Final Report

Improving biosecurity preparedness of the Australian citrus industry

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Delivery partner:

Plant Health Australia

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CT17001

Project:

Improving biosecurity preparedness of the Australian citrus industry (CT17001)

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Summary

The Australian citrus industry provides significant value to rural communities and the wider economy, and, throughout the period of this project, the industry underwent a period of significant growth in exports, reaching $509 million in 2019/20 (Hort Innovation 2020). The Australian citrus industry faces a number of exotic pest threats that have the potential to severely affect production and/or this ongoing growth in export markets. These include huanglongbing and its psyllid vectors, citrus canker, citrus variegated chlorosis (Xylella) and others.

The incursion or establishment of exotic pests could therefore have significant ramifications for industry, regional economies, and national exports. In recognition of the importance of these pest threats, the citrus industry has been strongly engaged in biosecurity for many years, and 'Reducing Biosecurity Risks' was identified in the citrus industry's Strategic Investment Plan 2017-2021 as one of four key areas for investment.

This project (CT17001) was established to improve the industry's ability to respond to exotic pests, raise awareness amongst the industry of the importance of exotic citrus pests and develop a nationally coordinated program for surveillance activities targeting exotic pests. To achieve these objectives, the project has developed a range of material under five 'themes' (Surveillance, Increased Awareness, Capacity building, Preparedness and Governance). Key outputs from this project are noted below:

- **Surveillance**
    - Collected surveillance data relating to exotic pests from commercial, urban, and peri-urban locations. Data was collected through:
        - Korea, China, Thailand (KCT) Surveillance Program (a program targeting established market access pests existed prior to this project but was expanded in 2019 to include five exotic pests of citrus).
        - Asian Citrus Psyllid Trapping Program (established in 2019 to trap and survey for Asian citrus psyllid).
- **Increased Awareness**
    - Created awareness material to increase grower awareness of exotic citrus pests and support surveillance activities.
    - Created communications material to promote biosecurity practices amongst growers.
    - Presented biosecurity information at citrus industry workshops.
- **Capacity building**
    - Employment of a National Citrus Surveillance Coordinator to coordinate surveillance and biosecurity activities involving the Australian citrus industry.
    - Maintained the First Detectors Network (first created under CT12022), who have been involved in the collection of surveillance data through the KCT and Asian Citrus Psyllid Trapping Programs.
- **Preparedness**
    - Identified pesticide control options for High Priority exotic pests of citrus.
- **Governance**
    - Established and held regular meetings of the Project Steering Committee.
    - Established and held regular meetings of the Huanglongbing Taskforce (which in 2020 merged with the Citrus Pest and Disease Prevention Committee).

These outputs/materials were aimed at various audiences including decision makers, researchers, and growers to ensure that all sections of the citrus industry are aware of the importance of biosecurity.

The completion of this project has provided valuable lessons for future citrus biosecurity and surveillance activities resulting in the following recommendations:

1. Maintenance of a National Citrus Biosecurity Program.
2. The need for greater focus on urban areas and areas in northern Australia.
3. The requirement to undertake a pathway risk modelling to better target surveillance activities.
4. Less reliance on volunteers where activities are time critical (e.g., deployment, retrieval, submission, and assessment of sticky insect traps).
5. Maintain oversight of changes to exotic pest management options used overseas.
6. Maintain emphasis on building capacity and capability for surveillance and diagnostics to support biosecurity in the citrus industry.
7. Improved preparedness for high priority pests.

Keywords

Awareness; Biosecurity; Citrus Psyllid; Citrus; Exotic pests; Preparedness; Surveillance

Introduction

The Australian citrus industry is a significant and mature horticultural industry with production made up of oranges, mandarins, lemons, limes, grapefruit, and tangelos. In 2019/20, the citrus crop was valued at $942.4 million, the highest value of production ever achieved. This figure includes $509 million in exports, reflecting a period of ongoing growth, which has seen an increase of 171% since 2012/13. Given this value of production, the citrus industry is an important contributor to the national economy.

The Biosecurity Plan for the Citrus Industry (Version 3; 2015) identified numerous exotic High Priority Pests (HPPs) that have the potential to have significant impacts on Australian citrus. The worst of these is Huanglongbing (HLB) and its psyllid vectors, which have devastated citrus industries overseas, but other pest threats also exist such as citrus canker and citrus variegated chlorosis (Xylella). Because of the impact of these potential threats on both production and market access, the citrus industry has been actively engaged in biosecurity for many years through Hort Innovation funded projects including CT12022 and this project, CT17001.

Establishment of exotic pests would have major ramifications for producers, regional areas as well as national exports. A recent example is the Citrus Canker Eradication Program that concluded in 2021, which cost $19 million for the eradication response and saw significant disruption to the citrus industry, nursery and garden industry and producers of crops such as kaffir lime leaves.

This project (CT17001) was designed to assist the citrus industry to improve its biosecurity awareness, preparedness, and surveillance capability to ensure that the industry is better able to detect new pests and respond to pest detections. These objectives included:

- Expanding on the base created in CT12022 by continuing to improve the industry's surveillance, awareness, capacity building, response, and preparedness activities.
- Increasing awareness of the high priority pests of citrus within industry and in urban and peri-urban communities.
- Maintaining the First Detector Network in the citrus industry to provide support for the early detection of high priority pests.
- Increasing awareness and adoption of biosecurity best practice for commercial citrus production.
- Coordinating regular collection of surveillance data to provide evidence of pest status (presence or absence) for high priority pests of citrus from commercial production areas.
- Improving preparedness for pest incursions with the identification and review of chemicals for suitable for eradication or control of high priority pests or their vectors.

Methodology

This project utilized a Steering Committee consisting of representatives from Citrus Australia, State and Commonwealth Governments, Auscitrus, citrus producers, Horticulture Innovation and Plant Health Australia to guide and oversee the direction of project.

A basic methodology is provided below for each of the major themes of the project.

Surveillance

The project took a multipronged approach to collecting surveillance data.

A National Citrus Surveillance Coordinator was employed in 2018 (see 'Capacity Building' section below) to coordinate surveillance activity within the citrus industry. One of the first tasks of the coordinator was to include exotic pests in the industry's Korea, China, Thailand (KCT) export program (Appendix 1). The KCT program is conducted by trained crop scouts who undertake surveillance to support the access of commercial orchard blocks to export markets. Prior to 2019, the KCT program targeted established pests of market access concern (Fuller's rose weevil, light brown apple moth, mealy bugs, blastobasid fruit borer, sorghum head caterpillar, orange fruit borer, fruit flies, greasy spot, septoria spot, and phytophthora rots). Since 2019, the KCT program has been expanded to include surveillance for five exotic pests (i.e., citrus canker, huanglongbing, Asiatic citrus psyllid, citrus variegated chlorosis, and glassy winged sharpshooter). To support their inclusion, this project provided information that was included in the online training module that crop monitors must undertake to register and participate in the KCT program.

An Asian Citrus Psyllid Trapping Program was established based on the use of food-based lures and yellow-coloured sticky traps imported from Alpha Scents, Inc., a United States company. These traps and lures are specially designed to be attractive to Asian citrus psyllid (*Diaphorina citri*) making them suitable for use in the surveillance program. These traps are also expected to be able to capture additional insect High Priority Pest (HPPs) such as African citrus psyllid (*Trioza erytreae*) and glassy winged sharpshooters (*Homalodisca vitripennis*) if present. Traps have been deployed in production, urban and peri-urban areas in Victoria, New South Wales, Queensland, South Australia, Western Australia, and the Northern Territory (Appendix 2). After deployment, traps were sent to laboratories for assessment. Instructional material was also produced to support surveillance using these traps (see 'Increased Awareness' section below).

Increased awareness

To improve the awareness of the citrus industry about biosecurity and surveillance activities the National Citrus Surveillance Coordinator and Plant Health Australia developed a range of awareness factsheets and instructional documents. These were developed based on current scientific knowledge and then professionally laid out by a graphic designer to provide easy to understand material aimed primarily for growers and consultants.

Similarly, the program has been involved in the development of media articles to promote biosecurity amongst citrus growers and gardeners (Appendix 3). To support improved awareness of pest threats in northern Australia, the project team provided input into development of the Exotic Pest Identification and surveillance guide for tropical horticulture. This guide has a section that covers 15 exotic pests of citrus, providing basic information on each pest and a general overview on how to conduct surveillance.

Finally, the National Citrus Surveillance Coordinator spent significant time visiting and presenting to growers and consultants at industry-led grower focused workshops. Over the course of the project workshops have been held in all major citrus producing regions and provided an opportunity for the coordinator to present biosecurity related information directly to growers allowing opportunity for discussions and transfer of knowledge.

Capacity building

Employment of the National Citrus Surveillance Coordinator within this project provided a valuable resource and a focal point for all surveillance and biosecurity activity within the citrus industry. The position was housed at the Mildura in the Citrus Australia offices allowing integration and ready access to industry information and events.

The National Citrus Surveillance Coordinator was responsible for coordinating and driving collaboration in the biosecurity and surveillance space. This included re-establishing contact with the First Detectors Network (first created under CT12022), many of whom were involved in the Asian citrus psyllid surveillance program or the collection of data through the KCT program, resulting in significant surveillance outcomes for the industry.

Preparedness

To prepare for possible outbreaks of exotic citrus pests this project investigated pesticide control options that could be used in Australia to manage or eradicate exotic pests. This involved a review of commercially applied pesticides used overseas and comparison to existing Australian citrus pesticide use patterns. This process identified potential pesticide control options that could be used in Australia to control exotic pests while ensuring crop safety, safe residue levels and operator safety considerations are not compromised. This information makes the industry well prepared to respond to future exotic pest detections.

The Huanglongbing Task Force was established originally as a subset of the National Citrus Surveillance Steering Committee (NCSSC) (see 'Governance' section below). The function of the Task Force was to review Huanglongbing related preparedness documents (including contingency plans, surveillance methods and so on), identify gaps, and provide suggestions for how gaps in the Australian citrus industry's preparedness for Huanglongbing (HLB) can be addressed. The HLB Task Force consisted of technical experts (entomologist and pathologist), Citrus Australia, Auscitrus, and Plant Health Australia. Several meetings of the Task Force were held before the function of the Taskforce was merged into the Citrus Pest and Disease Prevention Committee (CPDPC – an industry established, biosecurity focused committee), as a standing item on their quarterly meeting agenda. This occurred after significant overlap in the function of the two committees was identified, and both committees agreed to the merger.

Governance

The development and maintenance of a Citrus Biosecurity Program required suitable governance structures to be established. Overarching governance was provided by a Project Steering Committee. The committee consisted of representatives from the citrus industry (Citrus Australia and growers), Auscitrus, commonwealth and state governments, Plant Health Australia, and Horticulture Innovation. The Steering committee met face to face and virtually throughout the project to provide strategic direction and guidance to the project.

Foundational documents created at the start of the project included a detailed Project Plan, Monitoring and Evaluation Plan, and Stakeholder Engagement Plan. These documents assisted with the development and implementation of the project to ensure it met its objectives.

Outputs

This project was established to develop the resources and information needed to improve biosecurity capacity and technical capability of the citrus industry. The project has built the foundations of a nationally coordinated program for surveillance activities for citrus High Priority Pests such as Asian citrus psyllid, African citrus psyllid, huanglongbing, xylella, citrus canker and glassy winged sharpshooter.

Major outputs from this project include:

1. Regular collection and national collation of surveillance data relating to exotic citrus pests.
2. Instructional and awareness publications used to raise awareness of exotic pests and support surveillance activities (example publications are attached, refer to Attachments 1-6).
3. Capacity building through the recruitment of the National Citrus Surveillance Coordinator and reestablishment of contract with the First Detector Network.
4. Improved preparedness through the creation of a literature review of pesticide options suitable for the management of High Priority Pests of citrus. This review has identified control options and contains information to support the development of emergency use permits in the event of an exotic pest outbreak (refer to Attachment 7). Preparedness was also improved through the establishment of a huanglongbing taskforce to guide industry decisions regarding preparedness activities for exotic citrus pests.
5. Increased awareness of surveillance and biosecurity within the citrus industry through the creation and distribution of publications, attendance at industry events and creation of media articles.
6. Improved governance through the establishment of the National Citrus Surveillance Steering Committee (NCSSC).

Collection of surveillance data

This project has collected significant amounts of surveillance data from the KCT program, and an Asian citrus trapping program as described below.

KCT surveillance program

Prior to 2019 the KCT program targeted Fuller's rose weevil, light brown apple moth, mealy bugs, blastobasid fruit borer, sorghum head caterpillar, orange fruit borer, fruit flies, greasy spot, septoria spot, and phytophthora rots.

In 2019, 2020, 2021, the KCT program was expanded to include monitoring for citrus canker, huanglongbing, Asiatic citrus psyllid, citrus variegated chlorosis, and glassy winged sharpshooter. To support this work, this project provided information that was included in the online training module that must be undertaken to participate in the KCT program.

In 2019, the KCT program collected surveillance data for exotic citrus pests from more than 10,000 ha (~42%) of citrus orchards in all citrus production areas. The area covered in 2020 increased to cover approximately 11,500 ha. In 2021 the program has expanded further covering 11,965 ha representing approximately 44% of Australian citrus orchards. Commercial production areas covered by the KCT program include parts of Queensland, Riverina, Murray Valley, Riverland, and southern Western Australia (Figure 1).

Data collected by KCT registered crop monitors are sent to Citrus Australia. Plant Health Australia has worked with Citrus Australia to develop a method for uploading KCT data to AUSPest*Check*™*,* the national data aggregation system and data has been imported into AUSPest*Check*™ for 2020 (Figure 1, also refer to Appendix 1). Within the screenshots of outputs from AUSPest*Check*™ each circle represents the numbers of data points for the activities conducted for each targeted pest. Within the AUSPestCheck™ system itself, greater resolution can be seen than is represented in these screenshots, and additional reports can also be generated from the data.

By June 2021, over 142,000 data points had been uploaded to AUSPestCheck™ from the KCT program.

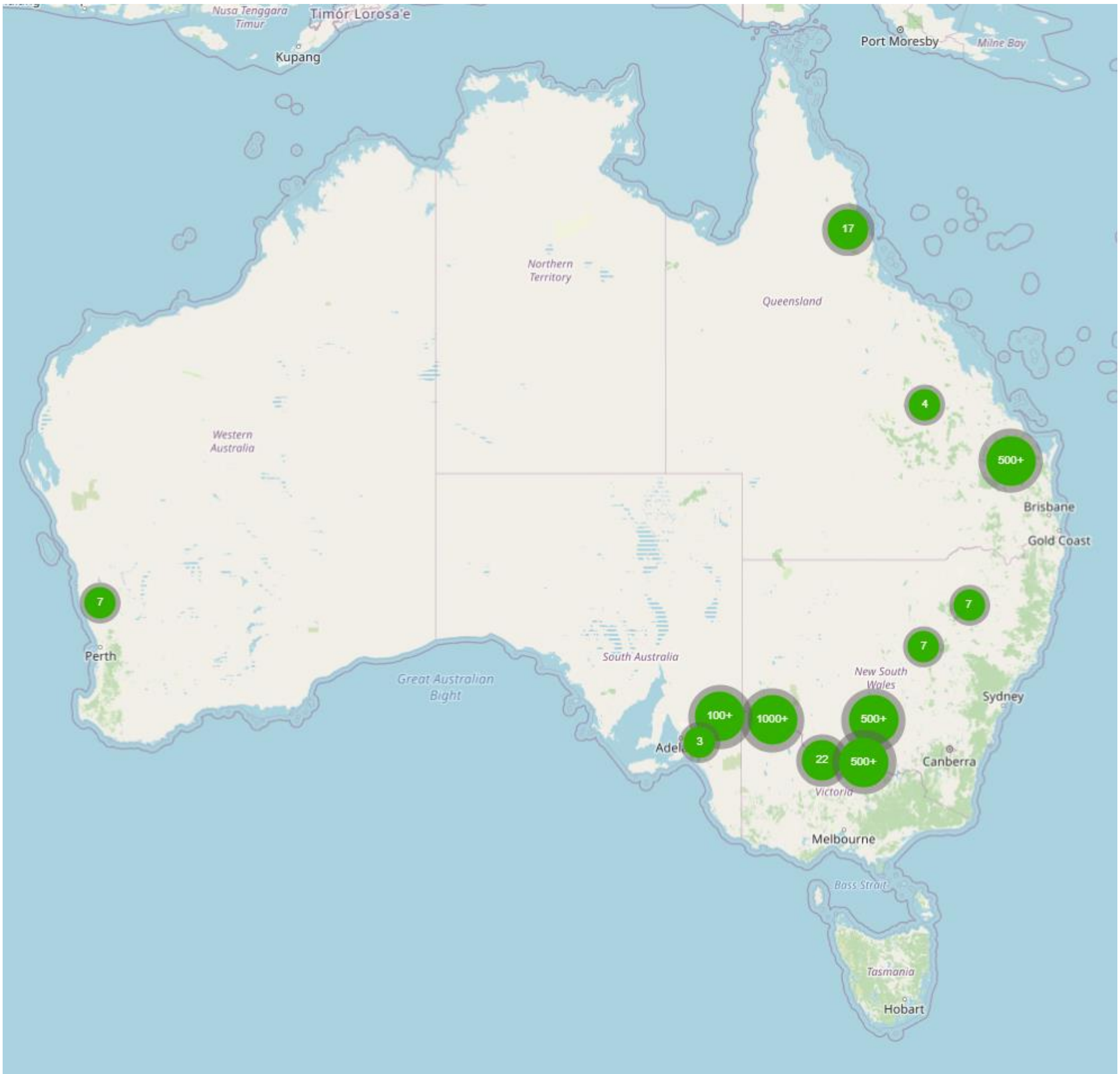


Figure 1 Map of orchards participating in the KCT Program

Asian citrus psyllid trapping

Asian citrus psyllid (ACP, *Diaphorina citri*) is considered by the citrus industry to be one of its most significant exotic pests due to its importance as a vector of huanglongbing (*Candidatus* Liberibacter asiaticus, *Ca*. L. africanus, and *Ca*. L. americanus).

In 2020 the project purchased 1,000 ACP food-based lures and yellow-coloured sticky traps from the United States to conduct surveillance for ACP. These traps are also expected to be able to capture additional insect pests such as African citrus psyllid (*Trioza erytreae*) and glassy winged sharpshooters (*Homalodisca vitripennis*) if present. Instructional documents have been developed to support the surveillance program (see Attachments 2-6).

Throughout this project, ACP traps have been deployed in Victoria, New South Wales, Queensland, South Australia, Western Australia, and the Northern Territory covering urban, peri-urban, northern Australia and commercial production areas. In total this project has generated 446 datapoints including 285 traps deployed since 2020 via this program and 161 datapoints provided by Andrew Miles from 2PH or provided by the Northern Territory Department of Industry, Tourism and Trade (Attachment 8; Figure 1).

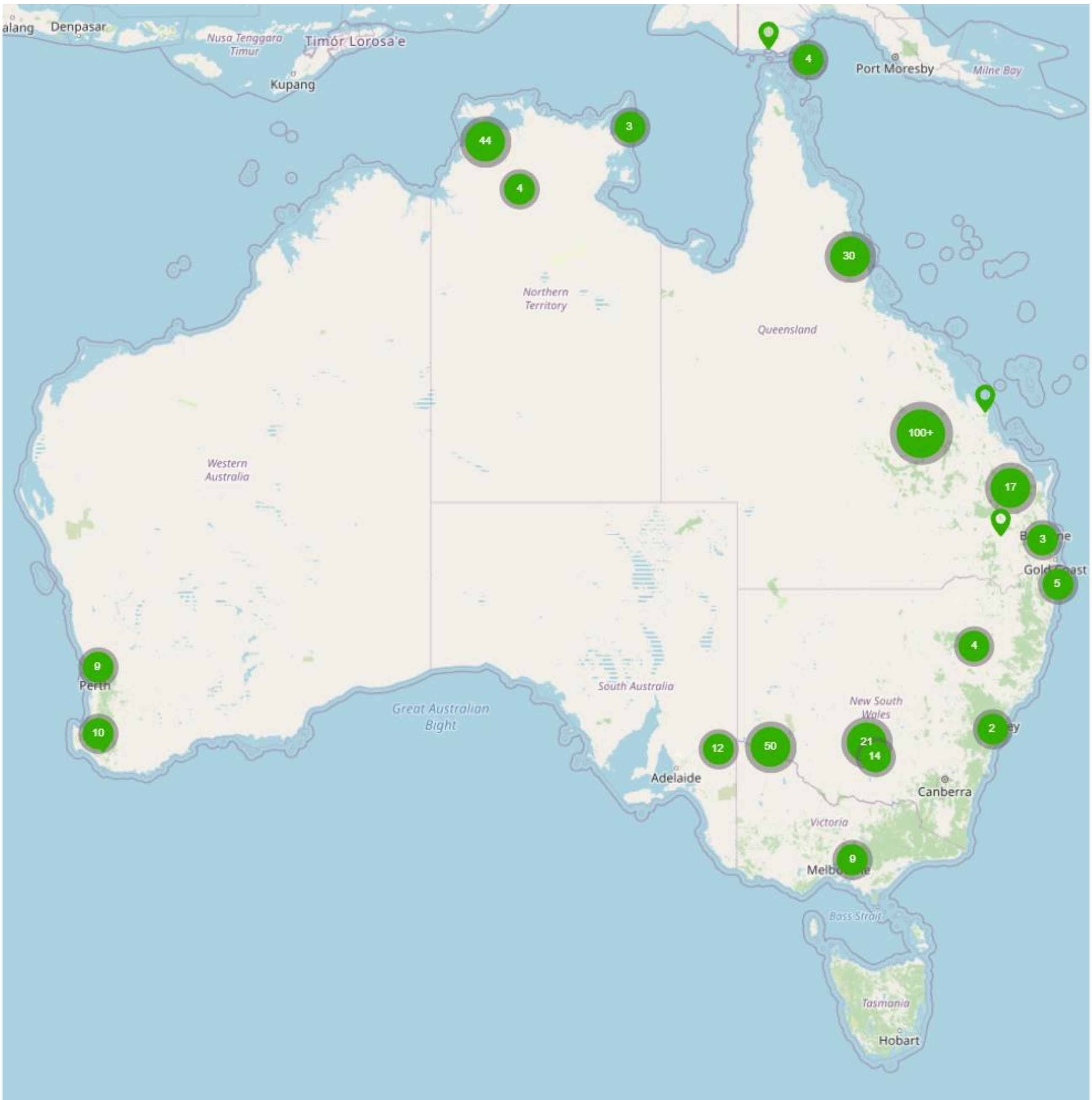


Figure 2 Asian citrus psyllid surveillance conducted through this project

These sites include locations in urban/peri-urban and northern Australia including:

- Torres Strait, Queensland
- Cairns, Queensland

- Melbourne, Victoria
- Bunbury, Western Australia
- Perth, Western Australia
- Atherton Tablelands, Queensland
- Darwin, Katherine and surrounds, Northern Territory

As well as commercial citrus growing locations including:

- Gayndah (Burnette River), Queensland
- Riverina, New South Wales
- Sunraysia, New South Wales/Victoria
- Riverland, South Australia
- Emerald, Queensland
- Gosford, New South Wales
- Gunnedah, New South Wales
- Southwestern Western Australia

Detailed maps showing the survey sites and a table of results is provided in Appendix 2.

Collaboration with other projects

This project has actively collaborated with other organisations and projects to provide benefit to the industry's biosecurity preparedness.

Throughout the project the National Citrus Surveillance Coordinator has been in contact with Northern Australia Quarantine Strategy (NAQS) staff. In early 2021 this culminated with NAQS staff testing the deployment of Asian citrus psyllid traps in north Queensland and the Torres Strait. Preliminary findings from this suggests that some modifications to the techniques will be required to better suit conditions in Northern Australia (e.g., use of string to suspend traps and reduce ant predation of caught insects). These modifications are being addressed in future surveys involving sticky traps planned for northern Australia.

This project has had close ties with CT17007 (*Improving diagnostics and biosecurity for graft-transmissible diseases in citrus*). This has included the collection of budstick samples by the First Detector Network and submitted to CT17007 to test the effectiveness of diagnostic methods and to screen samples for exotic graft transmissible pathogens – testing conducted to date has not detected any exotic pathogens. This collaboration has assisted both projects in achieving their goals and provides benefit to the Australian citrus industry.

In 2019 the citrus industry established a Citrus Pest and Disease Prevention Committee (CPDPC) to improve the industry's ability to respond to emerging citrus pest and disease issues. The National Citrus Surveillance Coordinator sits on the committee and provides significant support to its activities. This connection has been very beneficial to this project with CPDPC members active in assisting with the development of the Asian Citrus Psyllid Trapping Program including the ongoing deployment of Asian citrus psyllid traps. Since 2020 the CPDPC has also been expanded to include the function of the HLB Taskforce as a standing item on their quarterly meeting agenda. This occurred after significant overlap in the function of the two committees was identified, and both committees agreed to the merger.

The National Citrus Surveillance Coordinator has been an active contributor to the Tropical Plant Industries Biosecurity Surveillance Steering Committee, a group made up representatives from plant industries and governments that is responsible for identifying mechanisms to implement the Tropical Plant Industries Biosecurity Surveillance Strategy.

Increased awareness

Over the course of this project various published documents and communication materials have been produced. Additionally, the National Citrus Surveillance Coordinator attended and presented biosecurity and surveillance information at industry events as well as collaborating on activities focused on urban surveillance such as participation and contribution to the Urban Plant Health Network in Melbourne.

Material created includes:

- Awareness material/publications such as:
    - Surveillance information sheets (e.g., Attachment 1).
    - Best practice biosecurity documents (e.g., Attachment 2).
    - Instructional documents to support surveillance activities (e.g., Attachments 3-6).
- Media articles including:
    - Print media.
    - Electronic newsletters.
    - Social media content (see Appendix 3).

In addition to the creation of publications this project has contributed to increased levels of biosecurity awareness through the National Citrus Surveillance Coordinator's attendance and presentation at many industry events and workshops. Such events provide valuable face to face communication opportunities helping to raise the industry's awareness and knowledge of biosecurity.

Collaboration with other projects

This project has actively collaborated with other organisations and projects to provide benefit to the industry's awareness of biosecurity. An example of this is the National Citrus surveillance Coordinator's assistance with the development of the Exotic Pest Identification and Surveillance Guide for Tropical Horticulture (available from: https://www.planthealthaustralia.com.au/wp-content/uploads/2021/05/Exotic-Pest-Identification-and-Surveillance-Guide-for-Tropical-Horticulture.pdf). The publication includes a section on citrus pests and what growers should look for, raising awareness of exotic citrus pests amongst readers.

The National Citrus Surveillance Coordinator has also been actively involved in programs such as the Urban Plant Health Network (https://extensionaus.com.au/urbanplanthealthnetwork/home) which aims to improve biosecurity awareness in the Melbourne area by sharing information about plant pests between government, industry and the urban community.

Capacity building

National Citrus Surveillance Coordinator

The National Citrus Surveillance Coordinator was appointed in August 2018 and based in Mildura at the Citrus Australia office to ensure good connection with the industry. Throughout the project, the National Citrus Surveillance Coordinator has been responsible for working with industry bodies, growers, Commonwealth, and state and territory governments to coordinate citrus surveillance and biosecurity activities across Australia.

Early in their employment the National Citrus Surveillance Coordinator began re-establishing contact with the First Detector Network and other stakeholders. The National Citrus Surveillance Coordinator regularly attended industry events to promote biosecurity and surveillance within the Australian citrus industry. A key task undertaken by the National Citrus Surveillance Coordinator over the course of the project was the inclusion of exotic pests in the KCT surveillance program and the establishment of an Asian Citrus Psyllid

Trapping Program.

This work has assisted the industry improve its capacity to detect pests, raised the industry's awareness of exotic pests and built the industry's biosecurity capacity.

Reestablishment of the First Detector Network

The First Detector Network is a group of citrus stakeholders (including growers, crop scouts, agronomists, as well as Commonwealth, state, and territory government personnel) with an interest/involvement in citrus biosecurity. This network was first established under CT12022 but has since grown to now include more than 100 people since the First Detector Network was re-established in August 2018.

During this project, no formal meetings were held with the FDN as a group. Instead, individual FDN members have been regularly contacted at industry events, workshops, and similar avenues. At times emails were sent to FDN members seeking their participation in events such as the huanglongbing study tour (CT18003, which took place in March 2019), the Citrus Surveillance Triage Workshop (which took place in September 2019 – see below for details) or for assistance with the Asian Citrus Psyllid Trapping Program (2019 onwards).

Collaboration with other projects

This project has actively collaborated with other organisations and projects to provide benefit to the industry's biosecurity capacity to its ability to undertake surveillance.

In September 2019, a Citrus Field Triage Workshop was held to provide a training opportunity to members of Sub-committee on National Plant Health Surveillance (SNPHS). The workshop provided training in sample collection, transport, and decontamination procedures. Through collaboration with this project the workshop was extended to include citrus growers, researchers and advisors allowing networking and training opportunities for a range of citrus industry stakeholders.

Similarly, the National Citrus Surveillance Coordinator and members of the First Detector Network were able to attend a United States study tour (CT18003) to see the impacts of Huanglongbing and citrus psyllids on the United States citrus industry in Florida and California.

Improved preparedness

Literature review of chemical control options

A review has been undertaken to identify the commercially used pesticides that could be used for the control of the Australian citrus industry's HPPs (as identified in the Citrus Biosecurity Plan, PHA 2015).

The review considered overseas pesticide labels, scientific and agronomy publications to identify chemical control options for each citrus High Priority Pest (20 in total). The identified control options were then compared to existing Australian use patterns to determine which pesticides would be most suitable for use in an incursion. Using the results of these comparisons suitable pesticide control options were identified.

The review entitled "Pesticide control options for high priority citrus pests" is included as an attachment to this report (Attachment 7).

Huanglongbing Taskforce

Huanglongbing (HLB) is the most important exotic pest threat facing the Australian citrus industry (PHA 2015) and is responsible for significant yield losses and quality downgrades overseas. In response to this threat the project established a HLB taskforce. The HLB Task Force originally consisted of a subset of the National Citrus Surveillance Steering Committee. The function of the HLB Task Force was to review HLB related preparedness documents (including contingency plans, surveillance methods and so on), identify gaps, and provide suggestions for how gaps in the Australian citrus industry's preparedness for HLB could be addressed.

The HLB Task Force originally consisted of:

- Jeff Milne (National Citrus Surveillance Coordinator)
- Kate Sparks (Department of Agriculture, Water and the Environment – entomology background)
- Nathan Hancock (Citrus Australia representative)
- Nerida Donovan (NSW Department of Primary industries – citrus pathology background)
- Sharyn Taylor (Plant Health Australia representative)
- Tim Herrmann (Nursery industry representative)

In 2019, Citrus Australia established the Citrus Pest and Disease Prevention Committee (CPDPC). The CPDPC is an industry led committee with a focus on exotic and established pest and disease preparedness. As the CPDPC had significant overlap in its function with the HLB Taskforce and included all members of the HLB Task Force (with the exception of Kate Sparks) the merger of the two committees was investigated.

In May 2020, the CPDPC and the NCSSC agreed to merging the function of the HLB Task Force within the CPDPC, where it has become a standing item on CPDPC agendas. The first meeting under this new format was held on 7 September 2020. Three more meetings of the CPDPC (including standing items for the HLB Task Force) were held on 4 November 2020, 3 March 2021, and 10 June 2021. Main points of discussion focused on surveillance being conducted via this project and identification of chemical control of HLB's psyllid vectors.

Improved governance

Establishment of a National Citrus Surveillance Steering Committee

The National Citrus Surveillance Steering Committee (NCSSC) contributes to the project by providing Horticulture Innovation, industry and government contacts for the project and guidance and direction on project components.

