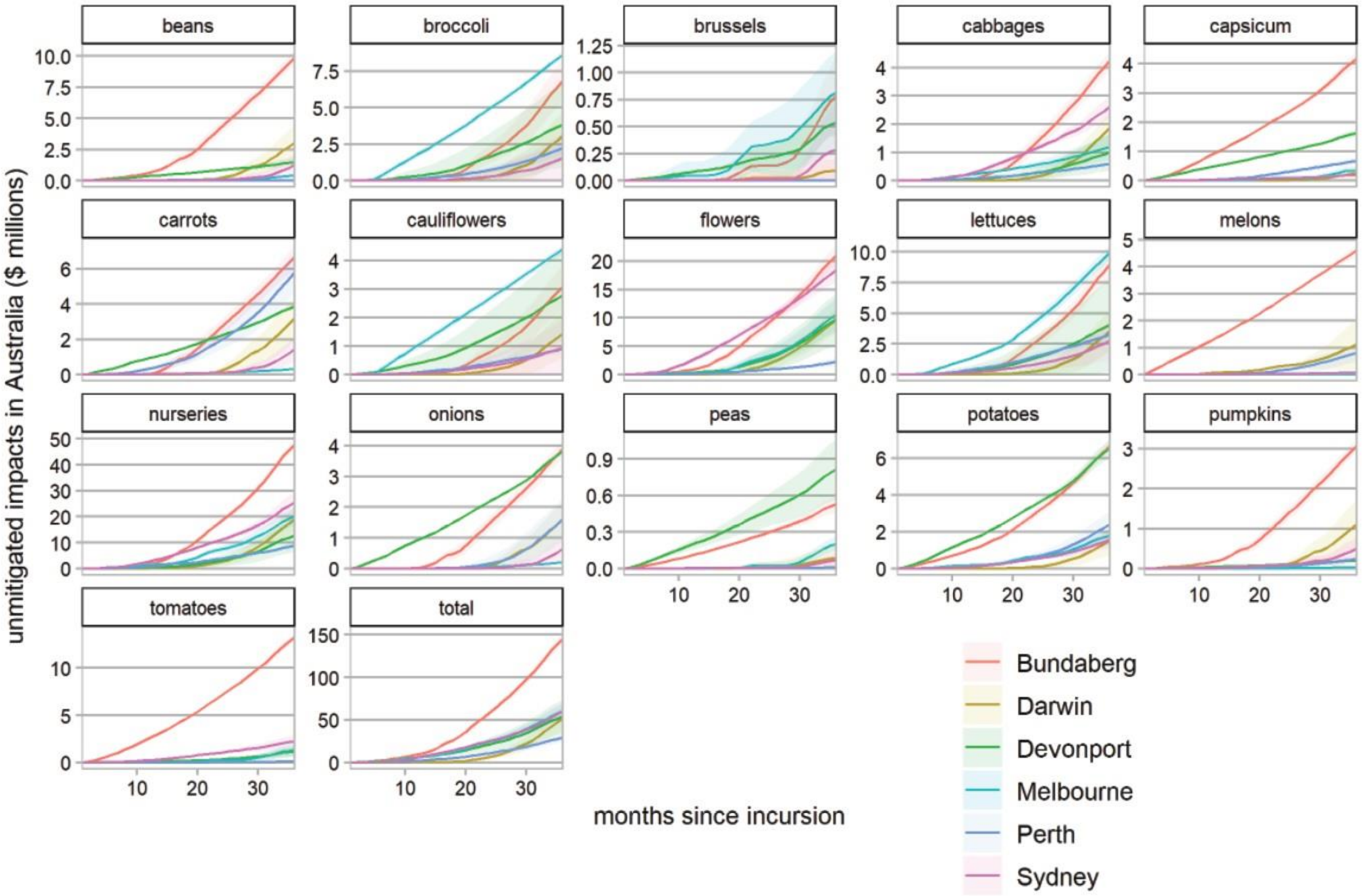

Figure 9 Australia wide accumulating unmitigated impacts in millions of dollars after 3 years resulting from a spring (September) incursion of L. trifolii *at key entry and establishment points across Australia.*