The NCSSC consists of the following members:

- Sharyn Taylor (Plant Health Australia (Chair))
- Nathan Hancock (Citrus Australia)
- Ranjith Subasinghe (Department of Agriculture, Water and the Environment)
- Ryan Arnold (Citrus grower)
- Jeff Milne (National Citrus Surveillance Coordinator)
- Louise Rossiter (New South Wales Department of Primary Industries (NSW DPI) and Subcommittee for National Plant Health Surveillance (SNPHS))
- Nerida Donovan (NSW DPI citrus pathologist)
- Greg Chandler (Horticulture Innovation)
- Tim Herrmann (Auscitrus)

During this project four additional members (Kylie Calhoun (Department of Agriculture, Water and the Environment), Penny Measham (Horticulture Innovation), John Hederics (Belah Heights), and Steve Burdette (Costa Group) previously sat on the committee but left due to career changes.

During the project, the committee met 12 times:

- 16 of May 2018 (teleconference)
- 25 July 2018 (face to face meeting)
- 30 October 2018 (face to face meeting)
- 10 April 2019 (face to face meeting)
- 18 December 2019 (teleconference)
- 12 February 2020 (face to face meeting)

- 21 May 2020 (teleconference)
- 9 September 2020 (Microsoft Teams meeting)
- 11 November 2020 (Microsoft Teams meeting)
- 11 February 2021 (Microsoft Teams meeting)
- 3 March 2021 (Microsoft Teams meeting) – special meeting to present information on a Centre of Excellence for Biosecurity Risk Analysis (CEBRA) developed pathway model
- 23 June 2021 (Microsoft Teams meeting)

Outcomes

This project set out to deliver the following outcomes:

1. **Establishment and maintenance of the First Detector Network in the citrus industry to provide support for the early detection of High Priority Pests (HPPs).**

   As noted above the First Detector Network now consists of over 100 members and covers all major citrus producing regions in Australia. This network has been beneficial in establishing the Asian Citrus Psyllid Trapping Program and are a key stakeholder group for improving the industry's biosecurity capability.

2. **Increased awareness of HPPs of citrus within industry and in urban and peri-urban communities.**

   Over the course of this project various published documents and communication materials have been produced. Additionally, the National Citrus Surveillance Coordinator has been active in attending and presenting biosecurity and surveillance information at industry events as well as collaborating on activities focused on urban surveillance (such as participation in the Urban Plant Health Network in Melbourne).

   National Citrus Surveillance Coordinator has attended meetings and provided biosecurity information to growers in most citrus producing regions. These activities help improve the industry's awareness of biosecurity and pest threats.

3. **Regular collection of surveillance data to provide evidence of pest status (presence/absence) for HPPs of citrus from commercial production areas and urban and peri-urban communities.**

   During CT17001 surveillance data for exotic pests has been collected through the KCT program (which covers over 40% of Australian citrus orchards) and the establishment of an Asian Citrus Psyllid Trapping Program (which has deployed approximately 300 traps and collected budsticks for the surveillance of graft transmissible diseases in collaboration with CT17007). This data has been uploaded to AUSPest*Check*™ allowing it to be visualised and analysed as required to support Australia's pest status claims and provide a national assessment of surveillance coverage and/or gaps in surveillance efforts.

4. **Improved preparedness for pest incursions through the identification of suitable pesticide control options and the development of packages of information to support future APVMA permit applications for eradication or control of HPPs and/or their vectors in the event of a future pest incursion.**

   This project conducted a review of overseas literature and pesticide labels to determine suitable chemical control options for citrus HPPs. The review considered the efficacy of pesticides as well as existing use patterns when recommending pesticides that could be used in the event of exotic pest outbreaks. This review provides information to support future APVMA permit applications for eradication or control of exotic pests and/or their vectors in the event of future pest incursions.

Monitoring and evaluation

Six Key Evaluation Questions (KEQs) were noted in the Monitoring and Evaluation Plan for CT17001 (Table 1). Project performance regarding these KEQs is discussed below.

Table 1 Key Evaluation Questions from CT17001 Monitoring and Evaluation Plan

Key Evaluation Questions (KEQ)	**Project-specific questions**
Effectiveness	
1. To what extent has the project achieved its expected outcomes?	To what extent has the project increased the adoption of biosecurity best practice and preparedness for exotic pests and diseases within the citrus industry?
Relevance	
2. How relevant was the project to the needs of intended beneficiaries?	To what extent has the project met the needs of industry levy payers?
Process effectiveness	
3. How well have intended beneficiaries been engaged in the project?	Have regular project updates been provided to the industry so the citrus industry is aware of the project and its importance to the industry?
4. To what extent were engagement processes appropriate to the target audience/s of the project?	How effective was the project's engagement with industry levy payers and the broader production and supply chain in the citrus industry? Was information presented in the preferred learning style(s) of the growers, crop scouts, researchers and community?
Efficiency	
5. What efforts did the project make to improve efficiency?	What efforts did the project make to improve efficiency?
Other	
6. Has the project established a framework for the citrus industry to continue to have an active biosecurity program beyond the completion of this project?	Has the project established a framework for the citrus industry to continue to have an active biosecurity program beyond the completion of this project?

Project Effectiveness

As noted in the regular milestone/progress reports and in this final report this project has been effective at increasing the adoption of biosecurity best practice activities and increasing the preparedness of the citrus industry for managing exotic pests and disease threats. This has been largely achieved through the work of the National Citrus Surveillance Coordinator in attending industry events, presenting information, and engaging/encouraging the industry to become involved in surveillance activities (including through the KCT program and the Asian Citrus Psyllid Surveillance Program). Measurement of project effectiveness in improving surveillance outcomes is evidenced through the establishment of two citrus surveillance programs in AUSPest*Check*™ and the regular collation of data. Surveillance data collation has improved in both quantity and regularity of collation, from a base of only approximately 40 data points at the commencement of the project to over 142,000 data points in June 2021 from the KCT program and 446 data points from the ACP trapping program.

The project has also worked to improve surveillance and pest awareness in urban areas. It has also improved the awareness and surveillance capability of the industry through the development of awareness and instructional material as well as through a review of pesticide control options for exotic High Priority Pests of citrus.

Project Relevance

The industry is aware of its biosecurity risks and biosecurity is a significant topic of discussion and interest at industry events, highlighting the importance of biosecurity to growers and levy payers. This project has successfully improved the industry's biosecurity preparedness, improved the industry's exotic pest surveillance system, meeting the needs of levy payers. This relevance is highlighted by the attendance of over 75 growers at an industry event in Gayndah in February 2021.

Project effectiveness

The Australian citrus industry has received regular updates about the project through media and the National Citrus Surveillance Coordinator's attendance and presentation at industry events. These contact points with industry have also allowed the project to engage with industry (growers and the wider supply chain) to raise the profile of biosecurity and surveillance activities.

When information was presented to industry effort was made to accommodate a range of learning styles through the development of written publications and the presentation of information at face-to-face workshops/meetings. This combination of communication approaches ensures the projects messages can be shared with the industry in an effective manner.

Project Efficiency

This project has sought ways to improve the Australian citrus industry's ability to conduct surveillance and to improve the industry's biosecurity awareness and preparedness. To achieve the project's required outcomes, efficiencies have been sought wherever possible. This has involved the collaboration with related projects to leverage benefit to growers. For example, this project added exotic pest targets to the existing KCT export program in 2019 resulting in the collection of surveillance data relating to exotic pests from >40% of Australia's citrus orchards for minimal additional effort as the program already targeted several established pests and had training systems in place. Similarly, this project has collaborated with CT17007 for the surveillance of graft transmissible pathogens in budstick samples and with the delivery of a Citrus Triage Workshop funded by DAWE, held in 2019.

Foundations for Future Projects

CT17001 has created solid foundations for future surveillance activities and biosecurity programs. This has included developing networks, and road-testing surveillance methods to determine the best way to undertake surveillance and the determination of diagnostic support needed to develop an expanded version of the existing surveillance activities. Similarly, this project created collaboration opportunities with other projects (e.g., collaboration with CT17007 and with NAQS to test surveillance methods in northern Australia) and those relationships will continue beyond the conclusion of the current project and into the future.

Recommendations

The delivery of CT17001 has resulted in the identification of the following recommendations:

1. Maintenance of a National Citrus Biosecurity Program.
    - Effort will be required to maintain and build on the strong base provided by CT17001 in establishing a surveillance program through KCT and the Asian Citrus Psyllid Trapping Program. Expansion of this program will require dedicated support for deployment of surveillance traps as well as diagnostic support to ensure timely processing of samples that supports the industry's need for early detection of High Priority Pests. A key finding from CT17001 was the need to maintain a Coordinator for the program to ensure resources are available to undertake surveillance and capacity building, and provide a focal point for industry biosecurity activities.
2. The need for greater focus on urban areas and areas in northern Australia.
    - The current program has achieved good coverage of commercial citrus orchards through the KCT and some coverage of urban areas through the Asian Citrus Psyllid Trapping Program. However, coverage of urban areas and areas in northern Australia require improvement. It is known from overseas experiences that many citrus pests are more likely to enter via urban areas (e.g., citrus canker, Asian citrus psyllid and huanglongbing all entered the United States through urban pathways before spreading to commercial orchards). Similarly, natural or assisted dispersal into northern Australia may be possible as several significant citrus pests occur in neighbouring countries (such as Indonesia, Timor-Leste, and Papua New Guinea), and weather systems may allow natural spread under certain conditions to Australia. Therefore, it is recommended that any future surveillance program targeting citrus pests includes coverage of urban areas as well as areas in northern Australia to address these risks.
3. The requirement to undertake a pathway risk modelling to better target surveillance activities.
    - As surveillance and diagnostics are resource intensive activities it is important that surveillance is carried out as efficiently and effectively as possible. Although it is assumed that Northern Australia and urban areas pose a significant risk it is unknown which areas pose the greatest risk. It is therefore recommended that pathway risk modelling is undertaken to determine where to focus surveillance resources.
4. Less reliance on volunteers where activities are time critical (e.g., deployment, retrieval, submission, and assessment of sticky insect traps).
    - Experience gained through this project highlighted that although volunteers (including growers and crop consultants) can be used for the deployment and retrieval of sticky traps, there is a risk that other activities in volunteer's lives take priority. This means traps may not be deployed or retrieved at the preferred times. This makes surveillance less effective (e.g., if ideal plant growth stages are missed) and diagnostic loads more challenging to manage if traps are deployed for lengthy periods of time. Because of this the project investigated the use of paid crop scouts for the deployment and retrieval of traps and believes this arrangement would be a better option for future citrus surveillance programs to consider. Similarly, reliance on in-kind contributions from government agencies to undertake diagnostics associated with assessment of psyllid traps provided variable results.
5. Maintain oversight of changes to exotic pest management options used overseas.
    - Many of the exotic high priority pests of citrus are still relatively new pests overseas and control options are evolving all the time. It would be beneficial for the Australian citrus industry to maintain oversight of changing management practices overseas so best practice can be adopted in Australia in the event of an exotic pest outbreak.
6. Maintain emphasis on building capacity and capability for surveillance and diagnostics to support biosecurity in the citrus industry.
    - While CT17001 was successful in building the network of individuals undertaking surveillance, and developed awareness and training material to increase capacity and capability, continued

work is required in this area. This should include expanding the types of training material for crop scouts as well as members of urban and peri-urban communities, and ensuring that the material developed is targeted at each type of stakeholder. Training materials are also needed for diagnostic laboratories undertaking assessment of psyllid traps as well as building specialist capacity in identifying the range of native psyllids that could impact citrus production or act as potential vectors for HLB.

7. Improved preparedness for high priority pests.

    - Review of the Citrus Industry Biosecurity Plan is required to ensure that the exotic pest list and Biosecurity Implementation Table are assessed and revised. This review will ensure the citrus industry's HPP list is current as this will form the basis used to prioritise preparedness activities. A key preparedness activity identified as part of the Citrus Canker Eradication Program, was the preparation of current and complete host lists for HPPs, as these underpin assessment and implementation of domestic movement controls in the event of a pest detection.

Refereed scientific publications

No refereed scientific papers were prepared as part of this project.

References

Hort Innovation (2020) Australian horticulture statistics handbook 2019/20. Available from: https://www.horticulture.com.au/australian-horticulture-statistics-handbook/

Plant Health Australia (2015) Biosecurity Plan for the Citrus Industry (version 3). Plant Health Australia. Canberra, Australia.

Intellectual property, commercialisation, and confidentiality

No commercialisation or confidentiality issues to report.

Appendices

Appendix 1: Additional details of KCT survey locations

Data collected by KCT registered crop monitors are sent to Citrus Australia. Plant Health Australia has worked with Citrus Australia to develop a method for uploading KCT data to AUSPest*Check*™*,* the national data aggregation system. Data has now been imported into AUSPest*Check*™ for 2020 (Figure 3 to Figure 7) Within the screenshots of outputs from AUSPest*Check*™ each circle represents the numbers of data points for the activities conducted for each targeted pest. Within the AUSPestCheck™ system itself, greater resolution can be seen than is represented in these screenshots, and additional reports can also be generated from the data.

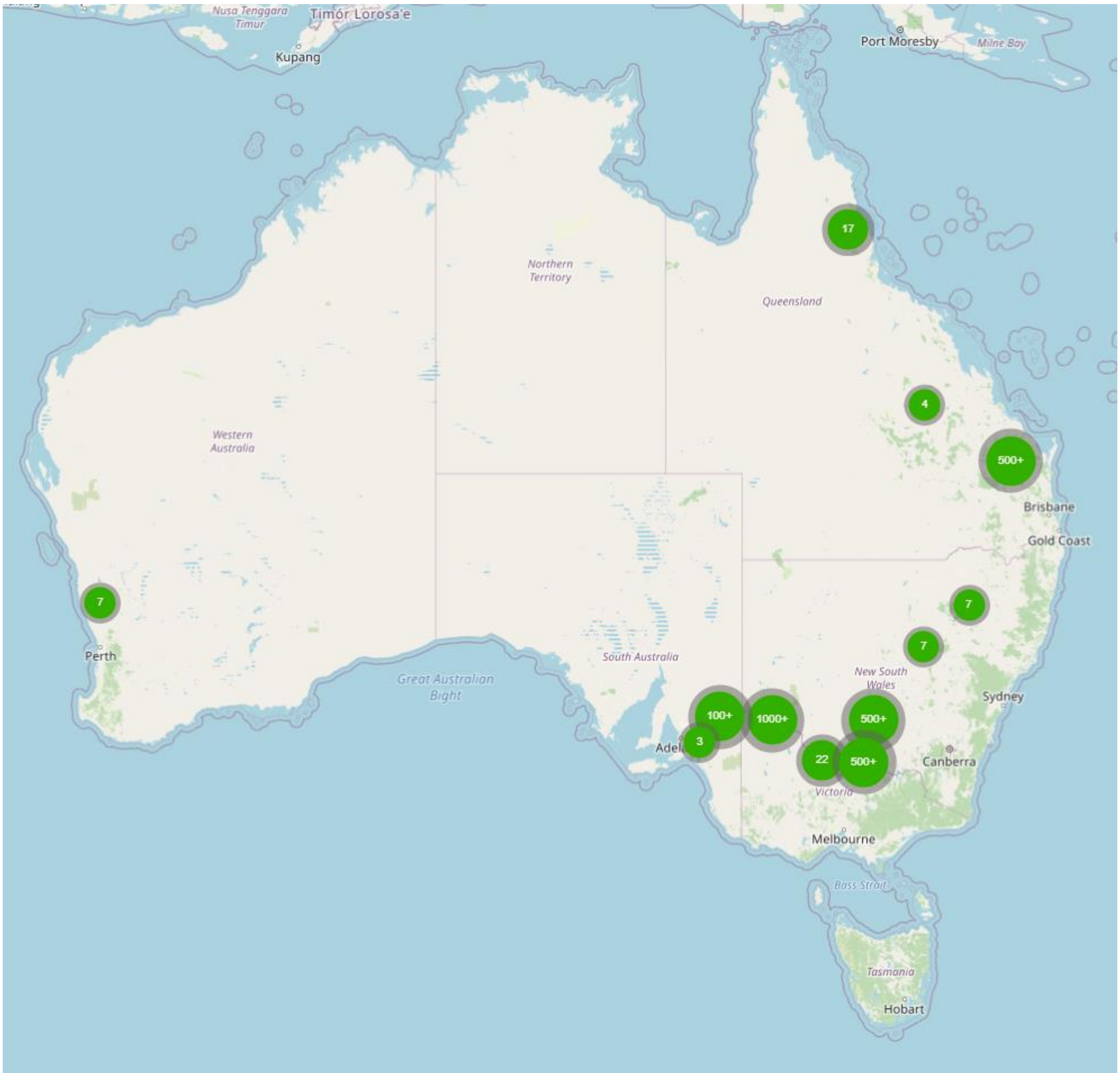


Figure 3 Map of orchards participating in the KCT Program

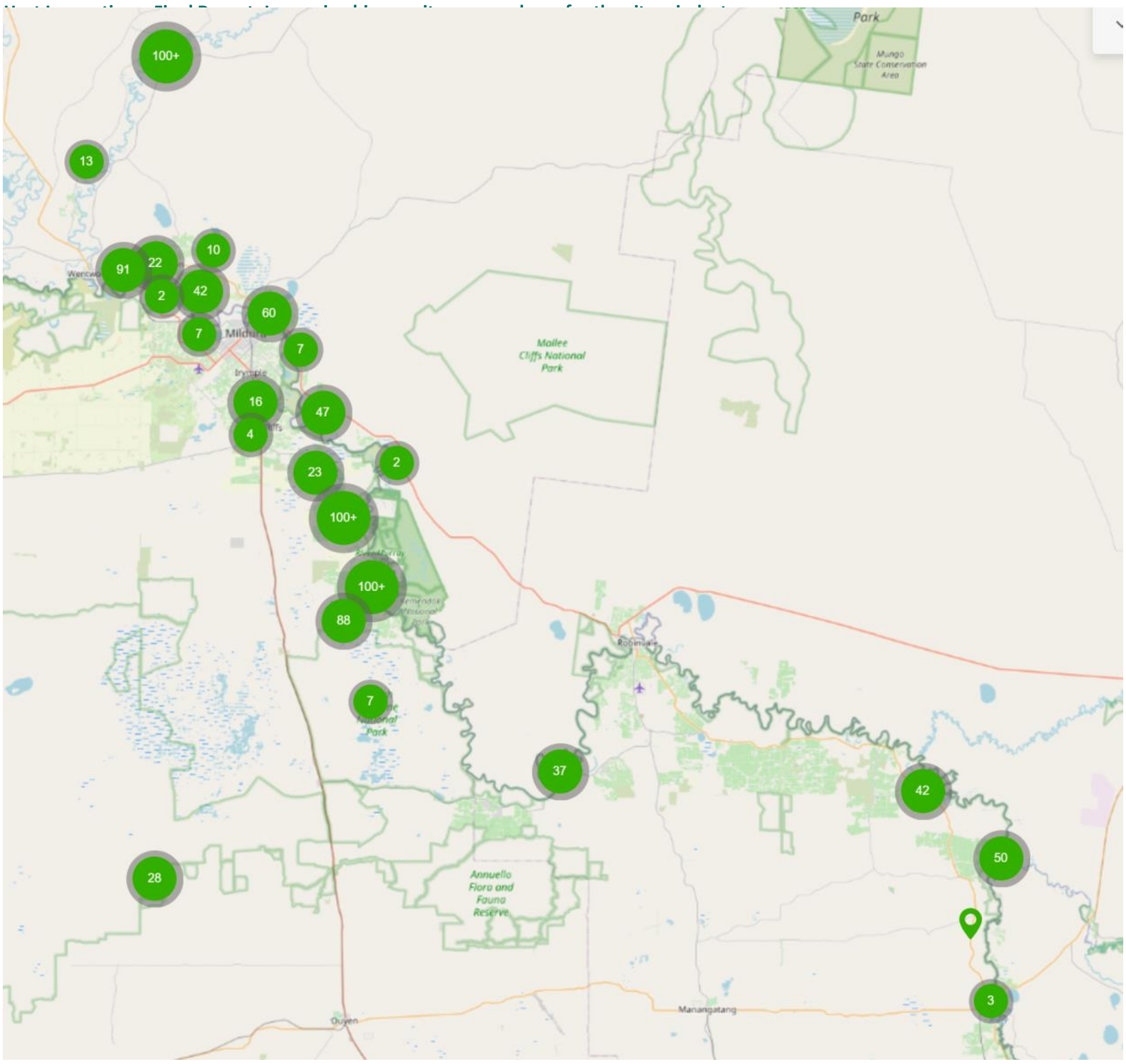


Figure 4 Map of orchards in the Sunraysia participating in the KCT Program

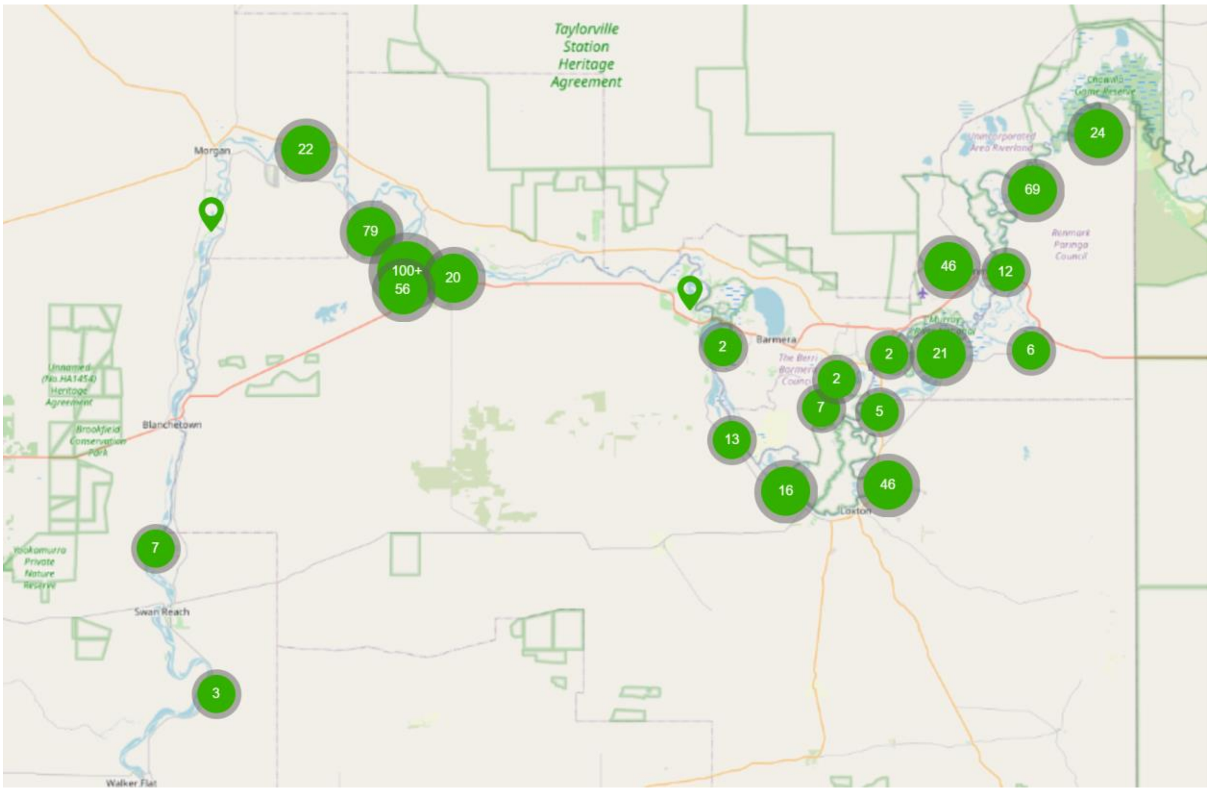


Figure 5 Map of orchards in the Riverland participating in the KCT Program

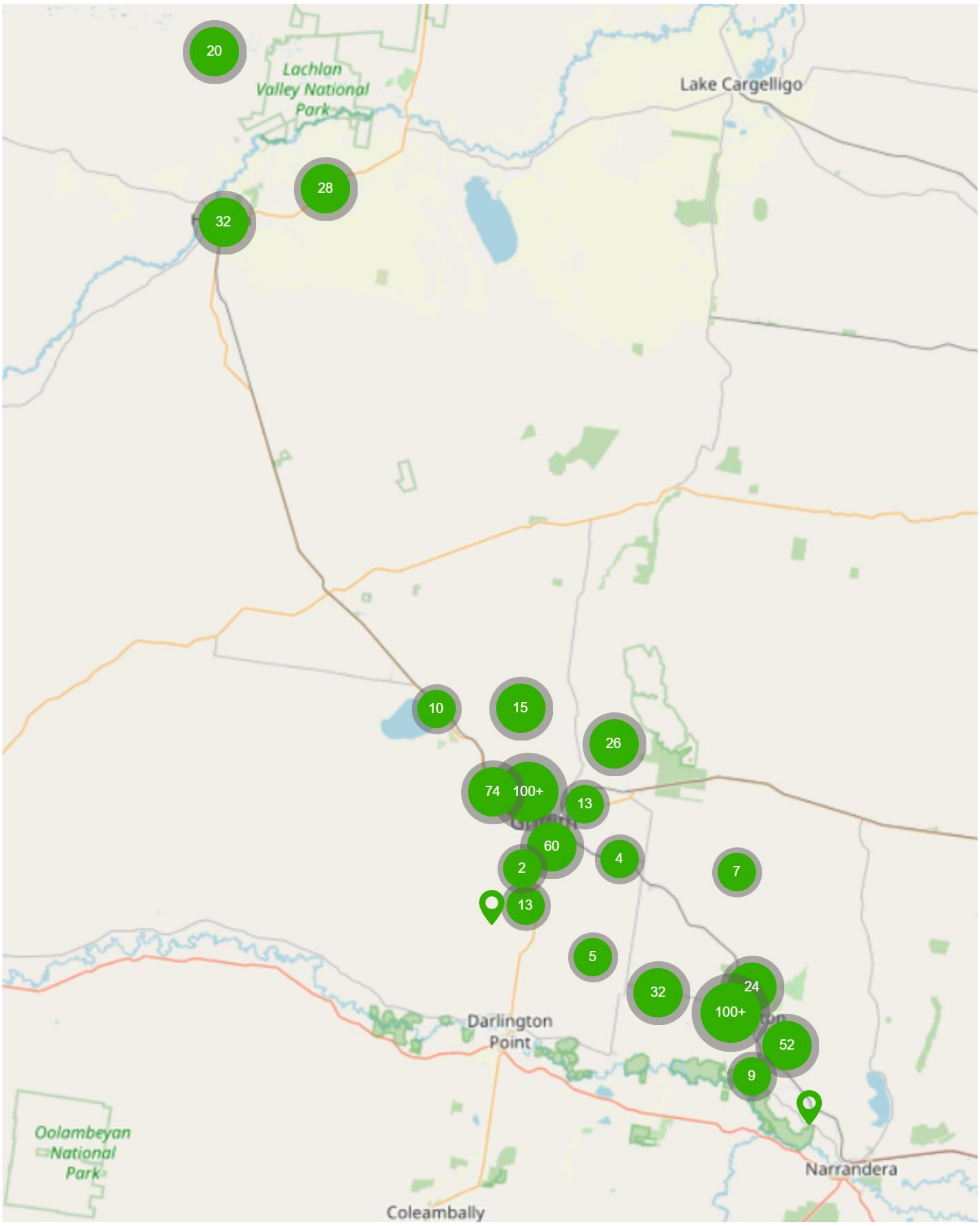


Figure 6 Map of orchards in the Riverina participating in the KCT Program

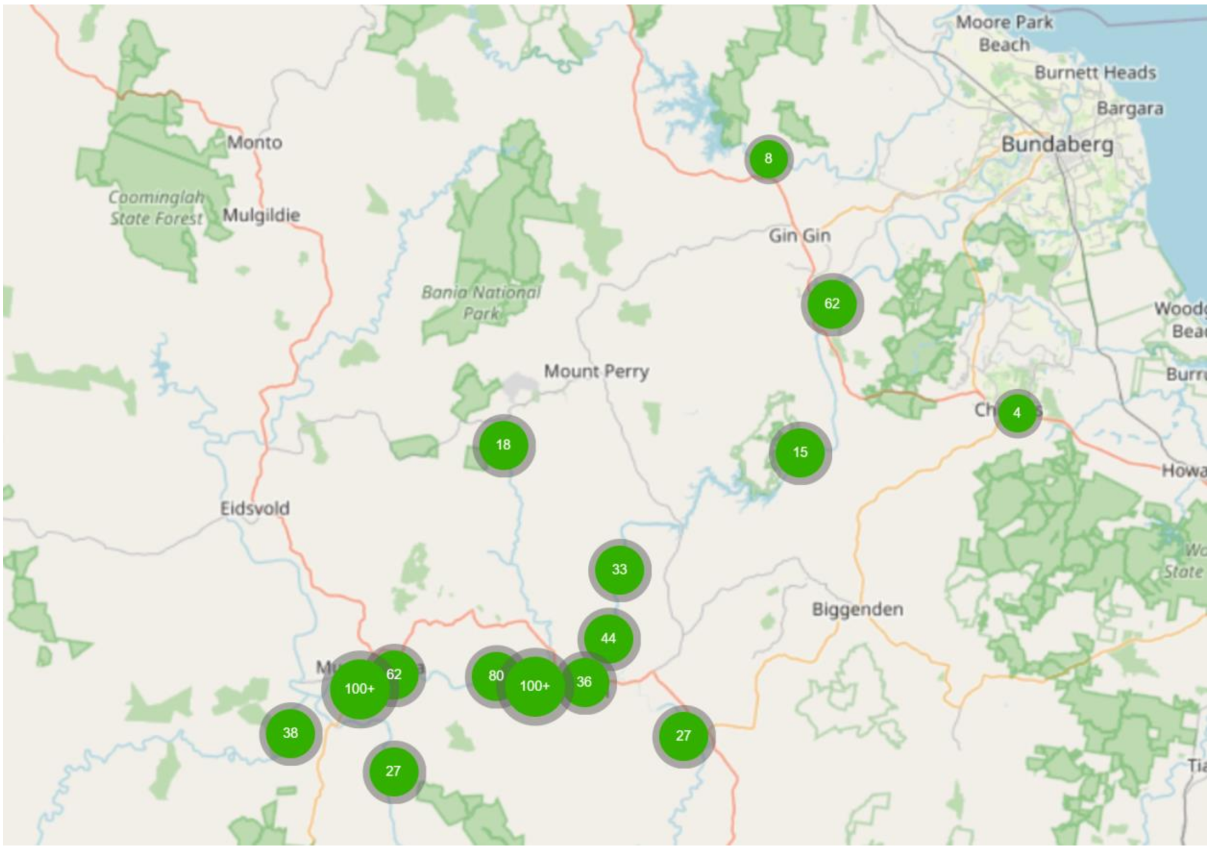


Figure 7 Map of orchards in the Burnett region participating in the KCT Program

Appendix 2: Additional details of Asian Citrus Psyllid Trapping Program survey locations

In total this project has generated 446 datapoints including 285 traps deployed since 2020 via this program and 161 datapoints provided by Andrew Miles from 2PH and provided by the Northern Territory Department of Industry, Tourism and Trade (Attachment 8)

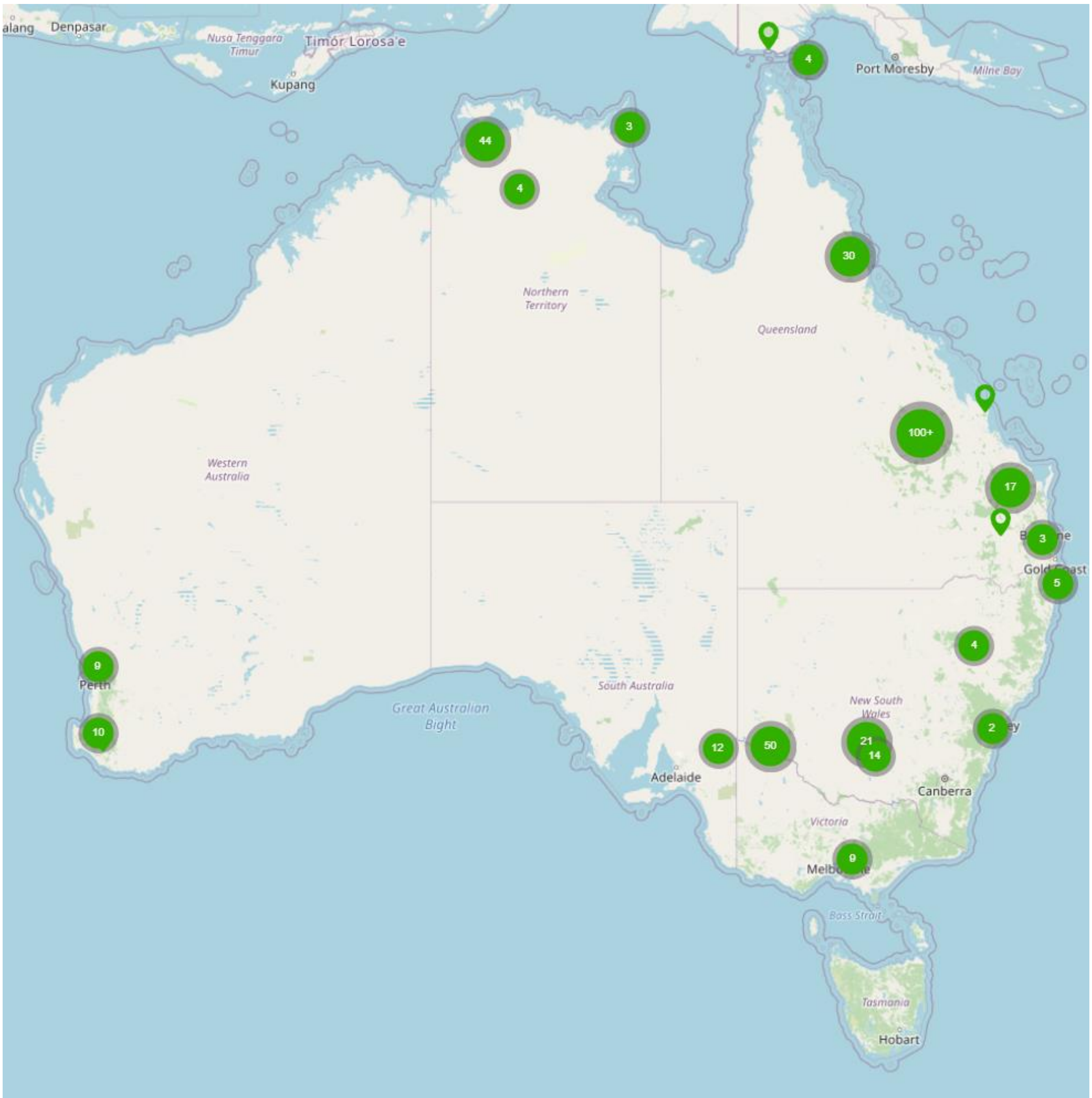


Figure 8 Asian citrus psyllid surveillance conducted through this project

These sites include locations in urban/peri-urban and northern Australia including:

- Torres Strait, Queensland
- Cairns, Queensland
- Melbourne, Victoria
- Bunbury, Western Australia
- Perth, Western Australia
- Atherton Tablelands, Queensland
- Darwin, Katherine and surrounds, Northern Territory

Commercial citrus growing locations including:

- Gayndah (Burnette River), Queensland
- Riverina, New South Wales
- Sunraysia, New South Wales/Victoria
- Riverland, South Australia
- Emerald, Queensland
- Gosford, New South Wales
- Gunnedah, New South Wales
- Southwestern Western Australia

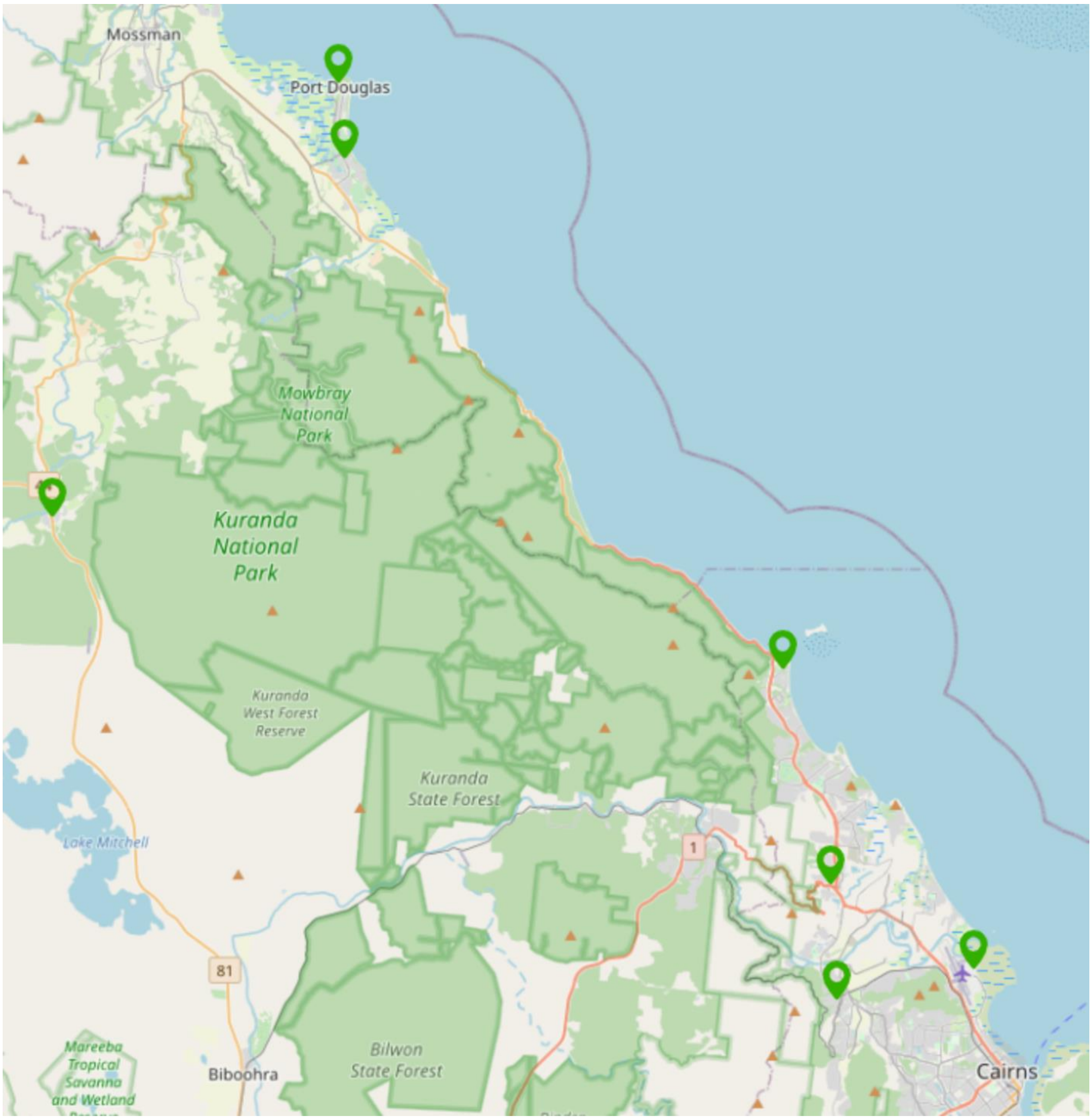


Figure 9 Trapping locations near Cairns, Queensland

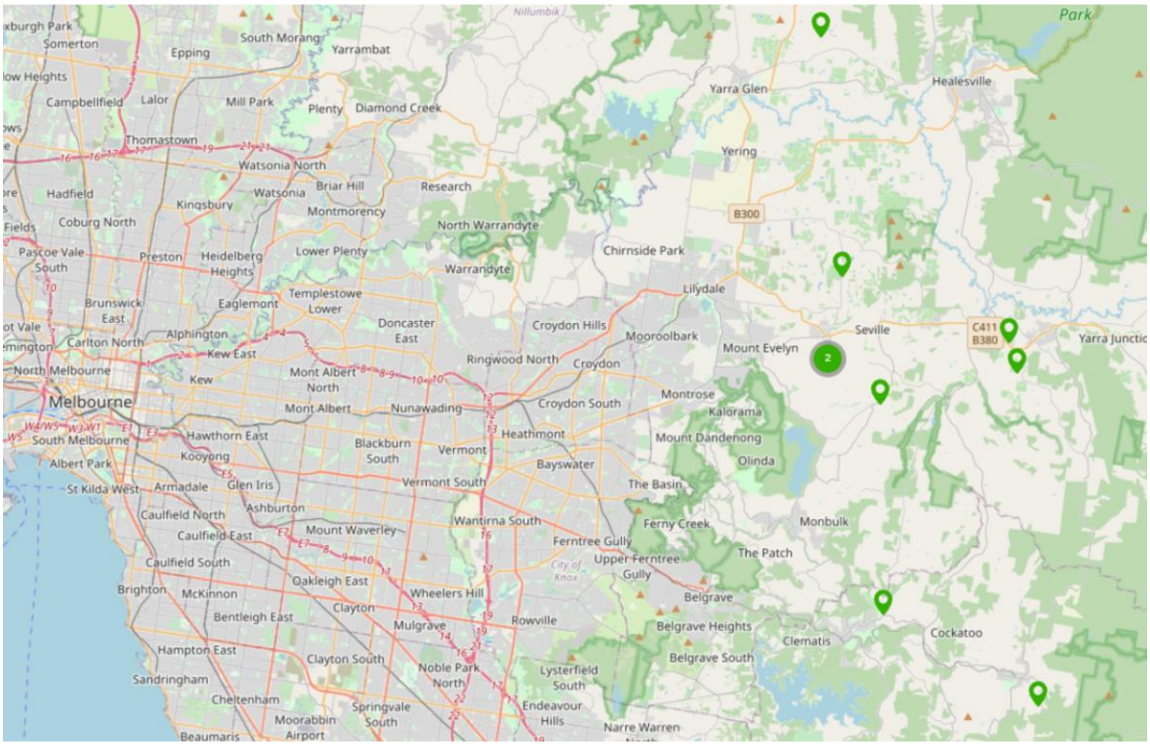


Figure 10 Trapping locations near Melbourne, Victoria

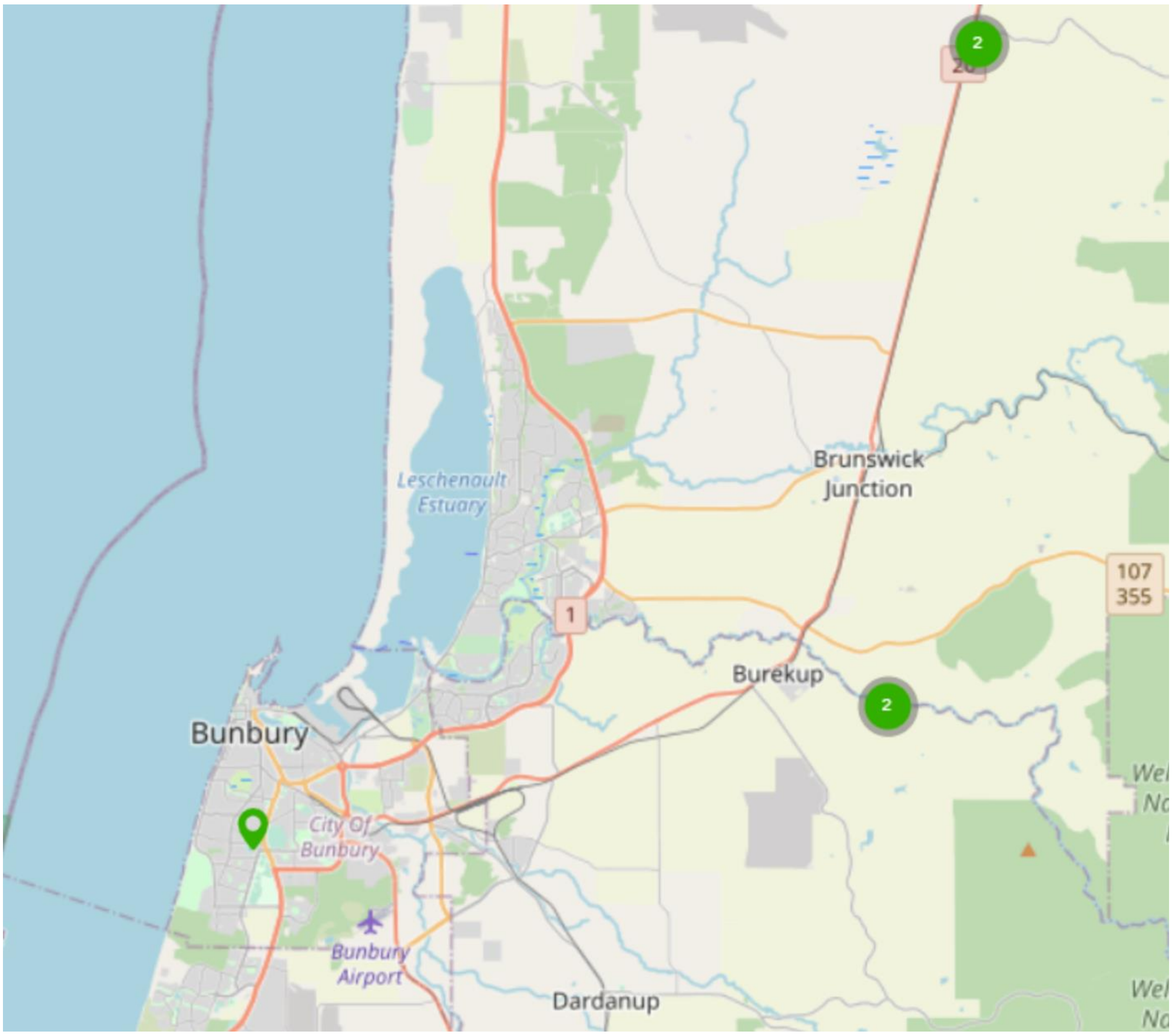


Figure 11 Trapping locations near Bunbury, Western Australia

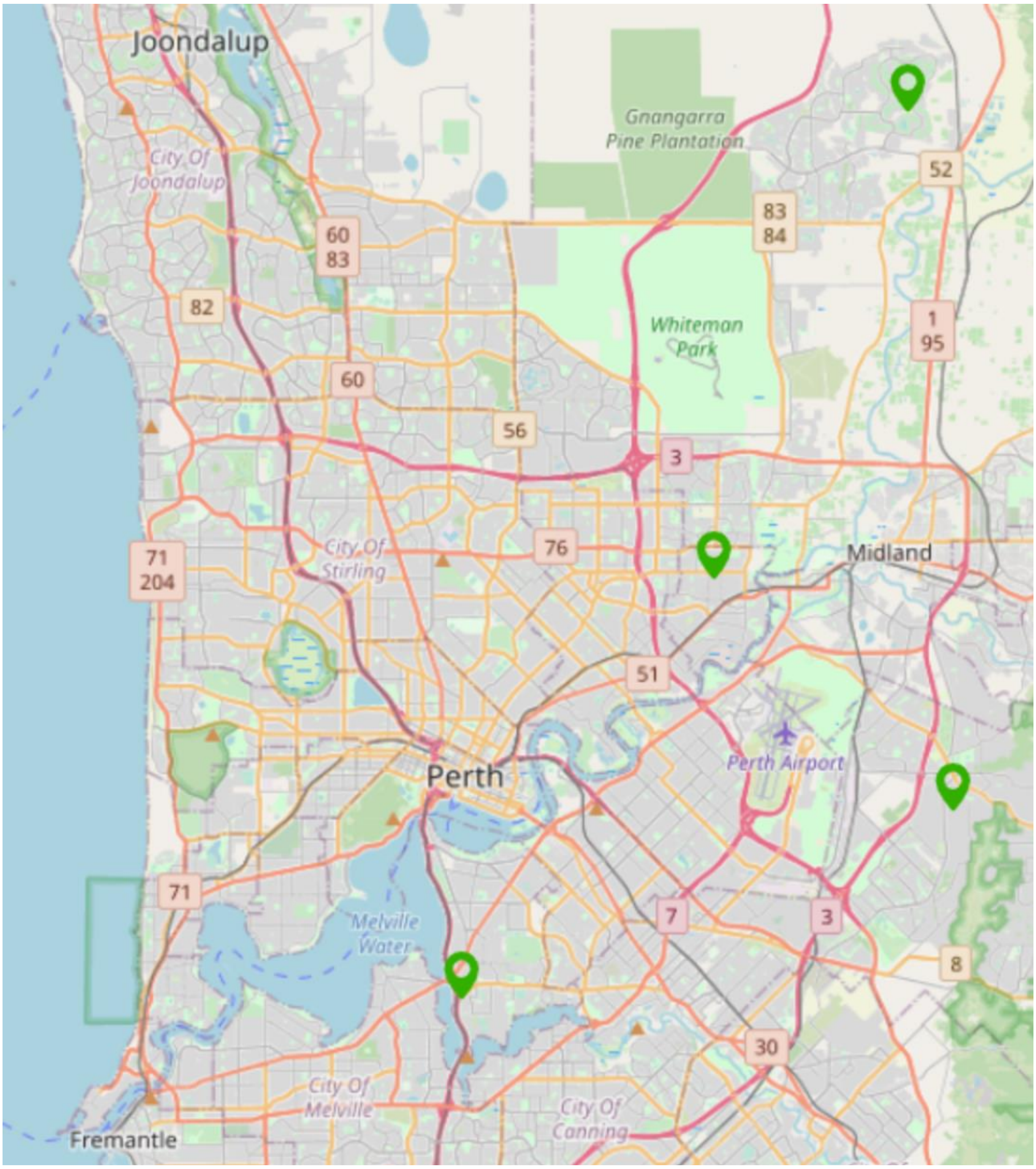


Figure 12 Trapping locations near Perth, Western Australia

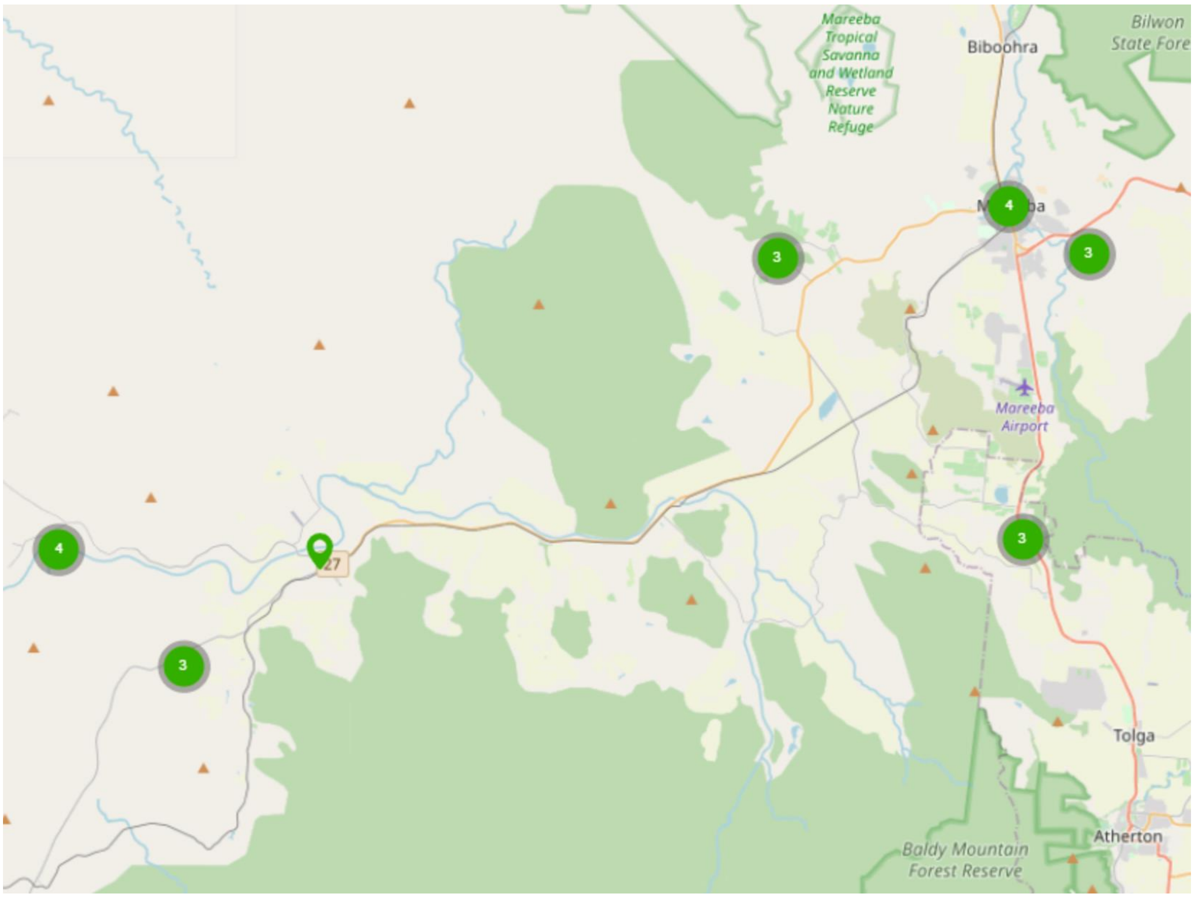


Figure 13 Trapping locations near Atherton Tablelands, Queensland

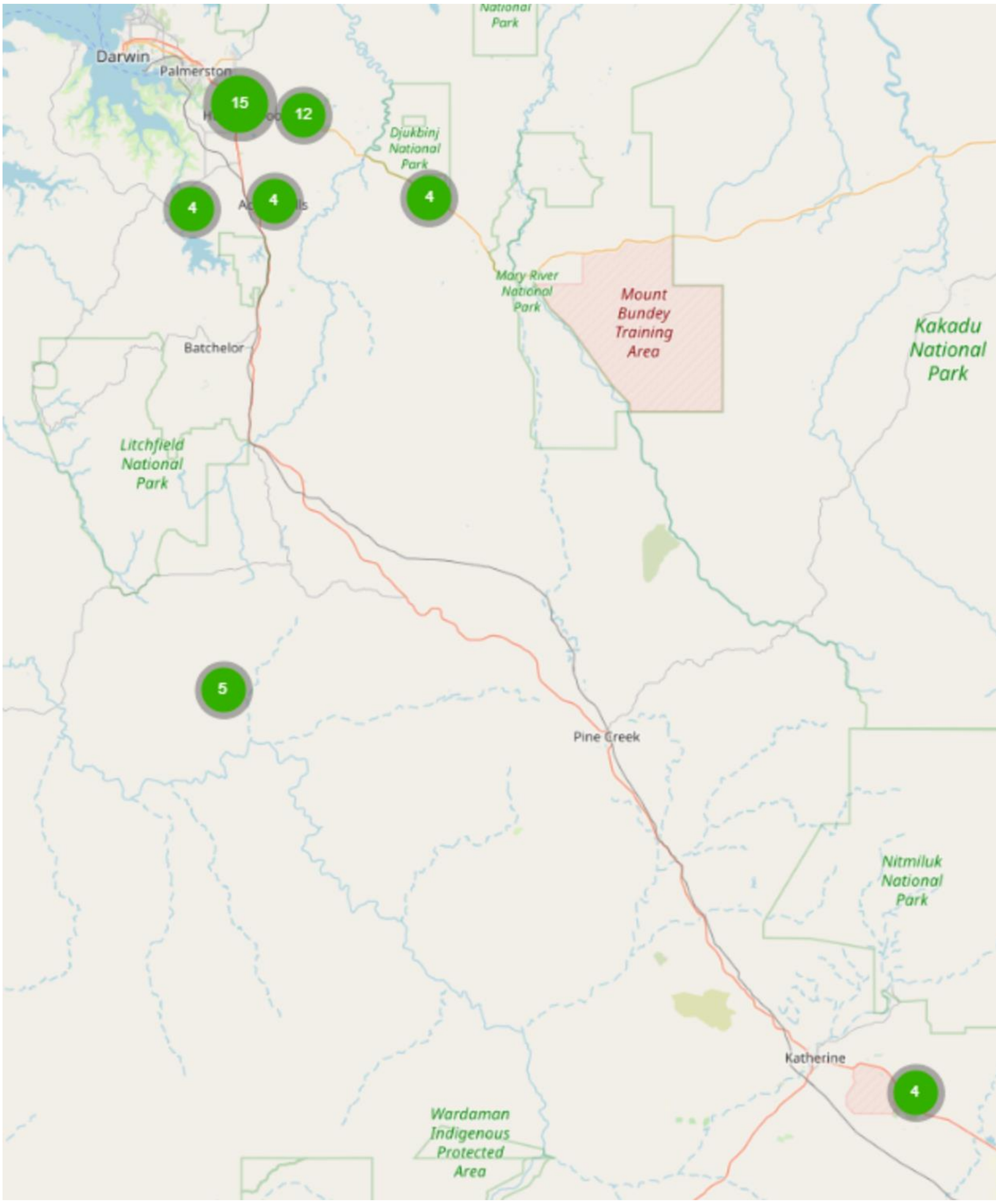


Figure 14 Trapping locations near Darwin, Katherine and surrounds, Northern Territory

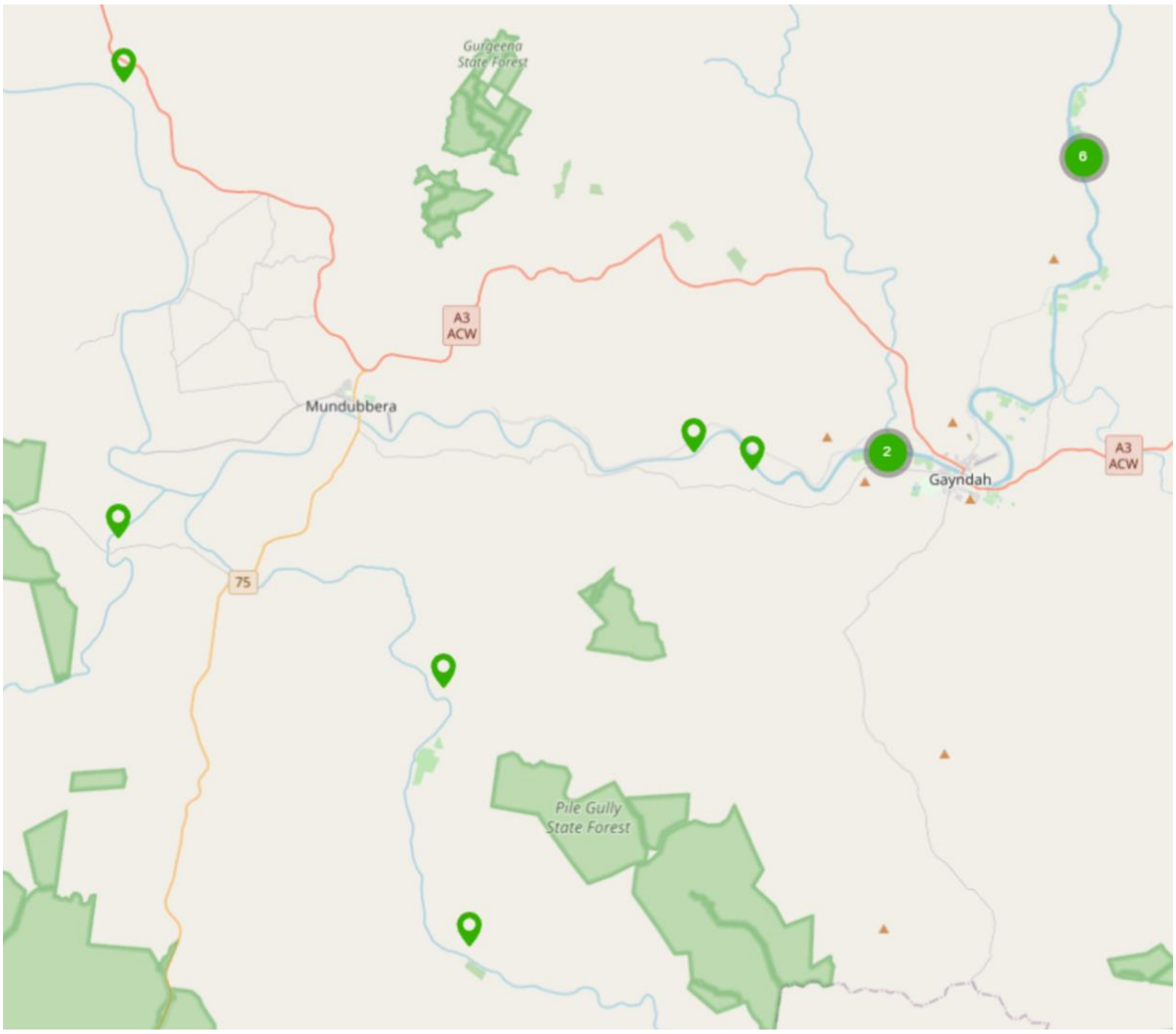


Figure 15 Trapping locations near Gayndah (Burnette River), Queensland

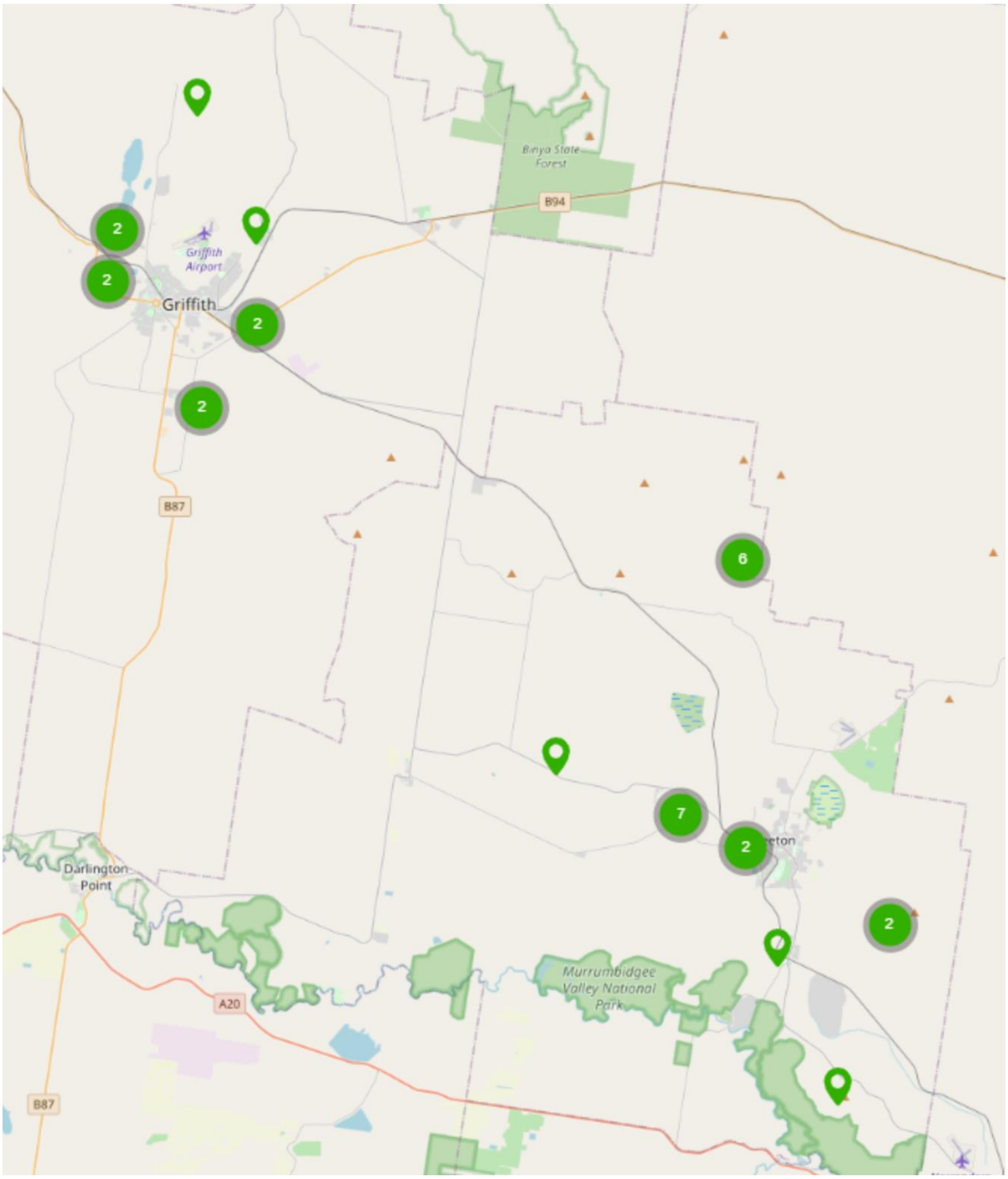


Figure 16 Trapping locations near Riverina, New South Wales

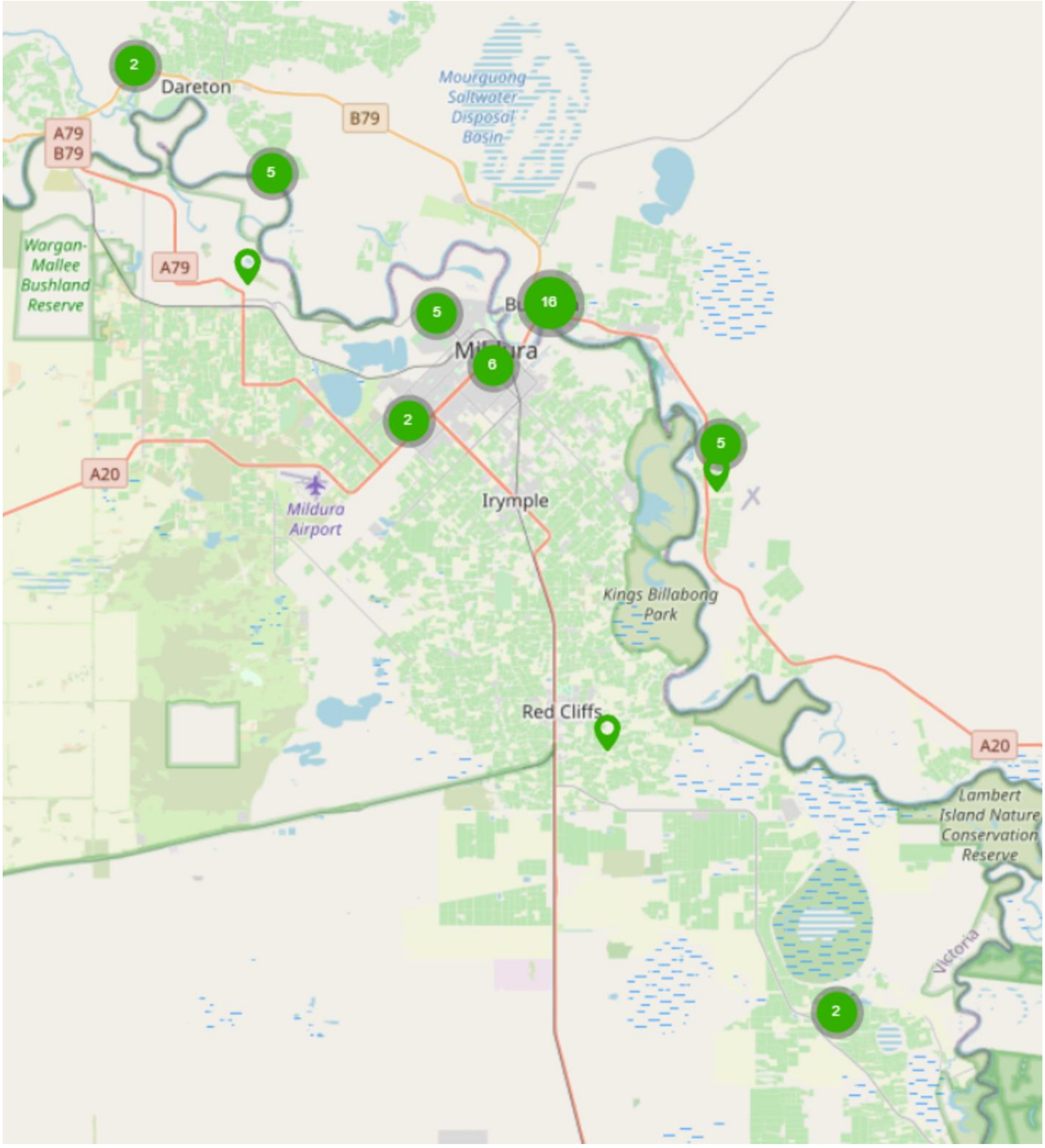


Figure 17 Trapping locations near Sunraysia, New South Wales/Victoria

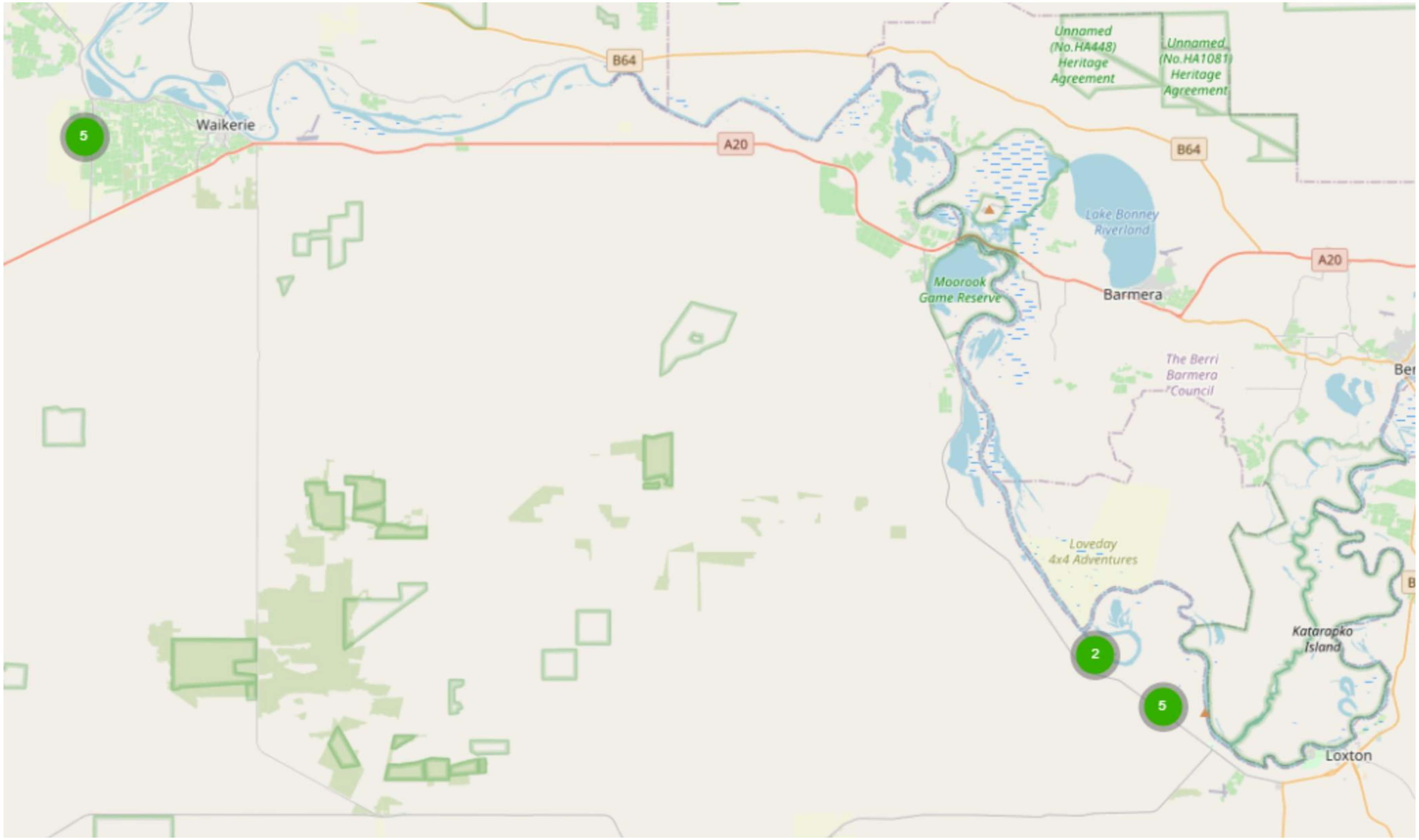


Figure 18 Trapping locations near Riverland, South Australia

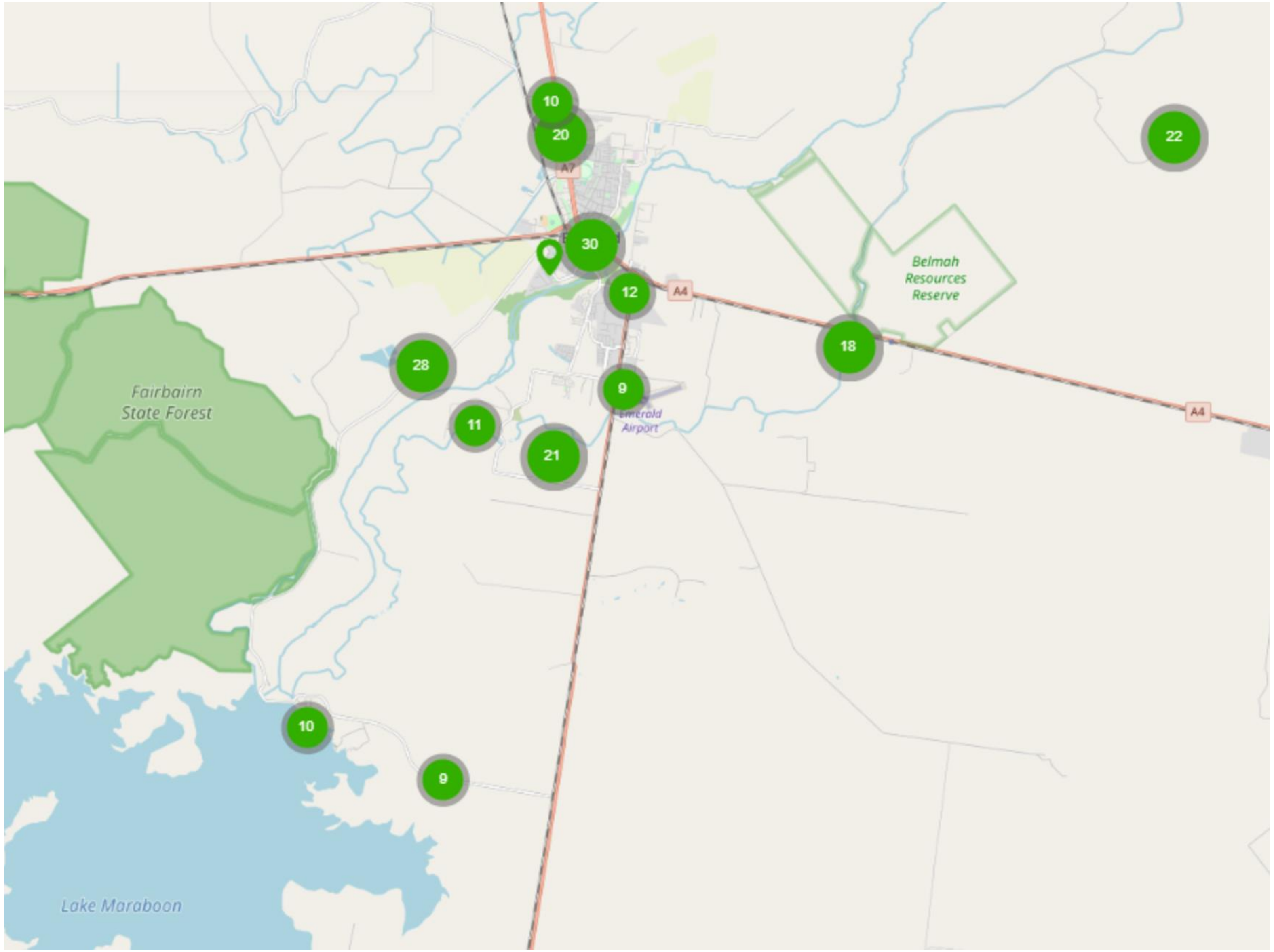


Figure 19 Trapping locations near Emerald, Queensland

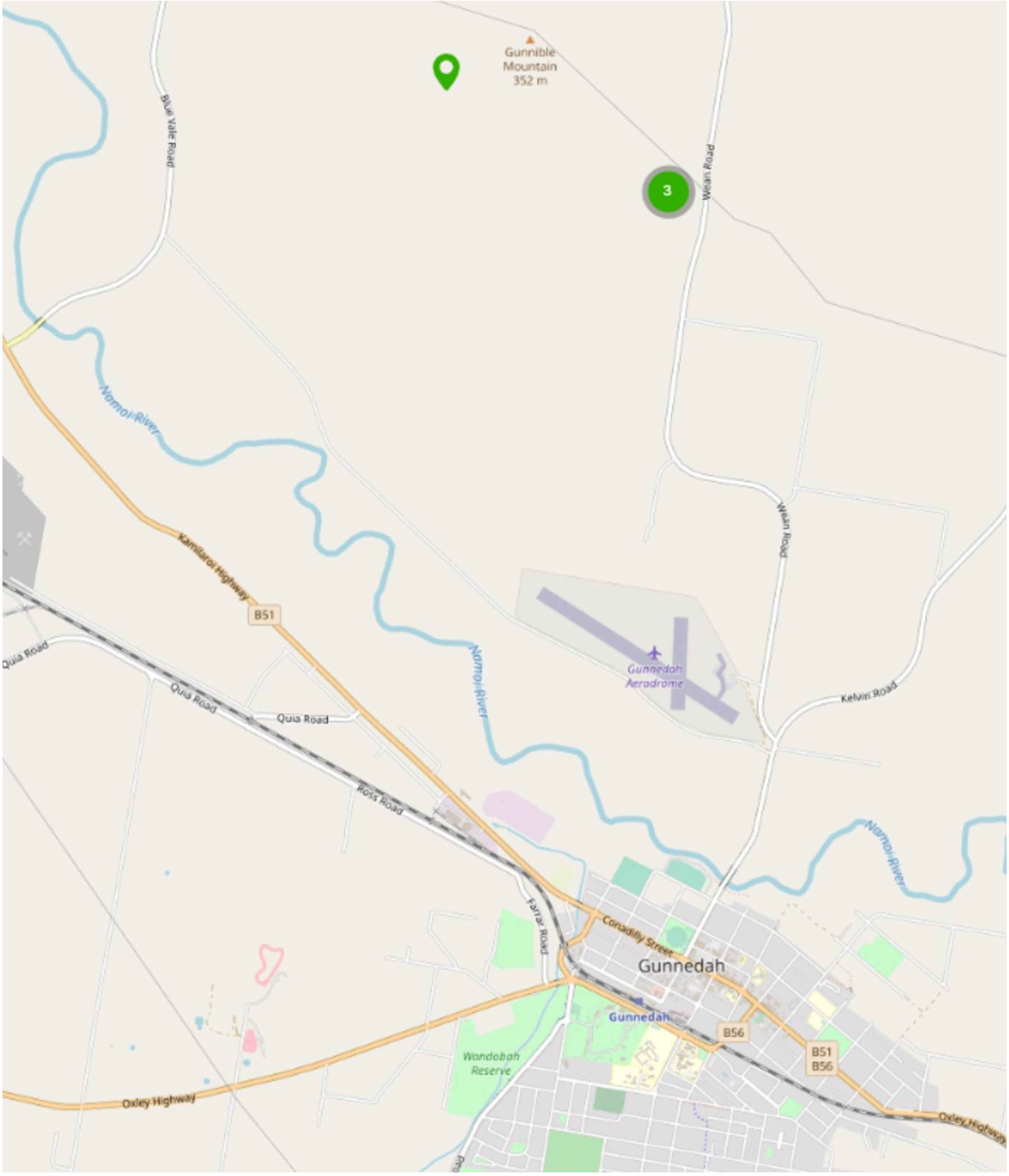


Figure 20 Trapping locations near Gunnedah, New South Wales

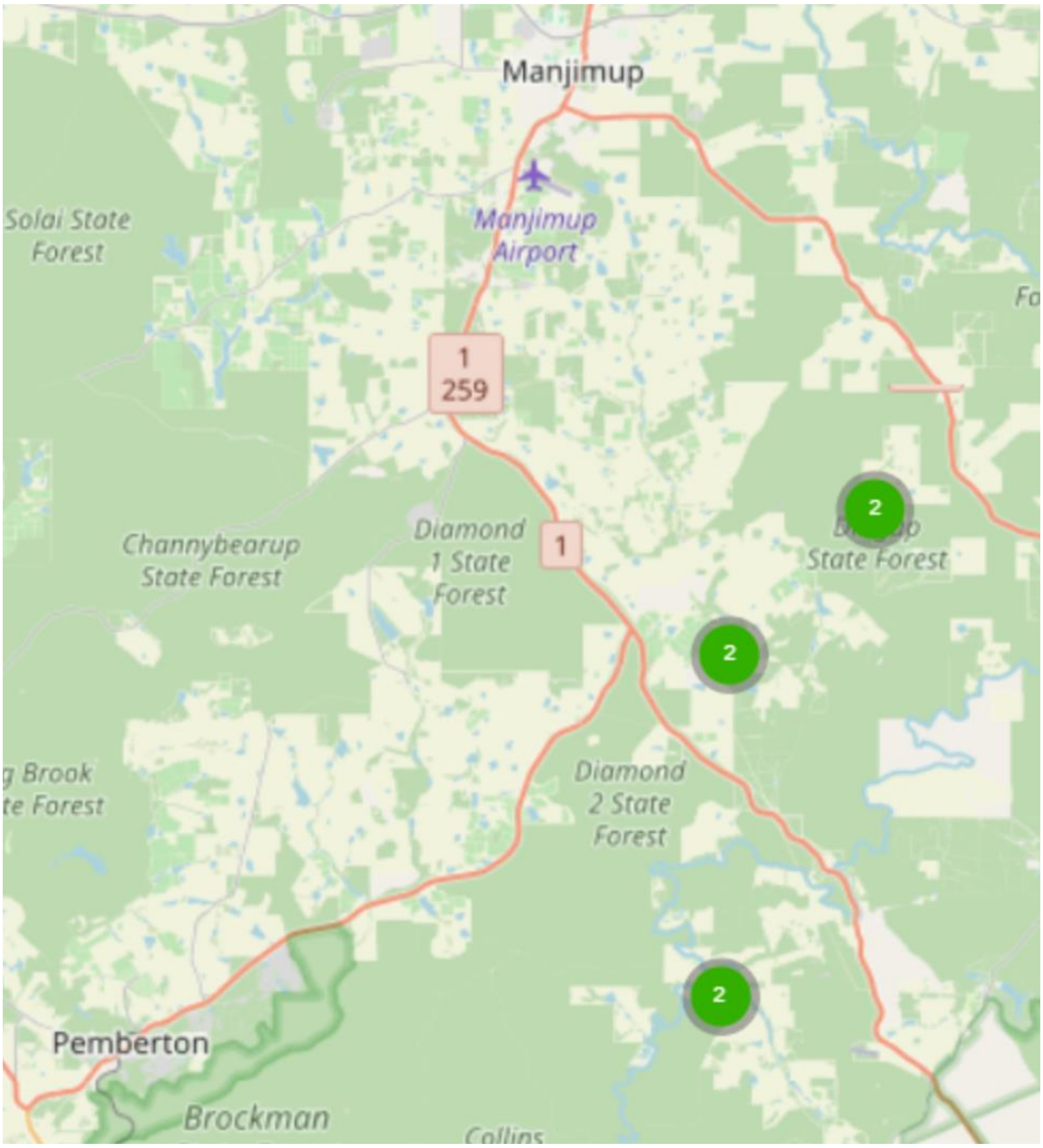


Figure 21 Trapping locations near Southwestern Western Australia

Appendix 3: Selected media created during CT17001

August 2018

Media article: 'National Citrus Surveillance Coordinator appointed'

www.citrusaustralia.com.au/news/latest-news/national-citrus-surveillance-coordinator-appointed

October 2019

'Do you have citrus gall wasp in your garden?' Jo Chong Wah and Jeff Milne

https://extensionaus.com.au/urbanplanthealthnetwork/do-you-have-citrus-gall-wasp-in-your-garden/

December 2019

'Look out for this citrus pest at your place as part of the bigger picture' Jeff Milne

https://extensionaus.com.au/urbanplanthealthnetwork/look-out-for-this-citrus-pest-at-your-place/

Selected Facebook posts

Citrus Australia
Published by Stephen Cooke [?] · 11 October at 13:57 ·

Hello gardeners! Do the branches on your citrus tree look like this? That's Citrus Gall Wasp, and unfortunately it will affect your tree's health and the fruit it produces. Click here to see how you can protect your tree (and future fruit supply).
Save our Citrus Melbourne Urban Plant Health Network Agriculture Victoria

EXTENSIONAUS.COM.AU
Do you have citrus gall wasp in your garden? - Urban Plant Health Network

205 People reached | 71 Engagements | Boost Post

12 | 10 shares

Citrus Australia
Published by Stephen Cooke [?] · 13 February ·

Queensland citrus growers developing their farm biosecurity plans at a Mundubbera workshop held by the Citrus Australia Queensland Regional Advisory Committee. National Citrus Surveillance Coordinator, Jeff Milne, is pictured outlining potential risks Hort Innovation

142 People reached | 42 Engagements | Boost Post

13 | 1 comment

Like | Comment | Share

Citrus Australia
Published by Stephen Cooke [?] · 16 October 2018 ·

Citrus Australia CEO Nathan Hancock and National Citrus Surveillance Coordinator Jeff Milne receive latest intel from Citrus Canker Incident Controller Greg Pickles in the canker incident response coordination centre at WA Dept Industries & Regional Development

38 People reached	0 Engagements	Boost Post

Selected Twitter posts

Citrus_Australia @CitrusAustralia · Feb 13

Qld citrus growers develop their farm biosecurity plans at a Mundubbera workshop held by Citrus Australia Queensland Regional Advisory Committee. National Citrus Surveillance Coordinator, Jeff Milne, pictured outlining potential risks @Hort_Au @planthealthaust @DeptAgNews

4 7

Pinned Tweet

Citrus_Australia @CitrusAustralia · Jun 24

Biosecurity needn't be expensive. For less then $200 you can set up to protect your orchard or protect your customers if
your role involves orchard visits. Visit our website here (citrusaustralia.com.au/wp-content/upl...) to see how to construct your kit #ausag

10 13

Citrus_Australia @CitrusAustralia · Oct 4

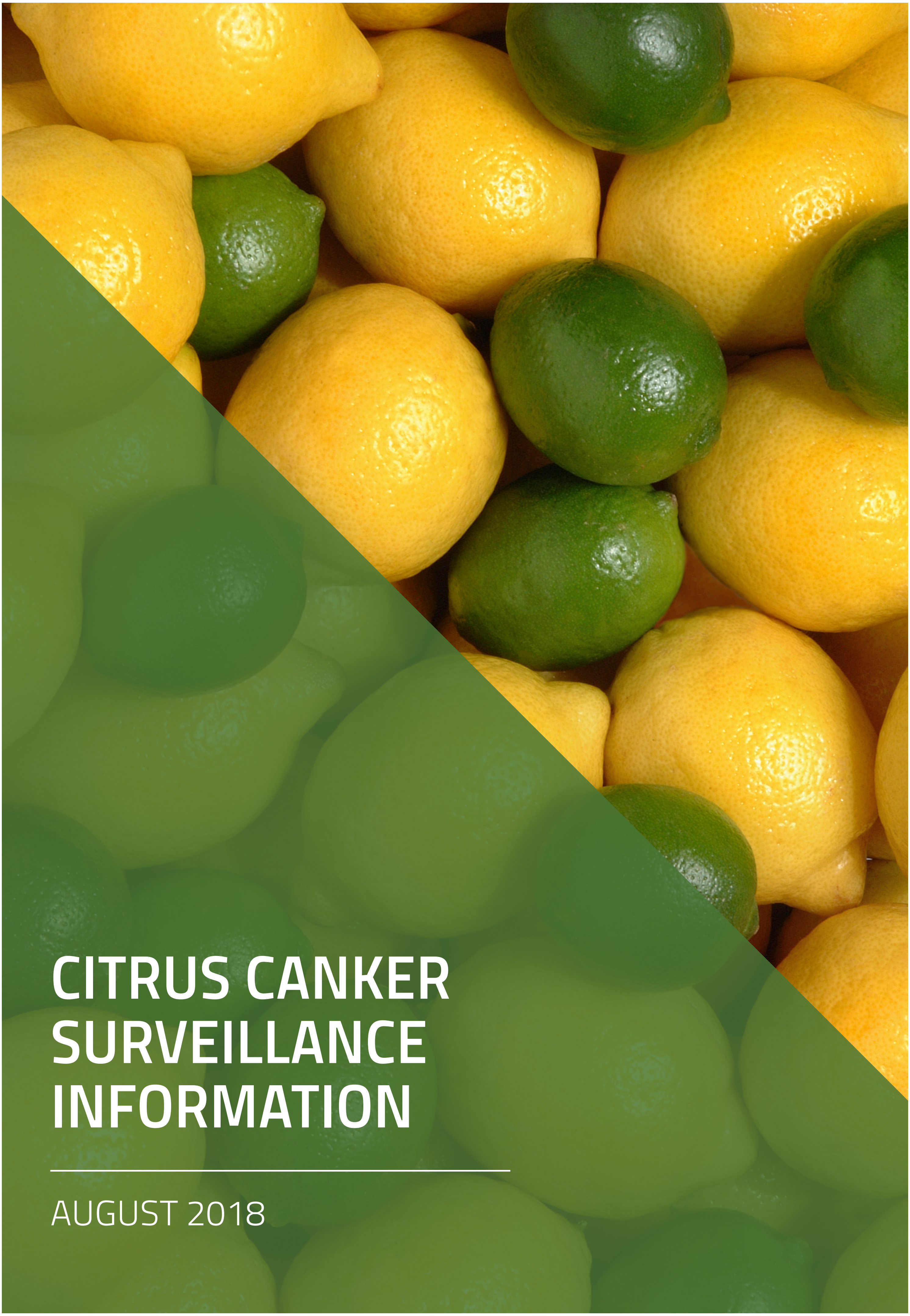
Citrus Australia is pleased to contribute to the Urban Plant Health Network, designed to form partnerships with backyard gardeners to detect pests and disease. We encourage everyone with a love for citrus trees to visit the website here:
extensionaus.com.au/urbanplantheal... #ausag

2 10

Appendix 4 List of Attachments

Eight documents are included as attachments to this report these are:

- **Attachment 1:** Citrus canker surveillance information
- **Attachment 2:** Biosecurity best practice checklist
- **Attachment 3:** Using MyPestGuide Reporter to record citrus surveillance data
- **Attachment 4:** Asian Citrus Psyllid Trapping Program in urban and peri-urban areas
- **Attachment 5:** Asian Citrus Psyllid Trapping Program in commercial production areas
- **Attachment 6:** Budwood sampling protocols for graft-transmissible exotic pathogens
- **Attachment 7:** Pesticide control options for high priority citrus pests
- **Attachment 8:** Asian Citrus Psyllid surveillance data (2019-21)



CITRUS CANKER SURVEILLANCE INFORMATION

AUGUST 2018

Citrus canker surveillance information

Plant Health AUSTRALIA

EXOTIC PEST – CALL THE HOTLINE IF SUSPECTED ON 1800 084 881

Why look for citrus canker?

Citrus canker (*Xanthomonas citri* subsp. *citri*) is a high priority disease of citrus that causes significant damage to leaves, stems, thorns and fruit.

Citrus canker has been found in parts of the Northern Territory and Western Australia and is currently being eradicated. Citrus canker has previously been detected in and eradicated from Australia.

If it was to establish in Australia it would cause significant yield losses, quality downgrades, and could cause market access issues.

What should I look for?

Citrus canker causes spots, lesions or scabs on leaves, fruit, stems and thorns.

- These look like brown to grey spots or lesions 2–10mm in diameter that take on a scabby appearance as they age.
- Spots or lesions on fruit and leaves often have a yellow halo.
- On close inspection the edges of the spot or lesion may have a watery or oily appearance.
- Spots or lesions on stems and thorns tend to be tan coloured.
- Spots or lesions are more common after heavy rain, high temperatures or during leaf flushes.

Spots or lesions are raised, rough and can be seen and felt on both sides of the leaf.

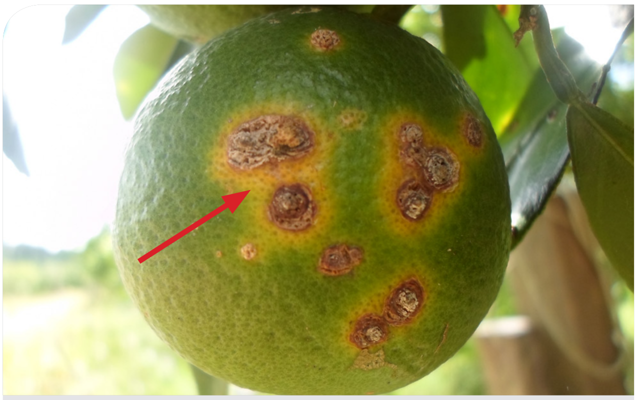
Similar symptoms may be caused by citrus scab (*Elsinoe fawcettii*). Citrus scab occurs in Australia but the rough spots or lesions only affect one side of the leaf. Citrus scab also causes leaf distortions, while citrus canker lesions occur on both sides of the leaf and do not cause leaf distortions.

When and where do I look?

Citrus canker symptoms are most obvious during warm (>20°C), humid conditions.

Surveillance is best carried out in the wet season in northern Australia. In southern Australia surveillance is best carried out after warm, humid conditions.

Surveillance can be conducted at any time in areas that are watered using overhead irrigation systems that create a humid microclimate (such as in urban areas or nurseries).



Symptoms on fruit: note that the spots or lesions are surrounded by a yellow halo (indicated by arrow)

Jonas Janner Hamann, Universidade Federal de Santa Maria (UFSM), Bugwood.org

A distinguishing feature of citrus canker lesions is that they can be seen and felt on both sides of the leaf

Timothy Schubert, Florida Department of Agriculture and Consumer Services, Bugwood.org

Citrus scab symptoms, note that lesions are only on one side of the leaf and the opposite side is distorted

Florida Division of Plant Industry , Florida Department of Agriculture and Consumer Services, Bugwood.org

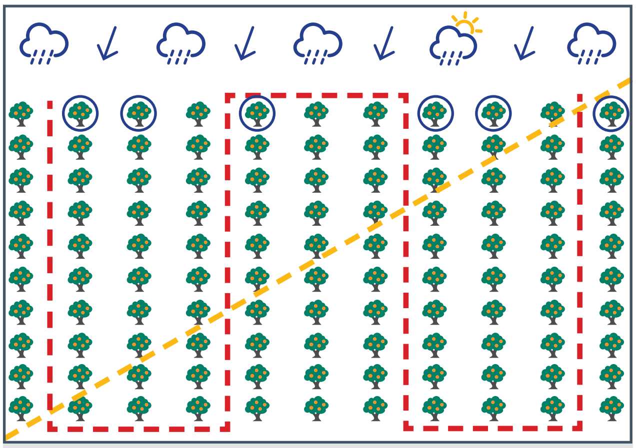
Citrus canker surveillance information

Plant Health AUSTRALIA

EXOTIC PEST – CALL THE HOTLINE IF SUSPECTED ON **1800 084 881**

How do I survey citrus orchards?

1. If there are fewer than 25 citrus trees, check each tree for symptoms.
2. If there are more than 25 trees, select blocks to survey based on which block is most likely to be infected. These include:
   - sites near entry points to the property
   - areas of higher traffic
   - blocks facing prevailing wind and rain.
3. Survey using a transect or W pattern across each block until up to 50 trees have been inspected. Survey trees along the side of the block that faces the prevailing wind and rain.
4. If any suspect lesions are seen on leaves or stems, call the **Exotic Plant Pest Hotline on 1800 084 881** for instructions on sending samples for diagnosis.
5. If no symptoms are detected, note date and location of surveillance and that no evidence of citrus canker was found.



If you have more than 25 trees, randomly inspect up to 50 trees per block following a transect (yellow), W pattern (red) or your normal inspection route depending on what is practical for the orchard. When inspecting the block also survey trees along the side that faces the prevailing wind and rain (blue)

How to assess each tree

1. Scan selected tree for symptoms of spots or lesions on leaves or fruit. Pay particular attention to young leaves.
2. If any symptoms are found focus on at least 10 leaves or fruit and look for the symptoms described.

Symptoms on a leaf: note the yellow halo surrounding the lesions

Florida Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Bugwood.org

Below is an example of a surveillance record. You can fill in your own findings here or use this table as a template to create a record sheet for use on your property.

Block and property name	Person conducting surveillance	Date of surveillance	Latitude	Longitude	Host plant	Pest name	Symptoms present/absent	Notes
Example: Block 1 Bill's orchard	Bill Smith	01/01/2018	-17.0030	145.4530	Orange	Citrus canker	Absent	

Citrus canker surveillance information

Plant Health AUSTRALIA

EXOTIC PEST – CALL THE HOTLINE IF SUSPECTED ON 1800 084 881

How do I inspect fruit in packing sheds?

In packing sheds periodically inspect fruit for citrus canker symptoms such as rough scabs or raised spots or lesions surrounded by a yellow halo.

If symptoms are found call the **Exotic Plant Pest Hotline on 1800 084 881** for instructions on sending samples for diagnosis.

How to report

If suspect symptoms are detected immediately call the **Exotic Plant Pest Hotline on 1800 084 881**. Early reporting improves the chance of successfully eradicating new pests.

More information

For further information refer to the Citrus Australia website **citrusaustralia.com.au/policy-representation/quarantine-biosecurity** or the Plant Health Australia website **planthealthaustralia.com.au/pests/citrus-canker/**

For information on the management of exotic pest and disease outbreaks visit **outbreak.gov.au**

IF YOU SEE ANYTHING UNUSUAL, CALL THE EXOTIC PLANT PEST HOTLINE

1800 084 881

On close inspection, the edges of lesions may have a watery or oily appearance

Jeffrey W. Lotz, Florida Department of Agriculture and Consumer Services, Bugwood.org

Spots or lesions on stems tend to be tan coloured

DPI&F archives, PaDIL padil.gov.au

Australian Government
Department of Agriculture and Water Resources

Plant Health AUSTRALIA

Citrus Australia

Hort Innovation Strategic levy investment | CITRUS FUND

This initiative is part of the Australian Government's *Agricultural Competitiveness White Paper*, the government's plan for stronger farmers and a stronger economy.

This project has been funded by Hort Innovation using the citrus research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au

PHA 18-021

BIOSECURITY BEST PRACTICE CHECKLIST

Biosecurity best practice checklist

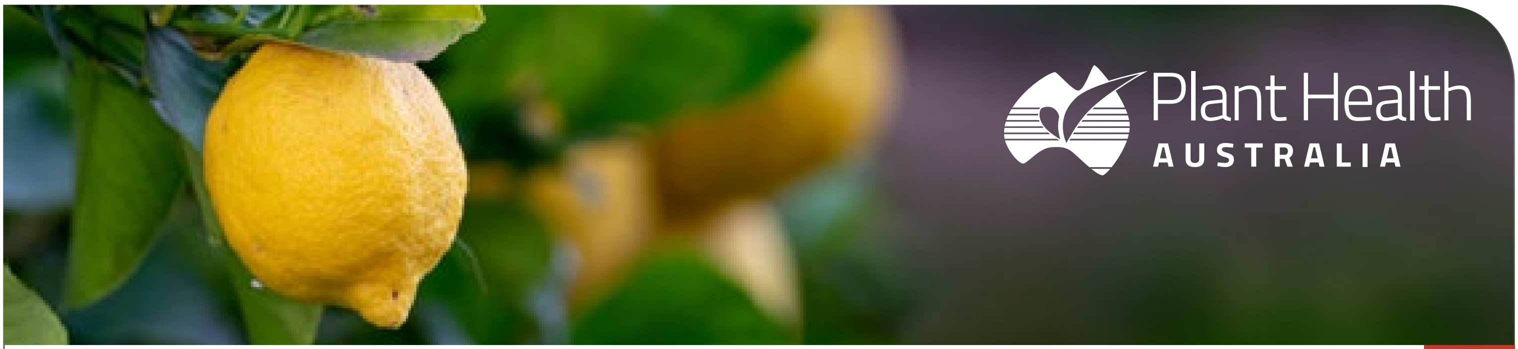
To ensure your property has the best protection against the introduction and spread of new pests, use the following self-assessment questions to identify the strengths and weaknesses of your orchard plant health or biosecurity activities.

This process forms the basis of an orchard biosecurity action plan which will allow you to systematically address any risks that you have identified. You can get further information and help to improve the biosecurity practices on your property from the National Citrus Surveillance Coordinator and at **farmbiosecurity.com.au**.

Date of biosecurity check: ____________________

RECOMMENDED PRACTICES	YES	COMMENTS
Monitoring crops and reporting anything unusual		
Orchard regularly inspected for exotic pests and anything unusual.		
Pest surveillance is regularly conducted, with activities and results recorded, even when nothing is found.		
You, your staff and family are familiar with identification of common established and exotic pests of citrus and associated symptoms.		
You, your staff and family know how to report suspect pests.		
Pest awareness material is available to staff and family.		
Using pest-free planting and propagating material		
Propagation material fully tested, pest-free and purchased from nurseries that source their material from Auscitrus.		
Seed, budwood and nursery trees are thoroughly checked for pests and diseases upon arrival.		
Records of seed, budwood and nursery trees and their source maintained.		

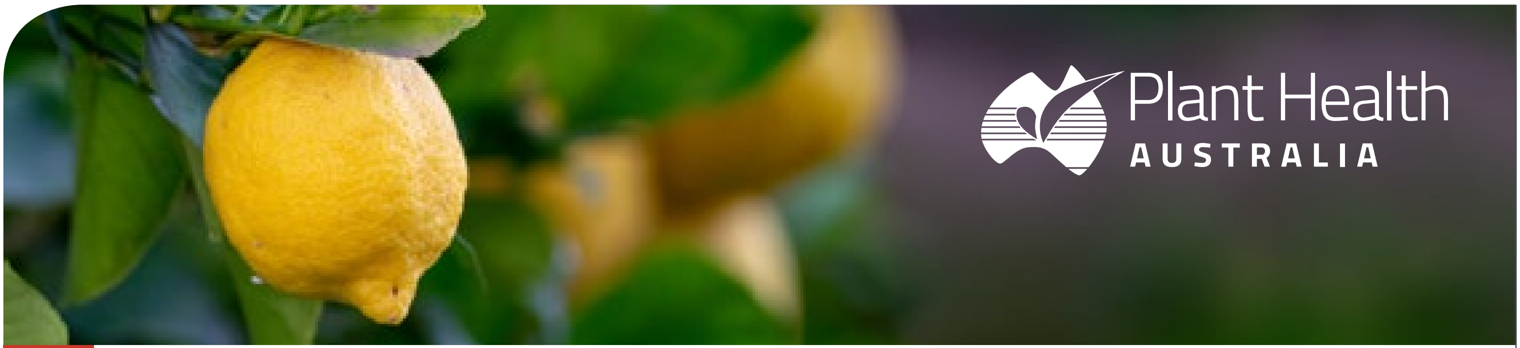
IF YOU SEE ANYTHING UNUSUAL CALL THE EXOTIC PLANT PEST HOTLINE ON **1800 084 881**



Plant Health AUSTRALIA

RECOMMENDED PRACTICES	YES	COMMENTS
Managing produce carefully		
Accredited chemical training undertaken for the safe use of pesticides.		
Pesticide labels and withholding periods adhered to.		
Equipment used to store or transport propagation material or fruit is cleaned on arrival and exit from the property.		
Fruit is covered during transport.		
Fruit is loaded on compacted surfaces away from production areas.		
Fallen or waste fruit, packing shed waste and plant trimmings are disposed of away from production areas and irrigation sources.		
Records of the movement of plant material and produce that has left your property maintained.		
Managing people movement		
Biosecurity signs with contact details are located at all entrances to the property.		
Visitor access is restricted to designated parking areas.		
Only on-site vehicles are used to transport visitors and equipment around the orchard. Otherwise visitor vehicles pass inspection prior to entry.		
Visitors sign a visitor register on arrival to track movements on orchard and for trace-back purposes.		
All visitor and staff clothing, footwear and tools are inspected for loose soil or plant matter before entering and leaving the orchard.		
All visitors and workers recently returned from overseas are checked to ensure they have clean footwear and clothing before entering the orchard.		
Staff trained in biosecurity measures and orchard hygiene practices.		
Contractor entry to orchard is conditional on being made aware of orchard biosecurity plans and hygiene protocols.		
Hygiene supplies available for use where appropriate (e.g. hand sanitiser, gloves, masks, disinfectant footbaths and scrubbing brushes).		
Contractors/visitors made aware if property has a declared or notifiable pest.		

IF YOU SEE ANYTHING UNUSUAL CALL THE EXOTIC PLANT PEST HOTLINE ON **1800 084 881**



IF YOU SEE ANYTHING UNUSUAL CALL THE EXOTIC PLANT PEST HOTLINE ON **1800 084 881**

RECOMMENDED PRACTICES	YES	COMMENTS
Reducing risks posed by vehicles and equipment		
Designated parking area for visitors and contractors is available and clearly signposted. Area checked regularly for new pests.		
Cleaning and wash-down facilities, preferably on a concrete pad, provided for people, machinery and equipment and clearly signposted with instructions.		
High pressure water or air available for use to remove plant material and soil from equipment and machinery.		
Sump installed in wash-down facility to catch unwanted weeds and stop run-off into waterways.		
Wash-down facility and surrounds inspected on a quarterly basis (i.e. check that everything works, clean the sump and check it for unwanted pests). Records kept and updated.		
Machinery entering the property is inspected for pests, soil and plant material prior to entering production areas.		
Vehicle movement is kept to a minimum in production areas.		
Secateurs used for trimming roots, budding and grafting knives are disinfected between trees.		
Borrowed and second-hand machinery and equipment is cleaned and disinfected before use.		
Machinery and equipment cleaned before being moved off property.		

More information

For general questions relating to citrus biosecurity contact the National Citrus Surveillance Coordinator Jeff Milne on 0427 352 742 or **jeff.milne@citrusaustralia.com.au**

IF YOU SEE ANYTHING UNUSUAL, CALL THE EXOTIC PLANT PEST HOTLINE

1800 084 881

Australian Government
Department of Agriculture and Water Resources

This initiative is part of the Australian Government's *Agricultural Competitiveness White Paper*, the government's plan for stronger farmers and a stronger economy.

Plant Health AUSTRALIA

Citrus Australia

Hort Innovation Strategic levy investment | CITRUS FUND

This project has been funded by Hort Innovation using the citrus research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au

PHA 18-080

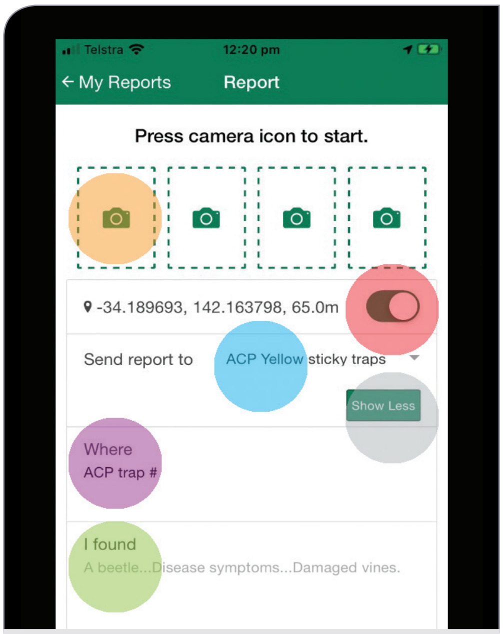
Using MyPest*Guide* reporter to record citrus surveillance data

Plant Health AUSTRALIA

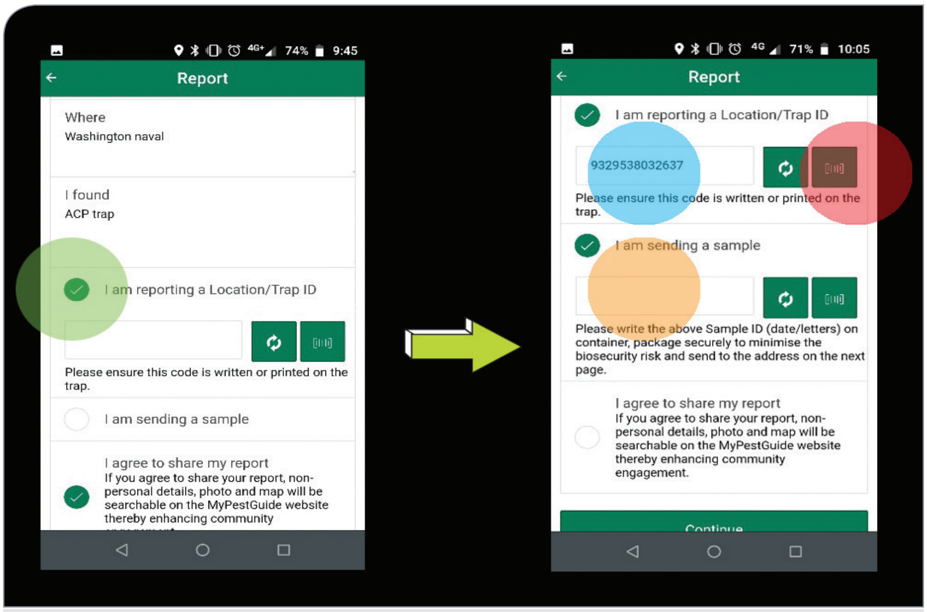
Citrus Australia

Step 1

- Download the MyPestGuide reporter app from: **www.agric.wa.gov.au/apps/mypestguide-reporter**
- Open the app
- Click 'My Reports' to create your report (iPhone) or click on the (+) sign on android phones
- Make sure location is on (*red circle*)
- While in the field take a photo of the trap showing its number and the tree or location of the trap by clicking on the camera icon (*orange circle*)
- In the 'Send Report To' field (*blue circle*) click the green (show more/show less) box (*grey circle*) to show all available options and scroll up and select "ACP yellow sticky traps"
- Under the 'Where' field (*purple circle*) write the number of the ACP trap (this is the number that appears on the trap's barcode)
- Use the 'I Found' field to record the variety and rootstock (if known) and any other observations (*green circle*)



Step 1 example



Step 2 example

Step 2

- Select 'I am reporting a Location/Trap ID' (*green circle*)
- Click on the barcode symbol (*red circle*). You will be taken to a new screen where you can scan the trap's barcode sticker. Once scanned a number will appear in the field (*blue circle*).
- Next select 'I am sending a sample' (*orange circle*). Click on the barcode symbol and scan the traps barcode again.

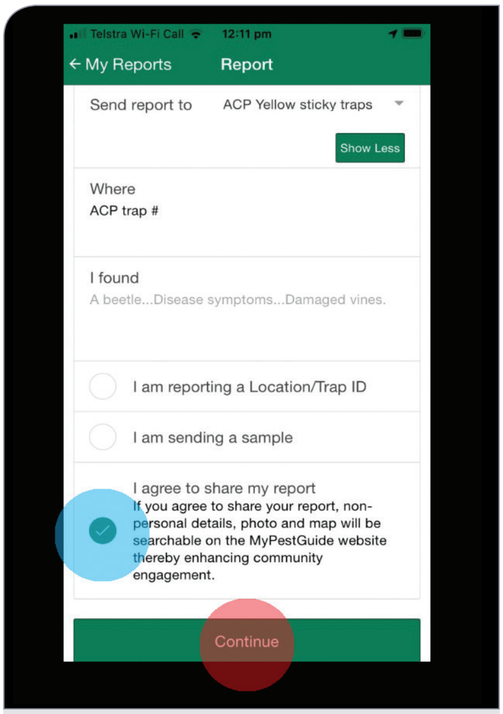
Using MyPest*Guide* reporter to record citrus surveillance data

Plant Health AUSTRALIA

Citrus Australia

Step 3

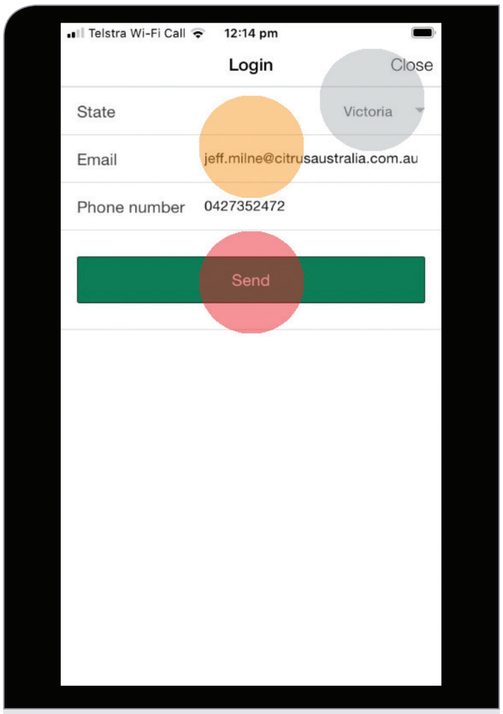
- Tick 'I agree to share my report' (*blue circle*)
- Make sure location is on (*red circle*)



Step 3 example

Step 4

- You will be brought to a new page.
- Select your state from the dropdown box (*grey circle*)
- Confirm your contact details are correct (*orange circle*)
- Click 'Send' (*red circle*) to submit your report



Step 4 example

PHA20-022

Asian citrus psyllid trapping program in urban and peri-urban areas

Plant Health AUSTRALIA

Citrus Australia

Trap set up

Step 1

Remove the protective cover from the sticky trap and insert the trap in plastic cage so that the barcode is visible when the cage is closed.

Acknowledgment: Citrus Australia

Step 2

Close the plastic cage, remove cover from attractant and attach attractant to the trap.

Acknowledgment: Citrus Australia

Step 3

Place trap in orchard or near citrus or Murraya trees. Traps should be placed on the outside of trees or on a post 1.5 metres above the ground. The trap should be positioned on outside rows of orchards, preferably on side of prevailing winds, water bodies, or roads. If using multiple traps place, traps at 400 metre intervals (i.e. 6 per 100 Ha). Mark the site with flagging tape to make trap location easier when retrieving the trap.

Acknowledgment: PHA

Collecting and packaging traps

Step 1

You will need:

- Mobile phone with MyPestGuide™ Reporter installed
- A4 sized plastic sleeves
- Zip lock bags

Step 2

Collect traps after 2 weeks. At the trap site record the trap's identification number; location; and, date of collection using the MyPestGuide™ Reporter app (see separate instructions).

Asian citrus psyllid trapping program in urban and peri-urban areas

Plant Health AUSTRALIA

Citrus Australia

Step 3

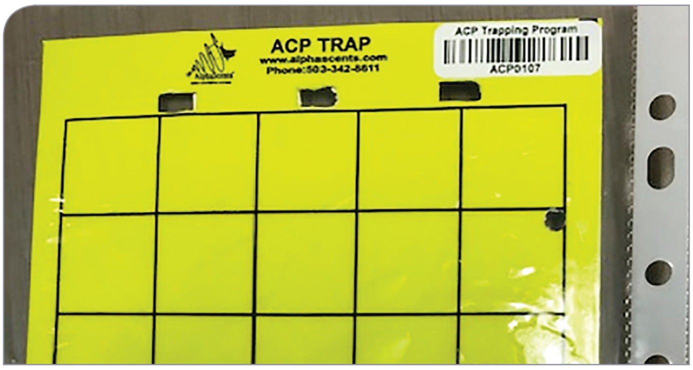
Remove the plastic cage from the tree/post.

Step 4

Remove the yellow sticky trap from the plastic cage.

Step 5

Cut a plastic document sleeve along the bottom and along one side and place the yellow sticky trap inside.



Acknowledgment: Citrus Australia

Step 6

Place the covered sticky trap in one of the smaller Ziplock bags supplied

Step 7

Retain the plastic cage for future trapping rounds.

Step 8

Place the bagged sticky trap (or multiple traps if you have used more than one) into the larger Ziplock bag.

Acknowledgment: Citrus Australia

Step 9

Send traps to the diagnostic centre in your state (see list below) by express post. Please send early in the week so traps are not in transit over the weekend.

STATE	POSTAL ADDRESS
NSW	Attention Peter Gillespie, Biosecurity Collections, Orange Agricultural Institute, 1447 Forest Road, Orange, NSW 2800
VIC	Attention Cait Selleck, DJPR, Agribio, 5 Ring Road, La Trobe University Bundoora, Victoria 3083
SA	Attention Kate Muirhead, SARDI Entomology, GPO Box 397, Adelaide SA 5001
WA	Attention Melinda Moir, DPIRD, DDLS Reception, 3 Baron-Hay Court, South Perth, WA 6151
NT	Attention Brian Thistleton, Biosecurity and Animal Welfare Berrimah Agricultural Laboratories, Berrimah Farm, Makagon Road, Darwin, NT 0828
QLD	Attention Justin Bartlett, PBL Entomology (DAF), GPO Box 267, Brisbane QLD 4001

PHA20-022

Asian citrus psyllid trapping program in commercial production areas

Trap set up

Step 1

Remove the protective cover from the sticky trap and insert the trap in plastic cage so that the barcode is visible when the cage is closed.

Acknowledgment: Citrus Australia

Step 2

Close the plastic cage, remove cover from attractant and attach attractant to the trap.

Acknowledgment: Citrus Australia

Step 3

Place trap in orchard or near citrus or Murraya trees. Traps should be placed on the outside of trees or on a post 1.5 metres above the ground. The trap should be positioned on outside rows of orchards, preferably on side of prevailing winds, water bodies, or roads. If using multiple traps place, traps at 400 metre intervals (i.e. 6 per 100 Ha). Mark the site with flagging tape to make trap location easier when retrieving the trap.

Acknowledgment: PHA

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- A4 sized plastic sleeves
- Zip lock bags

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Asian citrus psyllid trapping program in commercial production areas

Plant Health AUSTRALIA

Citrus Australia

Step 3

Remove the plastic cage from the tree/post.

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Remove the yellow sticky trap from the plastic cage.

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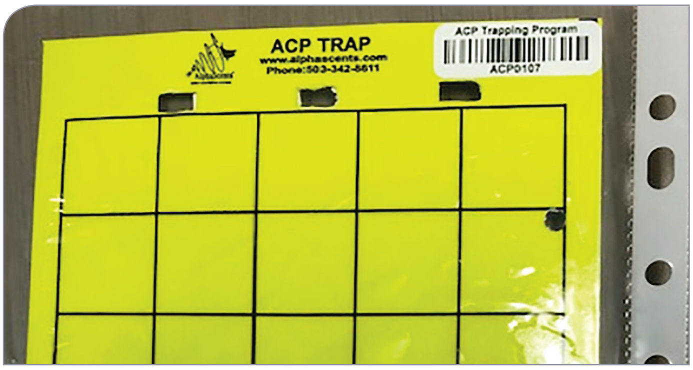
Cut a plastic document sleeve along the bottom and along one side and place the yellow sticky trap inside.



Acknowledgment: Citrus Australia

Step 6

Place the covered sticky trap in one of the smaller Ziplock bags supplied

Step 7

Retain the plastic cage for future trapping rounds.

Step 8

Place the bagged sticky trap (or multiple traps if you have used more than one) into the larger Ziplock bag.

Acknowledgment: Citrus Australia

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Send traps to the diagnostic centre in your state (see list below) by express post. Please send early in the week so traps are not in transit over the weekend.

STATE	POSTAL ADDRESS
NSW	Biosecurity Collections, Orange Agricultural Institute, 1447 Forest Road, Orange, NSW 2800
VIC	Attention Kyla Finlay, DJPR, Agribio, 5 Ring Road, La Trobe University Bundoora, Victoria 3083
SA	Attention David Hubbard, SARDI Entomology, 33 Flemington Street, Glenside, SA, 5065
WA	Attention Melinda Moir, DPIRD, DDLS Reception, 3 Baron-Hay Court, South Perth, WA 6151
NT	Attention Brian Thistleton, Biosecurity and Animal Welfare Berrimah Agricultural Laboratories, Berrimah Farm, Makagon Road, Darwin, NT 0828
QLD	Attention Justin Bartlett, PBL Entomology (DAF), GPO Box 267, Brisbane QLD 4001

PHA20-022

Budwood sampling protocols for graft-transmissible exotic pathogens

Plant Health AUSTRALIA Citrus Australia

Trap set up

Step 1

Randomly select two citrus trees to sample per farm/ garden.

Step 2

From each quadrant (quarter) of the tree cut or break off a 10 cm long budstick.

- Budsticks are small branches that are dark green and angular to rounded in cross section with fully expanded and hardened leaves. The bark should be green and not brown.
- Do not remove the leaves from the budstick.
- If use cutting tools, ensure they have been disinfected with chlorine bleach (1-2% sodium hypochlorite) before and after each tree.

Budsticks should be taken from the angular to rounded dark green section of the branch containing fully expanded hardened leaves. Image source: Nerida Donovan, NSW DPI

Step 3

Place the 4 budsticks with leaves attached into a Ziplock bag and attach a barcode sticker.

Step 4

Scan the barcode on the bag and record the location using the MyPestGuide™ Reporter app (see separate instructions).

Step 4

Scan the barcode on the bag and record the location using the MyPestGuide™ Reporter app (see separate instructions).

Step 5

Keep the sample cool and out of the sunlight, an esky is ideal.

Step 6

Place all the samples from your orchard in the larger Ziplock bag for despatch.

Step 7

Send samples to the NSW DPI EMAI Citrus Laboratory (see address below) by express post. Please send early in the week so budwood is not in transit over the weekend.

STATE	CONTACT NAME	POSTAL ADDRESS
All states and territories	Nerida Donovan	*EMAI Citrus Pathology Laboratory* *Elizabeth Macarthur Agricultural Institute* *Woodbridge Rd* *Menangle NSW 2568*

A permit is required to send citrus material out of Queensland to reduce the risk of spreading some citrus pathogens.
You must ensure that prior to dispatch from Queensland, the citrus plant material has been:

a) completely immersed in 150-250 ppm (mg/L) available chlorine for a minimum of two (2) minutes immediately prior to packaging; and

b) packaged using a triple layer system, the initial two layers being plastic bags and the third layer being a sealed sturdy outer packaging and accompanied by a label stating **"Quarantine Plant Material — Do Not Open"** affixed between the second and third layer of packaging.

Please contact Nerida Donovan *nerida.donovan@dpi.nsw.gov.au* before sending budstick samples.

PHA20-022

PESTICIDE CONTROL OPTIONS FOR HIGH PRIORITY CITRUS PESTS

Report prepared by Rohan Burgess and Sharyn Taylor
Plant Health Australia

October 2018

This project has been funded by Hort Innovation using the citrus research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au

Improving national biosecurity outcomes through partnerships

Executive summary

This document presents information on pesticides that are used overseas for the control exotic High Priority Pests of citrus and provides commentary on their suitability for use in Australian citrus based on a comparison of Australian and overseas use patterns.

Pests considered in this report are:

- Citrus canker (*Xanthomonas citri* subsp. *citri*)
- Citrus fruit borer (*Citripestis sagittiferella*)
- Citrus leprosis virus (*Citrus leprosis Cilevirus*)
- Citrus stubborn disease (*Spiroplasma citri*)
- Citrus variegated chlorosis (*Xylella fastidiosa* subsp. *pauca*) and its vectors
- Citrus tristeza virus (exotic strains)
- Exotic fruit flies including:
    - Carambola fruit fly (*Bactrocera carambolae*)
    - Fruit fly (*Bactrocera kandiensis*)
    - Fruit fly (*Bactrocera occipitalis*)
    - Mexican fruit fly (*Anastrepha ludens*)
    - New Guinea fruit fly (*Bactrocera trivialis*)
    - Oriental fruit fly (*Bactrocera dorsalis*) (Syn. *B. invadens, B. papayae, B. philippinensis*)
- Exotic thrips including:
    - Bean thrips (*Caliothrips fasciatus*)
    - Florida flower thrips (*Frankliniella bispinosa*)
- Glassy winged sharpshooter (*Homalodisca vitripennis*)
- Huanglongbing ('*Candidatus* Liberibacter africanus'; '*Candidatus* Liberibacter americanus'; '*Candidatus* Liberibacter asiaticus') and its vectors:
    - Asiatic citrus psyllid (*Diaphorina citri*)
    - African citrus psyllid (*Trioza erytreae*)

This report identified 22 pesticides that future Australian Pesticides and Veterinary Medicines Authority (APVMA) Emergency or Minor Use Permits could be developed for. The application for such permits would allow the citrus industry to be better prepared to respond to exotic pest detections.

Recommendations for future permit applications

The following recommendations have been made based on a comparison of overseas and Australian use patterns

1. Consider developing an APVMA permit for Imidacloprid to control: African citrus psyllid (a vector of HLB), Asiatic citrus psyllid (a vector of HLB), Glassy winged sharpshooter and *Oncometopia facialis* (a vector of Citrus Variegated Chlorosis)
2. Consider developing an APVMA permit for Chlorpyrifos to **suppress**: Exotic thrips and to control African citrus psyllid (a vector of HLB), Asiatic citrus psyllid (a vector of HLB) and Glassy winged sharpshooter
3. Consider developing an APVMA permit for Thiamethoxam to control: African citrus psyllid (a vector of HLB), Asiatic citrus psyllid (a vector of HLB) and Glassy winged sharpshooter
4. Consider developing an APVMA permit for Maldison (Syn. Malathion) to control Exotic thrips, Oriental Fruit fly, and Mexican fruit fly
5. Consider developing an APVMA permit for Pyrethrin to control: Asiatic citrus psyllid (a vector of HLB) and Glassy winged sharpshooter
6. Consider developing an APVMA permit for Spinosad to control: Mexican fruit fly and Oriental Fruit fly

7. Consider developing an APVMA permit for Abamectin to control: Asiatic citrus psyllid (a vector of HLB)
8. Consider developing an APVMA permit for Buprofezin to control: Glassy winged sharpshooter
9. Consider developing an APVMA permit for Carbaryl to control: Asiatic citrus psyllid (a vector of HLB)
10. Consider developing an APVMA permit for Clothianidin to control: Asiatic citrus psyllid (a vector of HLB)
11. Consider developing an APVMA permit for Cyantraniliprole to control: Asiatic citrus psyllid (a vector of HLB)
12. Consider developing an APVMA permit for Dicofol to control: *Brevipalpus* mites (vectors of Citrus leprosis virus)
13. Consider developing an APVMA permit for Dimethoate to control: African citrus psyllid (a vector of HLB)
14. Consider developing an APVMA permit for Fenbutatin-oxide to control: *Brevipalpus* mites (vectors of Citrus leprosis virus)
15. Consider developing an APVMA permit for Gamma-cyhalothrin to control: *Oncometopia facialis* (a vector of Citrus Variegated Chlorosis)
16. Consider developing an APVMA permit for Methomyl to control: Exotic thrips
17. Consider developing an APVMA permit for Spinetoram to control: Asiatic citrus psyllid (a vector of HLB)
18. Consider developing an APVMA permit for Spirotetramat to control: Asiatic citrus psyllid (a vector of HLB)
19. Consider developing an APVMA permit for Sulphur to control: *Brevipalpus* mites (vectors of Citrus leprosis virus)
20. Consider developing an APVMA permit for Copper – as Copper hydroxide to **suppress**: Citrus canker
21. Consider developing an APVMA permit for Copper – as Cuprous oxide to **suppress**: Citrus canker
22. Consider developing an APVMA permit for Methidathion to **suppress**: *Brevipalpus* mites (vectors of Citrus leprosis virus)

Table of Contents

Introduction

The citrus industry has identified 20 High Priority Pests in their Biosecurity Plan (PHA 2014; Table 1). Pesticide permits are required to allow the industry to prepare for incursions of these pests. The following document aims to identify chemical control options for each High Priority Pest, compare overseas control options to current management regimes used in Australia and identify suitable pesticides to develop APVMA permits for. When finalized these permits will allow the industry to be better prepared to rapidly respond to future pest incursions.

Table 1 High Priority Pests of the Citrus Industry

SCIENTIFIC NAME	COMMON NAME	NOTES
Anastrepha ludens	Exotic Fruit flies (various)	
Bactrocera carambolae		
B. dorsalis (Syn. *B. invadens, B. papayae, B. philippinensis*)		
B. kandiensis		
B. occipitalis		
B. trivialis		
'*Candidatus* Liberibacter africanus'	Huanglongbing/ citrus greening (African strain)	These bacterial pathogens are vectored by psyllid species, see below
'*Candidatus* Liberibacter americanus'	Huanglongbing/ citrus greening (American strain)	
'*Candidatus* Liberibacter asiaticus'	Huanglongbing/ citrus greening (Asiatic strain)	
Caliothrips fasciatus	Bean thrips	
Citripestis sagittiferella	Citrus fruit borer	
Citrus leprosis virus (Cilevirus)	Citrus leprosis	Vectored by: *Brevipalpus californicus, B. obovatus* and *B. phoenicis*(all reported in Australia)
Citrus tristeza virus (exotic strains)	Citrus tristeza virus (exotic strains)	Vectored by Black citrus aphid (*Toxoptera citricida*) (endemic in Australia)
Diaphorina citri	Asiatic citrus psyllid	Vector of Huanglongbing
Frankliniella bispinosa	Florida flower thrips	
Homalodisca vitripennis (Syn. *H. coagulata*)	Glassy winged sharpshooter	Vector of Xylella on grapevines experimental vector on citrus
Spiroplasma citri	Citrus stubborn disease	
Trioza erytreae	African citrus psyllid	Vector of Huanglongbing

SCIENTIFIC NAME	COMMON NAME	NOTES
Xanthomonas citri subsp. citri (Syn. *X. axonopodis* pv. *citri, X. campestris* pv. *citri*)	Citrus canker	Recently detected in the north of the Northern Territory and north west of Western Australia. Currently under eradication. For further information see: www.outbreak.gov.au
Xylella fastidiosa subsp. *pauca*	Citrus variegated chlorosis (CVC)	Vectored by a range of xylem feeding insects

Comparison of overseas and Australian labels

Comparing overseas and Australian use patterns is important as pesticides that are used overseas and in Australia at comparable rates are preferred when developing permits as this ensures pesticides are unlikely to cause residue, crop or operator safety issues and will fit neatly into existing pesticide regimes.

Many overseas pesticide labels only give rates per unit area (e.g. many United States labels give rates per acre) for the control of different citrus pests. This contrasts with Australia, where label rates for orchard crops are expressed in terms of a rate of pesticide per 100 L of water, sufficient volume of the solution is then applied to the crop until the point of run off is reached. This volume varies dependent on the size and density of the crop being treated. This makes comparison difficult in some instances where the overseas label is not expressed in terms of rate per a defined volume of water (e.g. ml of product/100 L water) but rather in terms of a rate of pesticide per unit area (e.g. ml of product/ha).

Where needed throughout this document attempts have been made to compare per unit area and per 100 L rates. To do this the Australian and overseas labels were reviewed to see if the label provided a suggested water volume per unit area as this would allow basic conversions and comparisons to be made. Where this information was not available a generic per hectare water volume of 3,300 L/ha (see below for an explanation of this figure) was used as the typical water volume required to treat one hectare of citrus. This figure allowed a rough comparison to be made between overseas and Australian use patterns, which can be used to identify suitable pesticides for future APVMA permit applications.

Typical water volume required per hectare

Furness and Thompson (2008) suggest that for most pesticides applied to citrus a rate of 50 - 60 L of solution/100 linear meters of 1 m high canopy (i.e. 50-60 L/100 m^2 of vertical canopy) is required to reach the point of run off. Assuming 7.3 m row spacing[1] as typical for citrus orchards (which equates to 1,370 m of row per ha) and an average canopy height of 4 m[2]; this equates to a water volume of approximately 3,300 L/ha[3].

Therefore, in the absence of other information a typical water volume of 3,300L/ha is used throughout this report for the comparison of Australian and overseas use patterns.

---

[1] 7.3 m row spacing based on: Queensland Department of Agriculture and Fisheries (2010) Citrus harvesting, yields and prices. Available from: www.daf.qld.gov.au/business-priorities/plants/fruit-and-vegetables/fruit-and-nuts/citrus/harvesting,-yields-and-prices.

[2] Citrus are typically maintained at a height of 4 - 4.6 m based on: Queensland Government (1997) Citrus Information Kit (reprint)-Growing the crop. Available from: http://era.daf.qld.gov.au/id/eprint/1649/4/3growcit.pdf

[3] 60 L * 4 (i.e. typical canopy height in meters) (which = 240 L required for100 m of row) * 13.7 (i.e. the number of 100 m rows per ha at 7.3 m row spacing) = 3,288 L (rounded to 3,300 L/ha).

Chemical control options for Citrus Canker

Background

Citrus canker is a serious disease of citrus caused by the bacterium *Xanthomonas citri* subsp. *citri* (also known as *X. axonopodis* pv. *citri*, and *X. campestris* pv. *citri*). Citrus canker infects the plant through wounds and natural openings on leaves, stems, thorns and fruit. The disease presents as lesions or cankers at infection sites and severely impacts fruit quality and yield. Symptoms are exacerbated by feeding injuries caused by Citrus leaf miner (*Phyllocnistis citrella*), a small moth that is widely distributed in Australia. Citrus canker incursions have occurred and been eradicated in the past. The most recent detection was in 2018 in the Northern Territory and northern Western Australia, this is currently being eradicated.

Control of Citrus canker

Control options used for the Northern Territory and West Australian Citrus Canker Outbreaks

The following table (Table 2) provides a summary of the permits that have recently been put in place (as of September 2018) for the control of the Citrus Canker outbreak in the NT and WA. Note that these permits are currently only for use in the NT and WA and would need to be altered to allow control of Citrus Canker in other states.

Table 2 Chemical control options for Citrus Canker in the NT and WA (as of September 2018)

PERMIT NUMBER	USE	PESTICIDE	EXPIRY DATE
PER86477	used for treatment prior to disposal	Tribasic copper sulphate	31/5/2020
PER86582	used as a preventable treatment	Tribasic copper sulphate	31/5/2020
PER86730	Post-harvest treatment	Sodium ortho-Phenylphenate Tetrahydrate	31/7/2023
PER86822	Post-harvest treatment	Chloride present as Sodium Hypochloroite	31/7/2020

Chemical control options used overseas

Overseas control of Citrus canker in areas where the disease isn't common revolves around the removal and burning of infected and nearby trees to reduce spread of the disease within the orchard. In orchards where it has become established Citrus canker can be suppressed to some extent using various pesticides such as copper sprays and Flupyradifurone to control the severity of Citrus canker symptoms (see Table 3).

In the past Citrus canker was eradicated from Australia via the removal of host plants. The chemicals noted below are used overseas for the management of the pathogen and **suppress** symptoms caused by Citrus canker rather than completely eradicating the pathogen.

Table 3 Chemical control options for Citrus Canker

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Flupyradifurone	United States	Sivanto 200SL label, Bayer, United States	**Suppression only** (host removal will be required for eradication)	Sivanto 200SL (1.67 lb. a.i/gallon (200 g a.i/L)) is used in the United States to **suppress** Citrus canker when applied by chemigation or basal drench at a rate of 28 fl. oz./acre (2,046.2 ml (409.24 g a.i)/ha)	Active ingredient has recently been listed in Australia but not yet labelled for use on citrus	N/A	Not at this time
Copper – as Copper sulfate pentahydrate	United States	CS 2005 label, Magna-Bon, United States	**Suppression only** (host removal will be required for eradication). Copper sprays reduce the incidence and severity of the disease (Behlau et al., 2010) and are widely used to manage the disease overseas (Gottwald et al., 2002)	CS 2005 (5% copper) is used to **suppress** Citrus canker in the United States when applied at a rate of 12.8 - 64 oz./acre (896.7 - 4,483.4g (44.8 - 224.2 g a.i)/ha)	Used in Australia but not on citrus. Other copper compounds are used (see below)	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Copper – as Copper hydroxide	United States	Kentan DF label, Isagro, United States	**Suppression only** (host removal will be required for eradication)	Kentan DF (40% a.i) is used in the United States for the **suppression** of Citrus canker when applied at a rate of 2 - 7.87 lb./acre (2,241.7 - 8,821.1 g (896.7 - 3,528.4 g a.i)/ha)	Champ 500 WG (500 g a.i/kg) is used in Australia to control citrus pathogens when applied at a rate of 105 – 160 g (52.5 – 80 g a.i)/100 L	Assuming a typical water volume required to achieve run off in citrus of 3,300 L/ha, the Australian and overseas rates are comparable	Consider further
Copper – as Cuprous oxide	United States	Nordox 30/30 WG label, Monterey AgResources, United States	**Suppression only** (host removal will be required for eradication)	Nordox 30/30 WG (30% a.i) is used in the United States for the **suppression** of Citrus canker when applied at a rate of 10.5 lb./acre (11,768.9 g (3,530.7 g a.i)/ha)	Nordox 750 WG (750 g a.i/kg) is used in Australia to control citrus pathogens when applied at a rate of 80 – 160 g (60 - 120 g a.i)/100 L	Assuming a typical water volume required to achieve run off in citrus of 3,300 L/ha, the Australian and overseas rates are comparable	Consider further

Concluding remarks

Based on a comparison of the chemicals used overseas and in Australia the following pesticides look to be suitable for future permit applications for the **suppression** of Citrus canker:

- Copper – as Copper hydroxide
- Copper – as Cuprous oxide

Note, these products are for **suppression** only. To ensure eradication of the pathogen host removal will also be required.

Chemical control options for Citrus fruit borer (*Citripestis sagittiferella*)

Background

The Citrus fruit borer (*Citripestis sagittiferella*) is a serious exotic pest of citrus that causes direct damage to fruit through the feeding activities of the larvae. Larvae cause damage by tunnelling into fruit, causing deformation and premature rotting. This leads to reduced yield and quality.

Larvae of the Citrus fruit borer are reddish-yellow in colour transitioning to a darker reddish-brown towards pupation. At their largest, larvae grow to be about 21 mm in length. Adults are grey-brown moths approximately 10 mm in length with a wing span of 27 mm. The forewings of adult moths are yellow-brown and mottled with dark markings, while the hindwings are almost transparent.

This species occurs in south east Asia including: Brunei, Indonesia, Malaysia, Singapore, Thailand and Vietnam. It has been intercepted in the United Kingdom on fruit from these countries (EPPO 2016).

Chemical control options used overseas

Pesticides are used for the control of this pest overseas, but this is generally in an ad hoc manner meaning permits and labels have not been identified and little information is available on rates used for the control of this pest overseas.

In Indonesia this species is controlled by Methomyl (using products such as: Lannate 25WP) and Methidathion (using products such as: Supracide 40EC), which are applied to young fruit (AIAT-East Kalimantan 2014). Indonesian labels for these products could not be accessed to determine rates. Both products are available in Australia and used on citrus. However, without information on the rates needed for efficacious control of the pest a comparison of Australian and overseas use patterns is not possible at this time.

Concluding remarks

No comparison between Australian and overseas chemical use patterns was possible given the lack of information on the rates of pesticide needed for the control of this pest overseas.

Chemical control of Citrus leprosis virus

Background

Citrus leprosis virus (Cilevirus) causes lesions on citrus fruit and stems and causes spotting on leaves. Infections can result in significant losses. The virus doesn't appear to spread systemically within the tree and is instead confined to the area around mite feeding sites (Childers et al., 2003; USDA 2013). The virus is more damaging in sweet orange and grapefruit. Other cultivars can be infected but don't show significant symptoms.

Three species of *Brevipalpus* mites vector the virus. In Brazil *B. phoenicis* is the main vector; in Argentina and Venezuela *B. obovatus* is the main vector; and in Florida *B. californicus* was the main vector (Childers et al., 2003).

The virus is currently found in: Brazil, Argentina, Colombia, Venezuela, Bolivia, Paraguay, Uruguay, Panama, Guatemala, Costa Rica, Nicaragua, El Salvador, Belize and Mexico. In the past the virus was reported from Florida but is no longer present and hasn't been seen for 50+ years. This is possibly because the mite vectors were controlled using pesticides (such as Sulphur) stopping disease transmission (Childers et al., 2003; Leon 2012). Significant frost events have also been associated with the disappearance of the disease in parts of Argentina (Childers et al., 2003). This suggests that control of the virus is possible by controlling the mite vectors.

All three vectors, *Brevipalpus phoenicis, B. obovatus* and *B. californicus* have been reported from parts of Australia. Currently there are no permits or labels in Australia that specifically mention the control of these mites on citrus, although there is a permit in place for the control of *B. phoenicis* on passionfruit (see Table 4). To control Citrus leprosis virus in the event of an incursion it will be necessary to control the vectors. Therefore, permits should be developed allowing the control/management of *Brevipalpus* mites on citrus in Australia.

Chemical control of Brevipalpus mites that vector Citrus leprosis virus

Table 4 provides a summary of the chemical control options currently used overseas for the control of the vectors of Citrus leprosis virus and how the overseas use patterns compare to Australian pesticide use patterns. Chemicals that are used in a similar way in Australia as they are used overseas are noted.

Table 4 Chemical control options for Brevipalpus mites

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Abamectin	Australia (passionfruit only)	PER14665; Leon (2012)	Abamectin products such as Vertimec 18 EC (18 g a.i/L) are used in overseas countries affected by Citrus leprosis virus (e.g. Brazil) for the control of *Brevipalpus phoenicis* but not on citrus. Leon (2012) suggests that there is some resistance from these mites to Abamectin on citrus orchards in Brazil.	Abamectin products containing 18 g a.i/L can be used in Australia under PER14665 to control of *Brevipalpus phoenicis* on passionfruit, where it is applied at a rate of 50 ml (0.9 g a.i)/100 L, with a recommended volume of 1,200 – 1,500 L/ha (i.e. 10.8 - 13.5 g a.i/ha). No overseas permits/ chemical labels have been identified for the control of *Brevipalpus* mites on citrus using Abamectin.	Sharda Abamectin 18EC (18 g a.i/L) is used on citrus in Australia for the control of citrus pests when applied at a rate of 15 - 25 ml (0.27 - 0.45 g a.i)/100 L. The label recommends 3,000 – 6,000 L/ha (i.e. up to 27 g a.i/ha)	The rate of product applied to citrus is greater than that used to control *Brevipalpus phoenicis* on passionfruit. However, possible resistance issues in Citrus leprosis virus infected countries, such as Brazil, suggests this may not be the best pesticide to use to control the mite vectors of the virus	Not considered further at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Bifenthrin	Brazil	Talstar 100EC label, FMC Brazil	Non-systemic pesticide that is registered for use overseas for the control of the pest	Talstar 100EC (100 g a.i/L) is used in Brazil for the control of *Brevipalpus phoenicis* on citrus when applied at a rate of 20 ml (2 g a.i)/100 L	Starlet 100EC (100 g a.i/L) is used in Australia on citrus for the control of leaf-eating weevils when applied to the ground under the tree at a rate of up to 25 ml (2.5 g a.i)/tree	Direct comparison difficult to make due to different application methods between Australia and overseas	Not considered further at this time Different application methods means additional data may be required to support use
Cyflumetofen	Brazil	Obny label, Arysta, Brazil	Non-systemic but can control all life stages of spider mite (Heath Canada Pest Management Regulatory Agency 2014)	Obny (200 g a.i/L) is used in Brazil to control *Brevipalpus phoenicis* when applied at a rate of 40 ml (8 g a.i)/100 L. Label suggests a water volume of 2,000 L (i.e. 160 g a.i)/ha	Pesticide is not currently used in Australia	N/A	Not at this time
Dicofol	Brazil	Tricofol label, Adama, Brazil	Non-systemic pesticide that is registered for use overseas for the control of the pest	Tricofol (480 g a.i/L) is used in Brazil to control *Brevipalpus phoenicis* when applied at a rate of 77 ml (36.96 g a.i)/100 L	Miti-Fol EC (240 g a.i/L) is used in Australia to control citrus pests when applied at a rate of 200 ml (48 g a.i)/100 L	Higher concentration of product used in Australia than used overseas	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Fenbutatin-oxide	South Africa	Torque SC label, BASF, South Africa	Fenbutatin-oxide is a non-systemic pesticide that is reported to provide good control of *Brevipalpus* mites in Brazil (Leon 2012) and Texas (French and Rakja 1994)	Torque SC (550 g a.i/L) is used in South Africa on citrus to control *Brevipalpus californicus* when applied at a rate of 20 ml (11 g a.i)/100 L	Vendex (550 g a.i/L) is used in Australia to control citrus pests when applied at a rate of 20 - 45 ml (11 - 24.75 g a.i)/100 L	Australian rate is comparable to the overseas rates	Consider further
Fenpyroximate	Brazil	Ortus 50 SC label, Arysta, Brazil	Non-systemic pesticide that is registered for use overseas for the control of the pest	Ortus 50 SC (50 g a.i/L) is used in Brazil to control *Brevipalpus phoenicis* on citrus when applied at a rate of 100 ml (5 g a.i)/100 L. Label recommends using 1,000 – 2,400 L (50 - 120 g a.i)/ha	Used in Australia on apple and pear but not on citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Hexythiazox	Brazil	Savey WP label, DuPont, Brazil	Non-systemic pesticide that is registered for use overseas for the control of the pest	Sawey WP (500 g a.i/kg) is used in Brazil to control *Brevipalpus phoenicis* on citrus when applied at a rate of 3 g (1.5 g a.i)/100 L	Used in Australia but not on citrus	N/A	Not at this time
Methidathion	South Africa	Suprathion 420EC label, Adama, South Africa	Non-systemic pesticide that is registered for the **suppression** of the pest overseas.	Suprathion 420EC (420 g a.i/L) is used South Africa in citrus to **suppress** *Brevipalpus* mites when applied at a rate of 100 ml (42 g a.i)/100 L	Suprathion 400EC (400 g a.i/L) is used in Australia on citrus to control various pests when applied at a rate of 25 - 125 ml (10 - 50 g a.i)/100 L	Higher concentration used in Australia than overseas	Consider further
Propargite	Brazil	Acarit EC label, Adama, Brazil	Non-systemic pesticide that is registered for use overseas for the control of the pest	Acarit EC (720 g a.i/L) is used in Brazil to control *Brevipalpus phoenicis* on citrus when applied at a rate of 100 ml (72 g a.i)/100 L	This pesticide is used in Australia but not on citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Propargite	Brazil	Omite 720CE label, Arysta, Brazil	Non-systemic pesticide that is registered for use overseas for the control of the pest	Omite 720CE (720 g a.i/L) is used in Brazil for the control of *Brevipalpus phoenicis* when applied at a rate of 100 ml (72 g a.i)/100 L	This pesticide is used in Australia but not on citrus	N/A	Not at this time
Spirodiclofen	South Africa	Envidor 240 SC label, Bayer, South Africa	Non-systemic pesticide that is registered for use overseas for the control of the pest	Envidor (240 g a.i/L) is used in South Africa to control *Brevipalpus californicus* on citrus when applied at a rate of 10 ml (2.4 g a.i)/100 L	This pesticide is not used in Australia	N/A	Not at this time
Spirodiclofen	Brazil	Envidor label, Bayer, Brazil	Non-systemic pesticide that is registered for use overseas for the control of the pest	Envidor (240 g a.i/L) is used in Brazil to control *Brevipalpus phoenicis* on citrus when applied at a rate of 20 - 25 ml (4.8 - 6 g a.i)/100 L	This pesticide is not used in Australia	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Sulphur	Brazil	Kumulus DF label, BASF, Brazil	Non-systemic pesticide that is registered for use overseas for the control of the pest	Kumulus DF (800g a.i/kg) is used in Brazil to control *Brevipalpus phoenicis* on citrus when applied at a rate of 500 g (400 g a.i)/100 L and applied at a rate of 2,000 L/ha (i.e. 8,000 g a.i/ha)	Zulfa 800WG (800g a.i/kg) is used in Australia to control citrus pests when applied at a rate of 200 - 500 g (160 - 400 g a.i)/100 L	Same concentration used in Australia as used overseas	Consider further
Sulphur	Brazil	Cover DF label, BASF, Brazil	Non-systemic pesticide that is registered for use overseas for the control of the pest	Cover DF (800 g a.i/kg) is used in Brazil for the control of *Brevipalpus phoenicis* when applied to citrus at a rate of 500 g (400 g a.i)/100 L. Label recommends 2,000 L/ha (i.e. 8,000 g a.i/ha)	Zulfa 800 WG (800 g a.i/kg) is used in Australia to control citrus pests when applied at a rate of 200 - 500 g (160 - 400 g a.i)/100 L	Same concentration used in Australia as used overseas	Consider further
Sulphur	Argentina	Kumulus DF label, BASF, Argentina	Non-systemic pesticide that is registered for use overseas for the control of the pest	Kumulus DF (80% a.i) is used in Argentina to control *Brevipalpus obovatus* on citrus when applied at a rate of 200 - 300 g (160 - 240 g a.i)/100 L	Zulfa 800 WG (800 g a.i/kg) is used in Australia to control citrus pests when applied at a rate of 200 - 500 g (160 - 400 g a.i)/100 L	Higher concentration used in Australia than used overseas	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Sulphur	South Africa	Thiovit Jet label, Syngenta, South Africa	Non-systemic pesticide that is registered for use overseas for the control of the pest	Thiovit Jet (800 g a.i/kg) is used in South Africa to control *Brevipalpus californicus* on citrus when applied at a rate of 150 g (120 g a.i)/100 L	Zulfa 800 WG (800 g a.i/kg) is used in Australia to control citrus pests when applied at a rate of 200 - 500 g (160 - 400 g a.i)/100 L	Higher concentration used in Australia then used overseas	Consider further

Chemicals to consider further

As summarized in Table 4 several pesticides have been identified as suitable for the control of the various mites that vector Citrus leprosis virus based on the similarity of the overseas and Australian use patterns. A summary of these pesticides is provided in Table 5 below.

Table 5 Summary of pesticides identified as suitable for the control of Brevipalpus mites (vectors of Citrus leprosis virus)

PESTICIDE	*BREVIPALPUS PHOENICIS*	*BREVIPALPUS OBOVATUS*	*BREVIPALPUS CALIFORNICUS*	*BREVIPALPUS* MITES ON CITRUS (SPECIES NOT SPECIFIED ON LABEL)
Dicofol	✓			
Fenbutatin-oxide			✓	
Methidathion				✓ (**suppression only**)
Sulphur	✓	✓	✓	

Concluding remarks

Based on a comparison of the chemicals used overseas and in Australia the following pesticides look to be suitable for future permit applications for the control of the *Brevipalpus* mites that vector Citrus leprosis virus:

- Dicofol
- Fenbutatin-oxide
- Methidathion (**suppression only**)
- Sulphur

These chemicals have been identified as their use overseas for the control of these pests are very similar to their existing use patterns in Australia. This means that these pesticides are good candidates for future permit applications.

Chemical control options for Citrus stubborn disease (*Spiroplasma citri*)

Background

Citrus Stubborn disease is a bacterial pathogen that occurs in the Mediterranean and in parts of the United States. Leaves from infected tress are shorter and broader than normal, cupped and held upright on the plant. Infected plants are bushy, stunted, flower out of season, have deformed fruit and produce lower yields than healthy plants (CABI and EPPO, date unknown). The bacterium is spread by grafting and by leafhopper vectors including the: Beet leaf hopper (*Circulifer tenellus*), *Scaphytopius nitridus* and *Circulifer haematoceps* (syn. *Neoaliturus haematoceps*) (CABI and EPPO date unknown). These leafhoppers are not known to occur in Australia.

In the United States the disease has historically be managed by surveying, culling and replanting using disease free planting material (Brown 1992).

No information was found on the chemical control of this disease or its vectors.

Chemical control options used overseas

No chemical control options were identified for this pathogen. CABI and EPPO (date unknown) suggests that insecticides are ineffective. This disease is managed overseas via high health planting material and removal of diseased trees rather than via chemical control.

Concluding remarks

No chemical control options were identified for this pathogen.

Chemical control options for Citrus variegated chlorosis and its vectors

Background

Citrus variegated chlorosis (CVC) is a serious disease of citrus caused by the bacterium *Xylella fastidiosa* subsp. *pauca*. This bacterium reproduces in the xylem of the plant and is transmitted by xylem-feeding Sharpshooters.

Most citrus species and hybrids are susceptible, although the severity of symptoms are variable. Plants infected with CVC show symptoms similar to nutrient deficiencies, including yellowing and loss of leaves. Leaf lesions may also occur. Infected trees may exhibit reduced vigour and growth, and may appear stunted, with defoliation at terminal twigs as well as small leaves. Fruit size is significantly reduced, and fruit may change colour early, have hard rinds, lack juice and have an acidic flavour.

Insects that are known to vector this disease include:

1. *Acrogonia citrina*
2. *Acrogonia virescens*
3. *Bucephalogonia xanthophis*
4. *Dilobopterus costalimai*
5. *Ferrariana trivittata*
6. *Fingeriana dubia*
7. *Homalodisca ignorata* (same genus as Glassy winged sharpshooter (GWSS), discussed separately, see Page 53)
8. *Macugonalia leucomelas*
9. *Oncometopia facialis*
10. *Parathona gratiosa*
11. *Plesiommata corniculata*
12. *Sonesimia grossa*

See: Yamamoto et al., (2007), and Redak et al., (2004) for further information. All are only reported to occur in South America, with the exception of *Plesiommata corniculata*, which is also found in Mexico (Wilson et al., 2009).

Of the 12 Sharpshooters known to transmit *X. fastidiosa* in Brazilian citrus; *Acrogonia citrina, Bucephalogonia xanthophis, Dilobopterus costalimai, Macugonalia leucomelas,* and *Oncometopia facialis,* are considered to be the most significant vectors for CVC spread (Almedia et al., 2005). GWSS has also been reported to be able to vector the disease based on laboratory experiments (Damsteegt et al., 2006). There are also several other strains of *X. fastidiosa* that cause disease symptoms on a range of other plants, which are vectored by their own set of insect vectors. For the purposes of controlling CVC only the above twelve vectors will be considered below.

Control of CVC vectors

Chemical control options used overseas

Table 7 provides a summary of the chemical control options currently used overseas and how these compare to Australian pesticide use patterns. Chemicals that are used in a similar way in Australia as they are used overseas are noted below.

Table 6 Summary of the information on the control of CVC vectors

VECTOR	OVERSEAS CONTROL
Acrogonia citrina	No labels found listing the control of this species. Limited information in literature about the control of this species
Acrogonia virescens	No labels found listing the control of this species. Limited information in literature about the control of this species
Bucephalogonia xanthophis	Paper found describing four pesticides that are effective at controlling this pest. However, no labels were identified that list the control of this pest overseas. See Table 7 for more information
Dilobopterus costalimai	Labels found. See Table 8 for more information
Ferrariana trivittata	No labels found listing the control of this species. Limited information in literature about the control of this species
Fingeriana dubia	No labels found listing the control of this species. Limited information in literature about the control of this species
Homalodisca ignorata	No labels found listing the control of this species. Limited information in literature about the control of this species
Macugonalia leucomelas	No labels found listing the control of this species. Limited information in literature about the control of this species
Oncometopia facialis	Labels found. See Table 9 for more information
Parathona gratiosa	No labels found listing the control of this species. Limited information in literature about the control of this species
Plesiommata corniculata	No labels found listing the control of this species. Limited information in literature about the control of this species
Sonesimia grossa	No labels found listing the control of this species. Limited information in literature about the control of this species

Table 7 Chemical control options for Bucephalogonia xanthophis a vector of Citrus Variegated Chlorosis

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Dimethoate	Trials conducted in Brazil	Bezerra-Silva et al., (2012)	Dimethoate is a contact and systemic pesticide that provided control of *B. xanthophis* for up to 3 weeks (Bezerra-Silva et al., 2012)	In their experiment Bezerra-Silva et al., (2012) used 1 ml of Perfekthion (a.i Dimethoate) (400 g a.i/L)/L of water (i.e. 40 g a.i/100 L) to control the pest	Various Dimethoate products such as Dimex 400EC (400 g a.i/L) are used on Australian citrus to control various pests including thrips when applied at a rate of 75 ml (30 g a.i)/100 L	Australian rates 25% lower than rates used by Bezerra-Silva et al., (2012)	Not at this time. Without overseas permits/labels additional data would likely be required to support this use pattern
Imidacloprid	Trials conducted in Brazil	Bezerra-Silva et al., (2012)	Imidacloprid is a systemic pesticide that provided control for up to 3 weeks (Bezerra-Silva et al., 2012)	In their experiment Bezerra-Silva et al., (2012) used 0.2 ml of Provado 200 SC (a.i Imidacloprid) (200g a.i/L)/L of water (i.e. 4 g a.i/100 L) to control the pest	In Australia Allez 350 SC (350 g a.i./L) is used to control various citrus pests when applied as soil drench or via micro-sprinkler or drip irrigation at a rate of 9 ml (3.15 g a.i)/tree	Comparison not made as the use patterns differ	Not at this time. Without overseas permits/labels additional data would likely be required to support this use pattern

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Imidacloprid	Trials conducted in Brazil	Bezerra-Silva et al., (2012)	Imidacloprid is a systemic pesticide that provided control for up to 3 weeks (Bezerra-Silva et al., 2012)	In their experiment Bezerra-Silva et al., (2012) also used Provado 200 SC (a.i Imidacloprid) (200g a.i/L) at rates of 1.4 – 35 ppm with 50 ml[4] applied per plant to the soil to control the pest Note trees were 1 m tall nursery plants. All concentrations were effective with the higher concentrations providing faster knockdown, but not as fast as Thiamethoxam treatments (see below)	In Australia Allez 350 SC (350 g a.i./L) is used to control various citrus pests when applied as soil drench or via micro-sprinkler or drip irrigation at a rate of 9 ml (3.15 g a.i)/tree.	Australian rate per tree higher than the rate used in the experiment.	Not at this time. Without overseas permits/labels additional data would likely be required to support this use pattern.

[4] 35 ppm = 35 mg a.i/1,000 ml. Therefore, 50 ml of solution per tree = 1.75 mg a.i/tree.

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Lambda-cyhalothrin	Trials conducted in Brazil	Bezerra-Silva et al., (2012)	Lambda-cyhalothrin is a non-systemic pesticide that was reported to provide knock-down for 1 week, so may be suitable for control of incursions (Bezerra-Silva et al., 2012) Bezerra-Silva et al., (2012) also found that Lambda-cyhalothrin provided control for up to 3 weeks	In their experiment Bezerra-Silva et al., (2012) used 0.2 ml of Karate Zeon 50 CS (a.i Lambda-cyhalothrin) (50 g a.i/L)/L of water (i.e. 1 g a.i/100 L) to achieve reasonable control of the pest.	Pesticide is used in Australia but not used on citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Thiamethoxam	Trials conducted in Brazil	Bezerra-Silva et al., (2012)	Thiamethoxam is a systemic insecticide that provided knock-down for 1 week (Bezerra-Silva et al., 2012)	In their experiment Bezerra-Silva et al., (2012) used Actara 250 WG (a.i Thiamethoxam) (250 g a.i/L) at rates of 0.08 - 20 ppm with 50 ml[5] applied per plant to the soil to control the pest. Note trees were 1 m tall nursery plants. All concentrations were effective with the higher concentrations providing faster knockdown	Actara (250g a.i/kg is used in Australia on Kelly's citrus thrips when applied at 20 – 30 g (5 - 7.5 g a.i)/100 L, the label permits up to 5,000 L/ha, which equates to up to 375 g a.i/ha.	Use patterns differ. Used as a drench by Bezerra-Silva et al., (2012) but is used as a foliar spray in Australia	Not at this time

[5] 20 ppm = 20 mg a.i/1000 ml. Therefore, 50 ml of solution per tree = 1 mg a.i/tree

Table 8 Chemical control options for Dilobopterus costalimai a vector of Citrus Variegated Chlorosis

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Lambda-cyhalothrin	Brazil	Karate zeon 50CS label, Syngenta, Brazil	Lambda-cyhalothrin is a non-systemic pesticide that is used overseas to control *Dilobopterus costalima*	Karate zeon 50CS (50 g a.i/L) is used in Brazil on citrus for the control of *Dilobopterus costalima* when applied at a rate of 200 - 400 ml (10 - 20 g a.i)/ha. Apply with 1,000 – 2,000 L of water/ha	Pesticide is available in Australia but not used on citrus	N/A	Not at this time
Thiacloprid	Brazil	Alanto label, Bayer, Brazil	Thiacloprid is a systemic pesticide that is used overseas to control *Dilobopterus costalima*	Alanto (480 g a.i/L) is used in Brazil on citrus for the control of *Dilobopterus costalima* when applied at a rate of 10 ml (4.8 g a.i)/100 L	Pesticide is available in Australia but not used on citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Thiamethoxam + Lambda-cyhalothrin	Brazil	Engeo Pleno label, Syngenta, Brazil	Thiamethoxam is a systemic and Lambda-cyhalothrin is a non-systemic insecticide. This combination of pesticides is registered overseas for the control of *Dilobopterus costalima*	Engeo Pleno (141 g a.i Thiamethoxam + 106 g a.i Lambda-cyhalothrin/L) is used in Brazil on citrus for the control of *Dilobopterus costalima* when applied at a rate of 15 – 25 ml (2.1 - 3.5 g a.i Thiamethoxam + 1.6 - 2.65 g a.i Lambda-cyhalothrin) /100 L	Pesticide is available in Australia but not used on citrus	N/A	Not at this time

Table 9 Chemical control options for Oncometopia facialis a vector of Citrus Variegated Chlorosis

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Bifenthrin	Brazil	Seizer 100EC label, Adama, Brazil	Bifenthrin is a non-systemic insecticide that is registered overseas for the control of *Oncometopia facialis*	Seizer 100EC (100 g a.i/L) is used in Brazil on citrus for the control of *Oncometopia facialis* when applied at a rate of 20 ml (2 g a.i)/100 L	Starlet 100EC (100 g a.i/L) is used in Australia on citrus for the control of leafeating weevils when applied to the ground under the tree at a rate of up to 25 ml (2.5 g a.i)/tree	Used as soil treatment in Australia compared to foliar spray overseas	Not at this time. Different use patterns mean additional data may be required to support this use
Deltamethrin	Brazil	Decis 25EC label, Bayer, Brazil	Deltamethrin is a non-systemic insecticide that is registered overseas for the control of *Oncometopia facialis*	Decis 25EC (25 g a.i/L) is used in Brazil on citrus for the control of *Oncometopia facialis* when applied at a rate of 15 ml (0.375 g a.i)/100 L. Label suggests that users apply 2 - 10 L (0.0075 - 0.0375 g a.i)/plant	Used in Australia but not on citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Gamma-cyhalothrin	Brazil	Nexide label, FMC, Brazil	Gamma-cyhalothrin is a non-systemic insecticide that is registered overseas for the control of *Oncometopia facialis*	Nexide (150 g a.i/L) Is used in Brazil on citrus for the control of *Oncometopia facialis* when applied at a rate of 2.5 - 5 ml (0.375 - 0.75 g a.i)/ 100 L	Trojan (150 g a.i/L) is used in Australia to control Fuller's rose weevil on citrus when applied at a rate of 250 ml (37.5 g a.i)/ 100 L	The pesticide is applied at a higher concentration in Australia than it is used overseas for the control of the pest	Consider further
Imidacloprid	Brazil	Winner label, Bayer, Brazil	Imidacloprid is a systemic insecticide that is registered overseas for the control of *Oncometopia facialis*	Winner (200 g a.i/L) is used in Brazil on citrus for the control of *Oncometopia facialis* when applied at a rate of 2.5 - 5 ml (0.5 - 1 g a.i)/plant	In Australia Allez 350 SC (350 g a.i./L) is used to control various citrus pests when applied as soil drench or via micro-sprinkler or drip irrigation at a rate of 9 ml (3.15 g a.i)/tree	The pesticide is applied at a higher rate in Australia than it is used overseas for the control of the pest	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Imidacloprid	Brazil	Provado 200 SC label, Bayer, Brazil	Imidacloprid is a systemic insecticide that is registered overseas for the control of *Oncometopia facialis*	Provado 200 SC (200 g a.i/L) is used in Brazil on citrus for the control of *Oncometopia facialis* when applied at a rate of 15 - 20 ml (3 - 4 g a.i)/100 L	In Australia Allez 350 SC (350 g a.i./L) is used to control various citrus pests when applied as soil drench or via micro-sprinkler or drip irrigation at a rate of 9 ml (3.15 g a.i)/tree	Different use pattern in Australia (where it is used as a drench) than overseas (where it is applied to foliage)	Not at this time. Different use patterns but other Imidacloprid use patterns appear more appropriate to consider further (see above)
Thiacloprid	Brazil	Calypso label, Bayer, Brazil	Thiacloprid is a systemic insecticide that is registered overseas for the control of *Oncometopia facialis*	Calypso (480 g a.i/L) Is used in Brazil on citrus for the control of *Oncometopia facialis* when applied at a rate of 10 ml (4.8 g a.i)/100 L	Pesticide is used in Australia but not on citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Thiamethoxam	Brazil	Actara 250 WG label, Syngenta, Brazil	Thiamethoxam is a systemic insecticide that is registered overseas for the control of *Oncometopia facialis*	Actara 250 WG (250 g a.i/kg) is used in Brazil on citrus for the control of *Oncometopia facialis* when applied to the soil under the tree at a rate of 3 g (0.75 g a.i)/plant or 600 g (150 g a.i)/ha	Actara (250 g a.i/kg is used in Australia on Kelly's citrus thrips when applied at 20 – 30 g (5 - 7.5 g a.i)/100 L, the label permits up to 5,000 L/ha, which equates to up to 375 g a.i/ha	Australian and overseas use patterns differ	Not at this time. Different use patterns may require additional data to support future permit applications
Thiamethoxam + Lambda-cyhalothrin	Brazil	Engeo Pleno label, Syngenta, Brazil	Thiamethoxam is a systemic and Lambda-cyhalothrin is a non-systemic insecticide. This combination of pesticides is registered overseas for the control of *Oncometopia facialis*	Engeo Pleno (141 g a.i Thiamethoxam + 106 g a.i Lambda-cyhalothrin/L) is used in Brazil on citrus for the control of *Oncometopia facialis* when applied at a rate of 15-25 ml (2.1 - 3.5 g a.i Thiamethoxam + 1.6 - 2.65 g a.i Lambda-cyhalothrin)/100 L	Pesticide is available in Australia but not used on citrus	N/A	Not at this time

Table 10 Summary of potential chemicals for the control of CVC vectors

	BUCEPHALOGONIA XANTHOPHIS	*DILOBOPTERUS COSTALIMA*	*ONCOMETOPIA FACIALIS*
Suitable pesticides for further consideration	Control options described in a study. No labels/permits available that specifically mention the control of this pest.	Several overseas labels refer to the control of this pest, but the products are not used in Australia on citrus	Two potentially suitable pesticides identified: • Gamma-cyhalothrin • Imidacloprid

Concluding remarks

Based on a comparison of the chemicals used overseas and in Australia the following pesticides look to be suitable for future permit applications for the control of *Oncometopia facialis*, see Table 10:

- Gamma-cyhalothrin
- Imidacloprid

Currently no suitable pesticides have been identified for the control of the other vectors of CVC. Due to the significance of this pathogen additional work may be required to more thoroughly research and identify suitable chemical control options for the vectors of CVC.

Chemical control options for Citrus tristeza virus (exotic strains)

Background

Some strains of Citrus tristeza virus occur in Australia (including Grapefruit stem pitting and orange stem pitting). There are also exotic strains that do not currently occur in Australia, such as the mandarin stem pitting strain, which is considered to be a high priority pest of this citrus industry (PHA 2014).

Citrus tristeza virus is vectored by aphids and is also graft transmittable. The main vectors are the endemic Black citrus aphid (*Toxoptera aurantii*) and the Black (sometimes called Brown) citrus aphid (*Toxoptera citricida*) (Roistacher and Moreno 1991). Other vectors include Melon aphid (*Aphis gossypii*) and occasionally Spiraea aphid (*Aphis citricola*) (Roistacher and Moreno 1991), both of which are endemic in Australia.

The virus affects all citrus, but severity varies between strains and citrus varieties. Citrus tristeza virus can cause tree stunting, poor yields, stem deformities and brittleness. Current strains are managed using resistance varieties and clean budwood schemes. Australian varieties may not have resistance to exotic strains of the virus, meaning that exotic strains of the virus could have a significant effect on Australia's citrus industry (PHA 2014).

Chemical control options

Management overseas and in Australia (for established strains) relies on the use of resistant varieties and root stocks and the planting of virus tested plating material.

If an outbreak of a new strain of the virus occurred control would likely rely on the removal of affected and nearby citrus plants. Pesticides would also be used to reduce the vector population and limit the potential spread of the virus to new areas while host removal occurs.

If pesticides are required to control the spread of the vector from an infected site there are several pesticides currently available in Australia that are labelled for the control of Black citrus aphids (Table 11) or for 'aphids' (species not specified) on citrus (Table 12), no insecticides were identified that specifically control Brown citrus aphids. These pesticides could be used, in conjunction with host removal, as part of an eradication response to the detection of exotic strains of the virus.

Table 11 Pesticide options currently available for the control of Black citrus aphid in Australia

PESTICIDE	EXAMPLE PRODUCT	APVMA APPROVAL NUMBER
Imidacloprid	Genfarm Imidacloprid 350 Insecticide	84404/110316
Methidathion	Suprathion 400 EC Insecticide	55599/100267

PESTICIDE	EXAMPLE PRODUCT	APVMA APPROVAL NUMBER
Pyrethrins + Piperonyl Butoxide	Richgro Pyrethrum Naturally Based Insect Killer	61617/51655 (note garden type rather than commercial pesticide)

Table 12 Pesticide options currently available for the control of 'aphids' in Australia

PESTICIDE	EXAMPLE PRODUCT	APVMA APPROVAL NUMBER
Dimethoate	Dimex 400 EC Insecticide	83009/112027
Maldison	Fyfanon 440 EW Insecticide	51150/101326
Pirimicarb	OzCrop Pirimicarb 500WG Aphicide	68494/58462

Concluding remarks

Should a detection of an exotic strain of Citrus tristeza virus occur the virus could be controlled via the removal of hosts and control of aphid vectors using the pesticides listed in Table 11 or Table 12. As these pesticides are currently labelled for the control of the pest in Australia additional emergency use pesticides are not likely to be required.

Chemical control options for Exotic fruit flies

Background

Fruit flies can be significant pests of citrus. Feeding damage can cause downgrades and the presence of fruit fly in a region can affect access to domestic and overseas markets. The Citrus Biosecurity Plan (PHA 2014) identified six species of fruit fly as being high priority pests for the industry, these are:

- Carambola fruit fly (*Bactrocera carambolae*)
- Fruit fly (*Bactrocera kandiensis*)
- Fruit fly (*Bactrocera occipitalis*)
- Mexican fruit fly (*Anastrepha ludens*)
- New Guinea fruit fly (*Bactrocera trivialis*)
- Oriental Fruit fly (*Bactrocera dorsalis* (Syn. *B. invadens, B. papayae, B. philippinensis*))

Carambola fruit fly (*Bactrocera carambolae*)

The Carambola fruit fly (*B. carambolae*) is a damaging fruit fly that affects a range of fruit including carambola (star fruit), mango, citrus, guava, jackfruit and others. This species is native to Asia but has since spread to parts of South America (Marchioro 2016). Countries that have the pest include: Thailand, Vietnam, Malaysia, Singapore, Indonesia, Andaman Islands, Surinam, French Guiana, Guyana, Brazil (PHA 2016).

This species is attracted to Methyl eugenol (PHA 2016).

Fruit fly (*Bactrocera kandiensis*)

The Fruit fly (*B. kandiensis*) is a destructive fruit fly that occurs in Sri Lanka (PHA 2016). Hosts include: pumelo, cashew, guava, papaya, carambola and *Syzygium* spp.

This species is attracted to Methyl eugenol (PHA 2016).

Fruit fly (*Bactrocera occipitalis*)

The Fruit fly (*B. occipitalis*) is a damaging fruit fly that affects a range of hosts including citrus. This species occurs in the Philippines, Malaysia, and Indonesia (PHA 2016).

This species is attracted to Methyl eugenol (PHA 2016).

Mexican fruit fly (*Anastrepha ludens*)

The Mexican fruit fly (*A. ludens*) is a significant pest of citrus and mango overseas, where it is managed using area wide management techniques (Weems et al., 2015). This pest occurs in the southern United States, Mexico and Costa Rica (PHA 2016).

This species is attracted to ammonia (PHA 2016).

New Guinea fruit fly (*Bactrocera trivialis*)

The New Guinea fruit fly (*B. trivialis*) is mostly a pest of guava and *Syzygium* spp. but also affects a range of other fruit including citrus. This species only occurs on the mainland of New Guinea.

This species is attracted to Cue lure (PHA 2016).

Oriental fruit fly (*Bactrocera dorsalis*)

The Oriental fruit fly (*B. dorsalis*) is part of a damaging complex of fruit flies. This species has a wide host range and is very invasive, occurring naturally in Asia but now introduced to other areas including Hawaii, Tahiti and Mariana Islands and large areas of Africa (CABI 2018). There are also periodic outbreaks in parts of the Torres Strait.

This species is attracted to Methyl eugenol (PHA 2016).

Chemical control options used overseas

Table 13 provides a summary of the chemical control options currently used overseas for the control of these pests and how these compare to Australian pesticide use patterns. Chemicals that are used in a similar way in Australia as they are used overseas are noted below.

Table 13 Chemical control options for exotic fruit flies

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Carambola fruit fly (*Bactrocera carambolae*)							
Maldison (Syn. Malathion)	Central America	Munroe (2002); Midgarden et al., (2016)	No labels specifying the control of this species were identified. Historically this species was controlled in Central America using Male Annihilation Techniques, but the program was cancelled, and the pest's range is again expanding (Midgarden et al., 2016). Reports suggest that Malathion with Methyl eugenol were used as part of this eradication program (Munroe 2002)	No rates found specifically for this species of fruit fly	Fyfanon 440 EW (440 g a.i/L) is used in Australia for the control of various pests in citrus when applied at rates of up to 230 ml (101.2 g a.i)/100 L	Without information on the rates used overseas a comparison cannot be made	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Fruit fly (*Bactrocera kandiensis*)							
No information on the effectiveness of insecticides. No labels specifying the control of this species identified							
Fruit fly (*Bactrocera occipitalis*)							
No information on the effectiveness of insecticides. No labels specifying the control of this species identified							
Mexican fruit fly (*Anastrepha ludens*)							
Maldison (Syn. Malathion)	United States	Malathion 8 Aquamul. Florida Special Local Need Reg. No. FL-1500006	Non-systemic insecticide. Widely used for control of fruit fly overseas	Malathion 8 Aquamul (8 lb. a.i/gallon (958.6 g a.i/L)) is used to control Mexican fruit fly on citrus in Florida when applied at a rate of 2.9 fl. oz./acre (211.9 ml (203.1 g a.i)/ha) with 9.6 fl. oz./acre (701.5 ml/ha) of hydrolase bait. The solution is then applied in 40 gallons of water per acre (374.15 L/ha). This equates to 54.3 g a.i Maldison + 187.5 ml hydrolase bait/100L	Fyfanon 440 EW (440 g a.i/L) is used in Australia for the control of various pests in citrus when applied at rates of up to 230 ml (101.2 g a.i)/100 L	Australian and overseas rates comparable	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATI ON?
Spinosad	United States	GF-120 NF Naturalyte supplemental label, Dow AgroSciences, United States	Spinosad is widely used for control of fruit fly and other pests overseas and in Australia	GF120 NF Naturalyte (0.002 lb. a.i/gallon (0.23 g a.i/L)) is used in the United States for the control of Mexican fruit fly when applied at a rate of 0.8 - 1.6 L (0.184 - 0.368 g a.i)/ha or 30 - 90 ml (0.0069 - 0.0207 g a.i)/tree	Naturalure (0.24 g a.i/L) is used in Australia for the control of fruit fly (including Queensland fruit fly and Mediterranean fruit fly) on a range of crops when applied at a rate of 1 L (0.24 g a.i)/ha	Overseas and Australian rates are comparable	Consider further
New Guinea fruit fly (*Bactrocera trivialis*)							
No information on the effectiveness of insecticides. No labels specifying the control of this species identified							

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATI ON?
Oriental Fruit fly (*Bactrocera dorsalis* (Syn. *B. invadens, B. papayae, B. philippinensis*))							
Spinosad	United States	GF-120 NF Naturalyte supplemental label, Dow AgroSciences, United States	Spinosad is widely used for the control of fruit fly and other pests overseas and in Australia	GF120 NF Naturalyte (0.002 lb. a.i/gallon (0.23 g a.i/L)) is used in the United States for the control of Oriental fruit fly when applied at a rate of 0.8 - 1.6 L (0.184 - 0.368 g a.i)/ha or 30 - 90 ml (0.0069 - 0.0207 g a.i)/tree	Naturalure (0.24 g a.i/L) is used in Australia for the control of fruit fly (including Queensland fruit fly and Mediterranean fruit fly) on a range of crops when applied at a rate of 1 L (0.24 g a.i)/ha	Australian rate per hectare is comparable to that used overseas	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Maldison (Syn. Malathion)	United States	Malathion 8 Aquamul. 2ee recommendation for Florida. United States. EPA Reg. No. 34704-474 Malathion 8 Aquamul. Florida Special Local Need Reg. No. FL-1500006	Non-systemic insecticide. Widely used for control of fruit fly overseas	Malathion 8 Aquamul (8 lb. a.i/gallon (958.6 g a.i/L)) is used to control Oriental fruit fly on citrus in Florida when applied at a rate of 2.9 fl. oz./acre (211.9 ml (203.1 g a.i)/ha) with 9.6 fl. oz./acre (701.5 ml/ha) of hydrolase bait. The solution is then applied in 40 gallons of water per acre (374.15 L/ha). This equates to 54.3 g a.i Maldison + 187.5 ml hydrolase bait/100L, applied at 374.15L/ha.	Fyfanon 440 EW (440 g a.i/L) is used in Australia for the control of various pests in citrus when applied at rates of up to 230 ml (101.2 g a.i)/100 L.	Australian and overseas rates comparable	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATI ON?
Naled	United States	Dibrom Special Local Need Registration, EPA Reg. No 5481-480. Hawaii, United States	Naled is a non-systemic insecticide that is widely used overseas for the control of fruit flies and other pests.	Dibrom (13.2 lb. a.i/gallon (1,581.7 g a.i/L)) is used in Hawaii to control Oriental fruit fly when applied at a rate of 23 fl. oz./3 quarts (239.6 ml (379 g a.i)/L) of Methyl Eugenol. Dibrom can be applied at a rate of 600 baits/square mile (=2.3 baits/ha) with repeated applications every 2 - 4 weeks. Each bait is about 25 ml (i.e. 9.475 g a.i).	Pesticide not used in Australia on citrus	N/A	Not at this time

Table 14 Summary of potential chemicals for the control of exotic fruit flies

ACTIVE SUITABLE FOR CONTROL OF PEST	CARAMBOLA FRUIT FLY (*BACTROCERA CARAMBOLAE*)	FRUIT FLY (*BACTROCERA KANDIENSIS*)	FRUIT FLY (*BACTROCERA OCCIPITALIS*)	MEXICAN FRUIT FLY (*ANASTREPHA LUDENS*)	NEW GUINEA FRUIT FLY (*BACTROCERA TRIVIALIS*)	ORIENTAL FRUIT FLY (*BACTROCERA DORSALIS*)
Spinosad				✓		✓
Maldison (Syn. Malathion)	Maldison has been used overseas but no information on rates available			✓		✓
No options identified		✓	✓		✓	

Concluding remarks

Based on a comparison of the pesticides used overseas and in Australia the following pesticides appear to be suitable for future permit applications for the control of exotic fruit flies (also see Table 16):

- Spinosad
- Maldison (Syn. Malathion)

These chemicals have been identified as their use overseas for the control of the pest is very similar to their existing use patterns (in terms of rates applied) in Australia. This means that these pesticides are good candidates for future permit applications.

Chemical control options for Exotic thrips

Background

Thrips can be significant pests of citrus. Feeding damage can cause downgrades and the presence of thrips can affect access to some markets. The Citrus Biosecurity Plan (PHA 2014) identified two thrips as being high priority pests for the industry, these are:

- Bean thrips (*Caliothrips fasciatus*)
- Florida flower thrips (*Frankliniella bispinosa*)

Bean thrips (*Caliothrips fasciatus*)

Bean thrips (*C. fasciatus*) are small dark coloured thrips. This species is found in the southern United States and Mexico (Weeks et al., 2012). They are considered a citrus pest as they can contaminate fruit shipments, meaning consignments require treatment to access some markets (Grafton-Cardwell et al., 2017a).

Florida flower thrips (*Frankliniella bispinosa*)

Florida flower thrips (*F. bispinosa*) are an economically important citrus pest in the United States. This species causes premature flower drop, due to feeding damage, resulting in reduced fruit set and yield losses (Childers and Nakahara 2006). This species has a wide host range feeding on the flowers of various hosts including; citrus, blueberries, strawberries, roses and vegetables (Arthurs et al., 2015). Florida flower thrips are found in the south west of the United States, Bahamas, Bermuda, Columbia, Japan, Mexico, Taiwan, and Trinidad (Martin et al., 2012a).

Chemical control options used overseas

Table 15 provides a summary of the chemical control options currently used overseas for the control of these pests and how these compare to Australian pesticide use patterns. Chemicals that are used in a similar way in Australia as they are used overseas are noted below.

Table 15 Chemical control options for exotic citrus thrips

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Chlorpyrifos	United States	Lorsban Advanced label, Dow AgroSciences, United States.	Chlorpyrifos is a non-systemic insecticide that is used in the United States for the **suppression** of thrips on citrus.	Lorsban Advanced (3.755 lb. a.i/gallon (~450 g a.i/L)) is used in the United States to control thrips on citrus when applied at a rate of 2 - 7 pints/acre (2,338.5 - 8,184.7 ml (1,052.3-3,683.1 g a.i)/ha). The label recommends using at least 100 gallons of water per 0.5 pints of Lorsban Advanced (meaning 400-1,400 gallons/acre (3,741.6-13,095.5 L/ha) (=28.12 g a.i/100 L) is required for the control of citrus pests In Florida the label notes higher rates of 6-12 pints/acre (7,015.5-14,030.9 ml (3,367.44-6734.8 g a.i)/ha) for the **suppression** of thrips. The label recommends using at least 100 gallons	Lorsban 500EC (500 g a.i/L) is used on citrus to control California red scale when applied at 100 ml (50 g a.i)/100 L, spray to the point of run off. Two applications are permitted per year	Based on the overseas water volumes per hectare the Australian and overseas rates are comparable	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
				of water per 0.5 pints of Lorsban Advanced (meaning 1,200-2,400 gallons/acre (11,224.75-24,449.5 L/ha) (=28.12 g a.i/100 L) is required for the control of citrus pests			
Dimethoate	United States	Dimethoate 400 label, Loveland Products, United States.	Dimethoate is a systemic insecticide that is used in the United States for the control of thrips on citrus	Dimethoate 400 (4 lb. a.i /gallon (480 g a.i/L)) is used in the United States for the control of thrips (species not specified) on citrus when applied at a rate of 0.5 - 1.0 pints/100 gallons (62.5 - 125 ml (30 - 60 g a.i)/100 L	Various Dimethoate products such as Dimex 400EC (400 g a.i/L) are used on Australian citrus to control various pests including thrips when applied at a rate of 75 ml (30 g a.i)/100 L	Lower overseas concentration is comparable to Australian use patterns	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Maldison (Syn. Malathion)	United States	Malathion 57% label, Cheminova, United States	Maldison is a non-systemic insecticide that is used in the United States for the control of thrips on citrus	Malathion 57% (5 lb. a.i/gallon (600 g a.i/L)) is used for the control of thrips (species not specified) on citrus when applied at a rate of 1.5 - 7.5 pints/acre (1,754 - 8769 ml (1,052.4 - 5,261.4 g a.i)/ha). The label suggests up to 500 gallons/acre (~4,700L/ha), which equates to 22.4-111.9 g a.i/100 L	Fyfanon 440 EW (440 g a.i/L) is used in Australia to control citrus pests when applied at a rate of 140 - 230 ml (61.6 - 101.2 g a.i)/100 L	Australian rates and overseas rates are comparable	Consider further
Methomyl	United States	Lannate LV label, DuPont, United States	Methomyl is a systemic insecticide that is used in the United States to control thrips in citrus.	Lannate LV (2.4 lb. a.i/gallon (287.6 g a.i/L)) is used in the United States for the control of thrips (species not specified) on citrus when applied at a rate of 1.5 - 3 pints/acre (1,753.9 - 3,507.7 ml (504.4 - 1,008.8 g a.i)/ha)	Lymo 225 (225 g a.i/L) is used in Australia for the control of citrus pests when applied at a rate of 25 - 200 ml (5.625 - 45 g a.i)/100 L	Assuming a typical water volume required to achieve run off in citrus of 3,300 L/ha, the Australian rates are greater than the overseas rates	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Piperonyl Butoxide + Pyrethrins	United States	AgriPest Cropfume P-H with Pyrethrins label, MGK, United States	Piperonyl Butoxide is a synergist that improves the efficacy of Pyrthrins (non-systemic insecticide). Together these are used to control Bean thrips (*Caliothrips fasciatus*) in the United States	AgriPest Cropfume P-H with Pyrethrins (32.26% Piperonyl Butoxide + 4.03% Pyrethrins) is used in the United States for the post-harvest management of Bean thrips (*Caliothrips fasciatus*) when applied as a fumigant at a rate of 5 g/1000 cubic feet (0.17 g (0.05 g a.i Piperonyl Butoxide + 0.007 g a.i Pyrethrins)/m^3) of storage space	This combination of pesticides are available for use on citrus but are used as a home garden rather than commercial product.	Different use patterns used in Australia and overseas.	Not at this time
Zeta-cypermethrin	United States	Mustang label, FMC, United States	Zeta-cypermethrin is a non-systemic insecticide that is used in the United States to control thrips in citrus	Mustang (1.5 lb. a.i/gallon) (180 g a.i/L) is used in the United States for the control of thrips (species not specified) on citrus when applied at a rate of 5.3 fl. oz./acre (387.3 ml (69.7 g a.i)/ha)	This pesticide is used in Australia but is not used on citrus	N/A	Not at this time

Table 16 Summary of potential chemicals for the control of exotic thrips

	BEAN THRIPS (*CALIOTHRIPS FASCIATUS*)	FLORIDA FLOWER THRIPS (*FRANKLINIELLA BISPINOSA*)	THRIPS (SPECIES NOT SPECIFIED) ON CITRUS
SUITABLE PESTICIDES FOR FURTHER CONSIDERATION	Control option available overseas but the pesticide is not used on commercial citrus plantings in Australia	No overseas labels that specifically refer to control of this species	Chlorpyrifos (**suppression only**) Dimethoate Maldison (Syn. Malathion) Methomyl

Concluding remarks

Based on a comparison of the chemicals used overseas and in Australia the following pesticides look to be suitable for future permit applications for the control of thrips, including the exotic Bean thrips (*Caliothrips fasciatus*), and Florida flower thrips (*Frankliniella bispinosa*), also see Table 16:

- Chlorpyrifos (**suppression only**)
- Dimethoate
- Maldison (Syn. Malathion)
- Methomyl

These chemicals have been selected as their use overseas is very similar to the existing use patterns used in Australia. This means that these pesticides are good candidates for future permit applications.

Chemical control options for Glassy winged sharpshooter (*Homalodisca vitripennis*)

Background

Glassy winged sharpshooter (*Homalodisca vitripennis*) (GWSS) is recognized as one of the main vectors of *Xylella fastidiosa* in the United States, especially on grape vines. Laboratory experiments have shown that it can transmit the strain of *X. fastidiosa* subsp. *pauca* that causes Citrus Variegated Chlorosis (a significant citrus pest, see Page 23) in South America (Damsteegt et al., 2006). GWSS is also a pest in the absence of pathogens. Nymphs can suck and expel 10 times their body weight in xylem fluid per hour, which can weaken plants. The expelled fluid coats plants and fruit causing discolouration that must be washed off prior to the sale of the fruit (Martin et al., 2012b). Feeding by GWSS has also been associated with yield and fruit size reductions with field experiments showing that orchards with high GWSS populations resulted in a lower proportion of large fruit and a lower yield of fruit than orchards with low GWSS populations (Hix et al., 2003).

Glassy winged sharpshooters are managed on citrus in the United States, however this is more as part of an area wide management program to control Pierce's disease of grapevines [In the United States the GWSS overwinter in citrus then move on to gapes vines and begin to spread Pierces disease (CDFA 2018)] than to manage the damage that the GWSS causes to citrus.

The GWSS is native to North America (southeast United States and north eastern Mexico (Grandgirad et al., 2006)), but has also been introduced to French Polynesia, Easter Island, Cook Islands and Hawaii.

Chemical control options used overseas

Table 17 provides a summary of the chemical control options currently used overseas and how these compare to Australian pesticide use patterns. Chemicals that are used in a similar way in Australia as they are used overseas are noted below.

Table 17 Chemical control options for Glassy winged sharpshooter (GWSS)

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Acetamiprid	United States	Assail 70WP label, Nippon Soda Co., United States	Acetamiprid is a systemic insecticide that is used overseas to control GWSS	Assail 70WP (70% a.i) is used in the United States to control GWSS when applied at a rate of 1.7 - 2.9 fl. oz./acre (124.2 - 211.9 ml (86.94 - 148.33 g a.i)/ha)	Pesticide is in Australia, but it is not used on citrus in Australia	N/A	Not at this time
Beta-cyfluthrin	United States	Baythroid XL label, Bayer, United States	Beta-cyfluthrin is a non-systemic insecticide that is used overseas to control GWSS	Baythroid XL (1 lb.. a.i/gallon (120 g a.i/L)) is used in the United States to control GWSS when applied at a rate of 1.6 - 3.2 fl. oz./acre (116.9 - 233.8 ml (14 - 28 g a.i)/ha)	Pesticide is available in Australia, but is not used on citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Bifenthrin + Imidacloprid	United States	Skyraider label, Adama, United States	Bifenthrin is a non-systemic insecticide. Imidacloprid is a systemic insecticide. Together these pesticides are registered for use in the United States for the control of Sharpshooters	Skyraider (2 lb. a.i Bifenthrin + 1 lb. a.i Imidacloprid/gallon (240 g a.i Bifenthrin + 120 g a.i Imidacloprid)) is used in the United States to control Sharpshooters when applied at a rate of 16 - 32 fl. oz./acre (1,169.2 - 2,338.5 ml (280.6 - 561.2 g a.i Bifenthrin + 140.3 - 280.6 g a.i Imidacloprid)/ha)	This pesticide is available in Australia, but it is not used on citrus	N/A	Not at this time
Bifenthrin + Imidacloprid	United States	Swagger label, Loveland, United States	Bifenthrin is a non-systemic insecticide. Imidacloprid is a systemic insecticide. Together these pesticides are registered for use in the United States for the control of Sharpshooters	Swagger (0.5 lb. a.i Bifenthrin + 0.5 lb. a.i Imidacloprid/gallon (60 g a.i Bifenthrin + 60 g a.i Imidacloprid)) is used in the United States to control Sharpshooters on citrus when applied at a rate of 32 - 64 fl. oz./acre (2,338.5 - 4,677 ml (140.3 - 280.6 g a.i Bifenthrin + 140.3 - 280.6 g a.i Imidacloprid)/ha)	This pesticide combination is available in Australia but is not currently used on Australian citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Buprofezin	United States	Applaud label, Nichino America, United States	Buprofezin is an insect growth regulator that targets Hemipteran insects (i.e. true bugs), including GWSS	Applaud (70% a.i) is used in the United States to control GWSS when applied at a rate of 34.5 - 46.0 oz./acre (2,416.8 - 3,222 g (1,691.76 - 2,255.4 g a.i)/ha)	Applaud (440 g a.i/L) is used in Australia to control citrus pests when applied at a rate of 30 - 60 ml (13.2 - 26.4 g a.i)/100 L. Label recommends using 7,000 - 12,000 L/ha (i.e. 920 - 3,168 g a.i/ha)	Upper Australian rates are comparable to overseas rates	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Chlorpyrifos	United States	Lorsban Advanced label, Dow AgroSciences, United States	Chlorpyrifos is a non-systemic insecticide used to control GWSS in the United States.	Lorsban Advanced (3.755 lb. a.i/gallon (~450 g a.i/L)) is used in the United States to control GWSS on citrus when applied at a rate of 2 - 7 pints/acre (2,338.5 - 8,184.7 ml (1052.3-3683.1 g a.i)/ha). The label recommends using at least 100 gallons of water per 0.5 pints of Lorsban Advanced (meaning 400-1,400 gallons/acre (3,741.6-13,095.5 L/ha) (=28.12 g a.i/100 L) is required for the control of ACP in citrus	Lorsban 500EC (500g .ai/L) is used in Australia to control citrus pests when applied at up to 100 ml (50 g a.i)/100 L	Assuming that the same volume of water is used in Australia as recommended on the overseas label the Australian and overseas rates are comparable	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Chromobacterium subtsugae strain PRAA4-1T and spent fermentation media	United States	Grandevo label, Marrone Bio Innovations, United States	This is an organically approved non-systemic pesticide registered for use in the United States to control GWSS	Grandevo (1000 cabbage looper killing units/mg) is used in the United States to control GWSS on citrus when applied at a rate of 3 - 5 lb./acre (3,362.55 - 5,604.26 g (3,362.55 - 5,604.26 million cabbage looper killing units)/ha)	This pesticide is not used in Australia	N/A	Not at this time
Cyfluthrin	United States	Tombstone label, Loveland, United States	Cyfluthrin is a non-systemic pesticide registered for use in the United States to control GWSS	Tombstone (2 lb. a.i/gallon (240 g a.i/L)) is used in the United States to control GWSS on citrus when applied at a rate of 1.6 - 3.2 fl. oz./acre (116.9 - 233.8 ml (28 - 56.1 g a.i)/ha)	This pesticide is available in Australia but is not currently used on Australian citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Fenpropathrin	United States	Danitol 2.4 EC label, Valent, United States	Fenpropathrin is a non-systemic pesticide registered for use in the United States to control GWSS	Danitol 2.4 EC (2.4 lb. a.i/gallon (287.6 g a.i/L)) is used in the United States to control GWSS when applied at a rate of 21.33 fl. oz./acre (1,558.7 ml (448.2 g a.i)/ha). Label recommends 50 - 200 gallons/acre (467.7 – 1,870.8 L/ha) to ensure coverage	Product is not used in Australia	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Imidacloprid	United States	Admire Pro label, Bayer, United States	Imidacloprid is a systemic pesticide registered for use in the United States to control GWSS. However, it should be noted that some GWSS populations in California are developing resistance to imidacloprid (CDFA 2018)	Admire Pro (4.6 lb. a.i/gallon (551 g a.i/L)) is used in the United States to control Sharpshooters when applied as a foliar spray at a rate of 3.5 - 7.0 fl. oz./acre (255.8 - 511.5 ml (140.9 - 281.8 g a.i)/ha) Admire Pro is used as a soil treatment to control Sharpshooters on citrus when applied at a rate of 7.0 - 14.0 fl. oz./acre (511.5 - 1,023.1 ml (281.8 - 563.7 g a.i)/ha) Admire Pro is used to control Sharpshooters in nurseries when applied at a rate of 0.33 - 0.5 ml (0.18 - 0.27 g a.i)/'citra' pot (0.1 cubic foot) (2.83 L)	In Australia Allez 350 SC (350 g a.i./L) is used to control various citrus pests when applied as soil drench or via micro-sprinkler or drip irrigation at a rate of 9 ml (3.15 g a.i)/tree. Number of trees per hectare varies dependent on variety and location. Typically, it is around 300 trees/ha[6], meaning up to 945 g a.i/ha may be used	Assuming a typical density of around 300 trees/ha[6] the Australian and overseas rates are comparable	Consider further

[6] Citrus Australia (2017)

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Imidacloprid + Cyfluthrin	United States	Leverage 2.7 label, Bayer, United States	Imidacloprid is a systemic insecticide. Cyfluthrin is a non-systemic insecticide. Together these pesticides are registered for use in the United States for the control of GWSS	Leverage 2.7 (1.6 lb. a.i Imidacloprid + 1.1 lb. a.i Cyfluthrin/gallon (191.7 g a.i Imidacloprid + 131.8 g a.i Cyfluthrin/L)) is used in the United States to control GWSS on citrus when applied at a rate of 3 - 5 fl. oz./acre (219.233 - 365.4 ml (42 - 70 g a.i Imidacloprid + 28.9 - 48.15 g a.i Cyfluthrin)/ha)	This pesticide combination is not used in Australia	N/A	Not at this time
Pyrethrins	United States	PyGanic EC 5.0 label, Valent, United States	Pyrethrin is a non-systemic pesticide registered for use in the United States to control GWSS.	PyGanic EC 5.0 (5% a.i) is used in the United States to control GWSS when applied at a rate of up to 17 fl. oz./acre (1,242.32 ml (62.116 g a.i)/ha)	PyGanic insecticide (13 g a.i/L) is used in Australia on citrus for the control of Greenhouse thrips when applied at a rate of 150 ml (1.95 g a.i)/100 L	Assuming a typical water volume required to achieve run off in citrus of 3,300 L/ha, the Australian and overseas rates are comparable	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Thiamethoxam	United States	Acatara label, Syngenta, United States	Thiamethoxam is a systemic pesticide registered for use in the United States to control GWSS There are reports that some populations are developing resistance to Thiamethoxam in California (Grafton-Cardwell et al., 2017b)	Actara (25% a.i) is used in the United States to control Sharpshooters when applied at a rate of 4.0 - 5.5 oz./acre (280.2 - 385.3 g (70 - 96.3 g a.i)/ha)	Actara (250 g a.i/kg is used in Australia on Kelly's citrus thrips when applied at 20 - 30 g (5 - 7.5 g a.i)/100 L, the label permits up to 5,000 L/ha, which equates to up to 375 g a.i/ha	Overseas rates comparable to Australian rates	Consider further but noting potential resistance issues reported in the United States

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Thiamethoxam + Abamectin	United States	Agri-flex label, Syngenta, United States	Imidacloprid is a systemic insecticide. Abamectin is a non-systemic insecticide. Together these pesticides are registered for use in the United States for the control of GWSS	Agri-flex (1.27 lb. a.i Thiamethoxam + 0.277 lb. a.i Abamectin/gallon (152 g a.i Thiamethoxam + 33 g a.i Abamectin/L) is used in the United States to control Sharpshooters when applied at a rate of 0.55 - 0.85 fl. oz./100 gallons (4.3 - 6.6 ml (0.65 - 1 g a.i Thiamethoxam + 0.14 - 0.21 Abamectin)/ 100 L) or 5.5 - 8.5 fl. oz./acre (401.9 - 621.2 ml (61.1 - 94.4 g a.i Thiamethoxam + 13.26 - 20.5 g a.i Abamectin)/ha)	This combination of pesticides is not available in Australia	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Thiamethoxam + Chlorantraniliprole	United States	Voliam Flexi label, Syngenta, United States	Thiamethoxam is a systemic insecticide. Chlorantraniliprole is a non-systemic insecticide. Together these pesticides are registered for use in the United States for the control of GWSS	Voliam Flexi (20% a.i Thiamethoxam + 20% a.i Chlorantraniliprole) is used in the United States to control GWSS when applied at a rate of 5.0 - 7.0 oz./acre (350.3 - 490.4 g (70.06 - 98.08 g a.i Thiamethoxam + 70.06 - 98.08 g a.i Chlorantraniliprole)/ha)	This combination of pesticides is used in Australia but not on citrus	N/A	Not at this time
Zeta-cypermethrin	United States	Mustang label, FMC, United States	Zeta-cypermethrin is a non-systemic pesticide registered for use in the United States to control GWSS	Mustang (1.5 lb. a.i/gallon (180 g a.i/L)) is used in the United States to control GWSS on citrus when applied at a rate of 4.3 fl. oz./acre (314.2 ml (56.5 g a.i)/ha)	This pesticide is available in Australia but is not currently used on Australian citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Zeta-cypermethrin + Avermectin	United States	Gladiator label, FMC, United States	Zeta-cypermethrin and Avermectin are both non-systemic pesticides. Together the two pesticides are registered for use in the United States to control GWSS on citrus.	Gladiator (0.172 lb. a.i Zeta-cypermethrin + 0.08 lb. a.i Avermectin/gallon (20.6 g a.i Zeta-cypermethrin + 9.6 g a.i Avermectin/L)) is used in the United States to control GWSS when applied at a rate of 4.75 fl. oz./100 gallons (37.1 ml (0.76 g a.i Zeta-cypermethrin + 0.35 g a.i Avermectin)/100 L) or 19 fl. oz./acre (1,388.48 ml (28.6 g a.i Zeta-cypermethrin + 13.3 g a.i Avermectin)/ha)	Product is not used in Australia	N/A	Not at this time

Concluding remarks

Based on a comparison of the pesticides used overseas and in Australia the following pesticides look to be suitable for future permit applications for the control of Glassy winged sharpshooter:

- Buprofezin
- Chlorpyrifos
- Imidacloprid
- Pyrethrins
- Thiamethoxam

These chemicals have been selected as their use overseas for the control of the pest is very similar to their existing use patterns (in terms of volume applied) in Australia. This means that these pesticides are good candidates for future permit applications.

Control options for Huanglongbing and psyllid vectors

Background

Huanglongbing is the most serious citrus disease worldwide (Sechler et al., 2009; Gottwald 2010). The bacterial disease causes fruit to become bitter, misshapen (lop-sided) and trees to go into decline and eventually die. In countries where the disease is endemic trees may only live for 5-8 years and never produce marketable fruit (Halb.ert and Manjunath 2004). In the absence of vectors, the disease is self-limiting as infected trees die as a result of the infection (Halb.ert et al., 2008). Although the disease can still be spread via grafts from infected trees.

The disease is caused by three strains of gram-negative bacteria, which colonise the phloem sieve tubes of the infected plant (Lopes and Frare 2008; Teixeira et al., 2008), limiting sugar transport (Tatineni et al., 2008). All three strains are transmitted by grafts, and marcotting (air layering) although not all grafts taken from an infected tree may be infected as the bacteria are not evenly distributed in the tree. This also means that false negatives can occur (Gottwald 2010).

There are three strains of bacteria that are reported to cause Huanglongbing:

- '*Candidatus* Liberibacter africanus' (African strain)
- '*Candidatus* Liberibacter americanus' (American strain)
- '*Candidatus* Liberibacter asiaticus' (Asiatic strain)

The strains differ in their ability to tolerate different temperatures and their current geographic distribution. But all cause similar symptoms.

The Asiatic strain is the most damaging of the three strains. It is widespread in Asia and has recently been reported from the United States, where is has spread rapidly and is having a significant impact on the United States citrus industry (Gottwald 2010). The Asiatic strain of the bacteria is described as heat tolerant and can cause symptoms and multiply at temperatures above 35°C (Lopes et al., 2009).

The African strain of Huanglongbing was first reported in the 1920s in South Africa (Pietersen et al., 2010). The strain is currently confined to Africa and the Middle East. This strain is reported to be heat sensitive, with plants able to recover from symptoms at temperatures above 32°C (Pietersen et al., 2010). Symptoms are similar to the Asiatic strain, but usually less severe die back is observed (Gottwald et al., 2007), meaning it is considered to be less damaging than the Asiatic strain (Van Den Berg 1990).

The American strain of Huanglongbing is the most recently described and has only been recorded in Brazil (Teixeira et al., 2005) and north western Argentina (Ramallo et al., 2008). It has been shown to be heat sensitive, with experiments showing that temperatures of over 32°C are detrimental to the bacteria (Lopes et al., 2009). Symptoms and severity are similar to the Asian strain (Gottwald et al., 2007).

Huanglongbing is vectored by four species of citrus psyllid (the vector-bacteria relationship is described in Table 18, below). Although the bacteria cannot be controlled using pesticides and infected trees should be removed, the vectors can be controlled using pesticides to reduce the spread of the disease to new areas.

Table 18 Huanglongbing and it vectors

PATHOGEN	KNOWN VECTORS	COMMENTS
'*Candidatus* Liberibacter asiaticus' (Asiatic strain)	Asiatic citrus psyllid (*Diaphorina citri*)	See PHA (2015) for further information
	African citrus psyllid (*Trioza erytreae*)	
	Pomelo psyllid (*Cacopsylla citrisuga*)	
	Black psyllid (*Diaphorina communis*)	
'*Candidatus* Liberibacter africanus' (African strain)	Asiatic citrus psyllid (*Diaphorina citri*)	
	African citrus psyllid (*Trioza erytreae*)	
'*Candidatus* Liberibacter americanus' (American strain)	Asiatic citrus psyllid (*Diaphorina citri*)	

Control of African citrus psyllid (*Trioza erytreae*)

Pest information

The African citrus psyllid (*Trioza erytreae*) is a small, sap-sucking insect that feeds on several varieties of citrus and closely related plants in the Rutaceae family.

This species damages citrus directly by feeding of new growth. Nymphs feeding on the underside of the leaves results in characteristic cup shaped leaf distortions and mild chlorosis (Catling 1973). More importantly, this psyllid is known to vector the Asiatic and African strains of Huanglongbing (Massonie *et al.*, 1976).

The African citrus psyllid is native to sub-Saharan Africa and has now spread across much of southern and eastern Africa, to off shore islands (such as Madagascar, the Canary Islands, Reunion and Saint Helena), parts of the Middle East and recently to Spain and Portugal (PHA 2015).

Chemical control options used overseas

Table 19 provides a summary of the chemical control options currently used overseas and how these compare to Australian pesticide use patterns. Chemicals that are used in a similar way in Australia as they are used overseas are discussed in detail below.

Table 19 Chemical control options for African citrus psyllid

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Acetamiprid	South Africa	Mulan 20 SP label, Adama, South Africa	Acetamiprid is a systemic insecticide used in South Africa for the control of African citrus psyllid	Mulan 20 SP (200 g a.i/kg) is used in South Africa to control African citrus psyllids when applied at a rate of 40 g (8 g a.i)/100 L of water	Pesticide is used in Australia, but it is not used on not used on citrus in Australia	N/A	Not at this time
Chlorpyrifos	South Africa	Pyrinex 250 CS label, Adama, South Africa	Chlorpyrifos is a non-systemic insecticide. The South African label recommends applying when eggs start to hatch for the management of the pest	Pyrinex 250 CS (250 g a.i/L) is used in South Africa for the control of the African citrus psyllid, when applied as a solution containing 115 ml (28.75 g a.i)/100 L of water	Lorsban 500EC (500 g a.i/L) is used on citrus to control California red scale when applied at 100 ml (50 g a.i)/100 L	Concentration used overseas is lower than the concentration used in Australia	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Dimethoate	South Africa	Catling (1970); Dimethoate EC label, Adama, South Africa	Catling (1970) showed Dimethoate (a systemic insecticide) to be effective at killing eggs and nymphs of the African citrus psyllid	Dimethoate in the product Dimethoate EC (400 g a.i/L) is used in South Africa for the control of the African citrus psyllid when applied at a rate of 40 ml (16 g a.i)/100 L of water	Various Dimethoate products such as Dimex 400EC (400 g a.i/L) are used on Australian citrus to control various pests when applied at a rate of 75 ml (30 g a.i)/100 L	Concentration used overseas is lower than the concentration used in Australia	Consider further
Imidacloprid	South Africa	Kohinor 350 SC label, Adama, South Africa	Imidacloprid is a systemic insecticide used in South Africa to control African citrus psyllids	Kohinor 350 SC (350 g a.i/L) is used in South Africa for the control of the African citrus psyllid when applied as a soil drench at a rate of 9 ml (3.15 g a.i)/tree.	In Australia Allez 350 SC (350 g a.i./L) is used to control various citrus pests when applied as soil drench or via micro-sprinkler or drip irrigation at a rate of 9 ml (3.15 g a.i)/tree.	Australian and overseas rates comparable	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Profenofos	South Africa	Selefos, label, RT chemicals, South Africa	Profenofos is a non-systemic insecticide used in South Africa to control African citrus psyllids	Selefos, (500g a.i/L) is used in South Africa to control African citrus psyllids when applied at a rate of 75 ml (37.5 g a.i)/100 L	Pesticide is in Australia, but it is not used on citrus	N/A	Not at this time
Thiamethoxam	Spain	Actara 25WG label, Syngenta, Spain	Thiamethoxam is a systemic insecticide used in Spain to control African citrus psyllids	Actara 25WG (25% a.i) is used in Spain for the control of African citrus psyllid when applied at a rate of 20 – 30 ml (5 - 7.5 g a.i)/100 L	Actara (250g a.i/kg is used in Australia to control various citrus pests when applied at 20 - 30 g (5 - 7.5 g a.i)/100 L	Australian and overseas rates comparable	Consider further

Control of Asiatic citrus psyllid (*Diaphorina citri*)

Pest information

Asiatic citrus psyllid (ACP) (*Diaphorina citri*) is a small insect that feeds on citrus and other plants in the Rutaceae family. This species can spread all three strains of the Huanglongbing causing bacteria.

The Asiatic citrus psyllid is native to southern Asia and is currently present in tropical and subtropical Asia, from Arabia and Afghanistan through the Indian subcontinent, eastern Asia and Southeast Asia, including the Indonesian archipelago and Papua New Guinea. It is also present in American Samoa, Guam, the Northern Mariana Islands, southern states of the United States, Mexico, parts of South America, Central America, the Caribbean and the islands of Mauritius and Reunion (PHA 2015).

Strategies used overseas to control Asiatic citrus psyllid

Pesticides are widely used overseas to manage this pest. Boina and Bloomquist (2014) note that ACP may develop resistance overtime if a single pesticide mode of action is regularly used and highlight the need to rotate between different modes of action to assist in the ongoing management of this pest.

Foliar applications of pesticides offer good control of ACP. When using contact, non-systemic insecticides it is important to note that adult insects are more likely to be controlled than nymphs or eggs as they are more mobile (California Department of Food and Agriculture 2017), and it can be difficult to get contact insecticides to all nymphs feeding on the plant (Boina and Bloomquist 2014). Therefore the use of systemic foliar or soil applied insecticides should also be considered as these insecticides are taken up by the tree and delivered to the feeding nymphs and adults.

For the ongoing management of ACP it is recommended that a mixture of systemic and non-systemic, soil and foliar applied pesticides with a variety of modes of action are considered for APVMA permits to provide a range of management options in the event that ACP is found in Australia. Table 20 provides a summary of the overseas use patterns for the chemicals identified and discussed in more detail in Table 21.

Table 20 Summary of actives used for different scenarios overseas

APPLICATION SITE[7]	SYSTEMIC	DUAL ACTIVES CONTAINING BOTH SYSTEMIC AND NON-SYSTEMIC PESTICIDES	NON-SYSTEMIC
Foliage	Acetamiprid (**suppression only**) Azadirachtin (**suppression only**) *Cyantraniliprole* Dimethoate Flupyradifurone	Abamectin + Thiamethoxam Bifenthrin + Imidacloprid Chlorantraniliprole + Lambda-cyhalothrin Imidacloprid + Beta-cyfluthrin	*Abamectin* Beta-cyfluthrin Bifenthrin *Carbaryl* *Chlorpyrifos* Cyfluthrin

[7] Pesticides that appear suitable for permit applications are italicised. For further information see Table 21.

APPLICATION SITE[7]	SYSTEMIC	DUAL ACTIVES CONTAINING BOTH SYSTEMIC AND NON-SYSTEMIC PESTICIDES	NON-SYSTEMIC
Foliage	Imidacloprid Oxamyl *Spinetoram* *Spirotetramat* Thiacloprid *Thiamethoxam* Thiamethoxam + Chlorantraniliprole	Thiamethoxam + Lambda-cyhalothrin Zeta-cypermethrin+ Avermectin	Diflubenzuron Fenpropathrin Fenpyroximate Lambda-cyhalothrin Maldison (syn. Malathion) Naled Phosmet *Pyrethrin* Terpene Constituents of the Extract of Chenopodium ambrosioides near ambrosioides Zeta-cypermethrin
Soil	Aldicarb *Clothianidin* Cyantraniliprole Flupyradifurone *Imidacloprid* Thiamethoxam	Bifenthrin + Imidacloprid	

Chemical control options used overseas

Table 21 provides a summary of the chemical control options currently used overseas and how these compare to Australian pesticide use patterns. Chemicals that are used in a similar way in Australia as they are used overseas are discussed below.

Table 21 Chemical control options for Asiatic citrus psyllid (ACP)

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Abamectin	United States	Agri-Mek SC label, Syngenta, United States	Abamectin is a non-systemic insecticide that controls ACP adults and nymphs	Agri-Mek SC (0.7 lb./gallon (~84 g a.i/L) is used in the United States to control ACP when applied at a rate of 2.25 - 4.25 fl. oz./acre (165 - 311 ml (13.86 - 26.12 g a.i)/ha)	Abamectin in the product Abamix 18EC (18g a.i/L) is used on citrus to control various pests when applied at 12 - 25 ml (0.216 - 0.45 g a.i)/100 L, it is recommended to use 3,000 – 6,000 L of solution (i.e. 6.48 - 27 g a.i)/ha	Australian and overseas rates comparable	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Abamectin + Thiamethoxam	United States	Agri-flex label, Syngenta, United States	Abamectin is a non-systemic insecticide. Thiamethoxam is a systemic insecticide. Overseas recommendations suggest to apply this pesticide to flush in spring, summer, and autumn to protect new leaves from ACP	Agri-flex (0.277 lb. Abamectin + 1.27 lb. Thiamethoxam/gallon (33.2 g a.i Abamectin + 152.2 g a.i Thiamethoxam/L)) is used in the United States to control ACP when applied at a rate of: 5.5 - 8.5 fl. oz./acre (402 - 621 ml (13.3 - 20.6 g a.i Abamectin + 61.2 - 94.5 g a.i Thiamethoxam)/ha) for concentrate sprays; or, 0.55 - 0.85 fl. oz./100 gallons (4.3 - 6.6 ml (0.15 - 0.22 g a.i Abamectin + 0.65 - 1.0 g a.i Thiamethoxam)/100 L) for dilute sprays	This pesticide combination is not used in Australia	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Acetamiprid	United States	Assail 70WP label, UPL, United States	Acetamiprid is a systemic insecticide that is used for the **Suppression** of ACP Note: Childers and Rogers (2005) report it to be ineffective against ACP	Assail 70WP (70% a.i) is used in the United States to **suppress** ACP on citrus when applied at a rate of 3 - 5.7 oz./acre (210 - 400 g (147 - 280 g a.i)/ha)	Pesticide is used in Australia but not on citrus	N/A	Not at this time
Aldicarb	United States	Temik 15G label, Bayer, United States	Aldicarb is a systemic insecticide that is used to manage ACP overseas. Note this pesticide is being phased out overseas and is currently not available in Australia	Temik 15G (15% a.i) is used in the United States to control ACP when applied as a soil treatment at a rate of 33 lb./acre (36,988.1 g (5,548.2 g a.i)/ha), when trees are planted on 18 - 25-foot (5.4 - 7.6 m) rows	Pesticide not used in Australia	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Azadirachtin	United States	Neemix 4.5 label, Certis, United States	Azadirachtin is a systemic insecticide that is used for the **suppression** of ACP overseas	Neemix 4.5 (0.39 lb. a.i/gallon (175 g a.i/L)) is used in the United States to **suppress** ACP when applied at 7 - 16 fl. oz./acre (511.5 - 1,169 ml (89.5 - 204.6 g a.i)/ha)	Used in Australia but not on commercial citrus	N/A	Not at this time
Beta-cyfluthrin	United States	Baythroid-XL label, Bayer United States	Beta-cyfluthrin is a non-systemic insecticide that is used to control ACP overseas	Baythroid-XL (1 lb. a.i /gallon (~120 g a.i/L)) is used in the United States to control ACP when applied at a rate of 2.4 - 6.4 fl. oz./acre (175 - 468 ml (21 - 56 g a.i)/ha)	Not used in Australia on citrus	N/A	Not at this time
Bifenthrin	Mexico	Seizer 10CE label, Adama, Mexico.	Bifenthrin is a non-systemic insecticide that is used to control ACP overseas Low levels of resistance reported in Mexico (Pardo et al., 2018)	Seizer 10CE (100 g a.i/L) is used in Mexico to control ACP on citrus when applied at a rate of 500 - 600 ml (50 - 60 g a.i)/ha	Starlet 100EC (100 g a.i/L) is used in Australia on citrus for the control of leaf eating weevils when applied to the ground under the tree at a rate of up to 25 ml (2.5 g a.i)/tree	Australian and overseas methods of application differ	Not at this time. Different application methods mean additional data may be required to support future permit applications

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Bifenthrin + Imidacloprid	Mexico	Galil SC label, Adama, Mexico	Bifenthrin is a non-systemic insecticide and Imidacloprid is a systemic insecticide. These insecticides are used to control ACP overseas	Galil SC (250 g a.i Imidacloprid + 50 g a.i Bifenthrin/L) is used in Mexico to control ACP when applied at a rate of 50 ml (12.5 g a.i Imidacloprid + 2.5 g a.i Bifenthrin)/100 L of water	Used in Australia but not on citrus	N/A	Not at this time
Bifenthrin + Imidacloprid	United States	Skyraider label, Adama, United States	Bifenthrin is a non-systemic insecticide and Imidacloprid is a systemic insecticide. These insecticides are used to control ACP overseas	Skyraider (2 lb. a.i Bifenthrin + 1 lb. a.i Imidacloprid/gallon (240 g a.i Bifenthrin + 120 g a.i Imidacloprid/L) is used in the United States to control ACP when applied to the bare ground under trees at a rate of 16 - 32 fl. oz./acre (1,170 – 2,340 ml (280.8 - 561.6 g a.i Bifenthrin + 140.4 - 280.8 g a.i Imidacloprid)/ha)	Used in Australia but not on citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Carbaryl	United States	Sevin XLR plus, 2ee label, EPA REG NO. 61842-37	Carbaryl is a non-systemic, contact insecticide that is used overseas for the control of ACP	Sevin XLR plus (4 lb. a.i /gallon (480 g a.i/L)) is used to control ACP in the United States when applied at 1.5 - 3 quarts/acre (i.e. 3,507.5 - 7,015 ml (1,683.6 - 3,367.2 g a.i/ha)	Kendon Carbaryl 500SC (500 g a.i/L) is used on citrus to control various pests when applied at a rate of 100 - 200 ml (50-100 g a.i)/100 L	Assuming a typical water volume required to achieve run off in citrus of 3,300 L/ha, the Australian and overseas rates are comparable	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Chlorpyrifos	United States	Lorsban Advanced label, Dow AgroSciences, United States	Chlorpyrifos is a non-systemic insecticide. Chlorpyrifos is reported by Childers and Rogers (2005) as being very effective at controlling ACP. However, Pardo et al., (2018) report that ACP populations in Mexico are developing some resistance to Chlorpyrifos	Lorsban Advanced (3.755 lb. a.i/gallon (~450 g a.i/L)) is used in the United States to control ACP on citrus when applied at a rate of 5 Pints/acre (5,846 ml (2,630.7 g a.i)/ha). The label recommends using at least 100 gallons of water per 0.5 pints of Lorsban Advanced (meaning 1,000 gallons/acre (9,353 L/ha) (= 28.1 g a.i/100 L) is required for the control of ACP in citrus	Lorsban 500EC (500 g a.i/L) is used on citrus to control California red scale when applied at 100 ml (50 g a.i)/100 L	If the volumes listed in the overseas label are used the Australian and overseas rates are comparable	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Clothianidin	United States	Belay label, Valent, United States	Clothianidin is a systemic insecticide that is used overseas for the control of ACP	Belay (23% ai by weight) is used in the United States for the control ACP on citrus when applied as a soil drench at a rate of 3 - 6 fl. oz. /acre (219.2 - 438.5 ml (56 - 112 g a.i)/ha). Alternatively, it can be applied at 0.02-0.04 fl oz. (0.59-1.18 ml (0.13-0.26 g a.i)/tree. Use lower rate for trees less than 3 foot (0.9m) tall and higher rate for trees 3-5 foot (0.9-1.5m) tall	This pesticide is used in Australia on citrus to control Citrus gall wasp under permit PER81925. This permit allows the use of Samurai (500 g a.i/kg) applied via micro irrigation at a rate of 8 g (4 g a.i)/tree	Australian rates and overseas rates are comparable, both in terms of rate per unit area (assuming a typical stocking rate of 300 trees/ha[8]) and rate per tree	Consider further

[8] 300 trees/ha is a typical stocking rate (Citrus Australia 2017).

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Chlorantraniliprole + Lambda-cyhalothrin	Brazil	Ampligo label, Syngenta, Brazil	Chlorantraniliprole is a systemic insecticide and Lambda-cyhalothrin is a non-systemic insecticide. These insecticides are used to control ACP overseas	Ampligo (50 g a.i Lambda-cyhalothrin +100 g a.i Lambda-cyhalothrin/L) is used in Brazil to control ACP when applied at a rate of 10 - 30 ml (0.5 - 1.5 g a.i Lambda-cyhalothrin + 1 - 3 g a.i Lambda-cyhalothrin)/ha	Combination not used in Australia	N/A	Not at this time
Cyantraniliprole	United States	Verimark label, FMC, United States	Cyantraniliprole is a systemic insecticide that is used overseas to control ACP	Verimark (1.67 lb. a.i./ gallon (~200 g a.i/L)) is used in the United States to control ACP when applied as soil drench, micro sprinkler, or by chemigation a rate of 15 - 30 fl. oz./acre (1,096 - 2,192 ml (219.2 - 438.4 g a.i)/ha) if trees are less than 3 foot (~91cm) tall or 20 - 30 fl. oz./acre (1,462 - 2,192 ml (292.4 - 438.4 g a.i)/ha) if trees 3 - 5 foot (91 - 152 cm) tall	Exirel (100 g a.i/L) is used in Australia on citrus to control various pests when applied at a rate of 75 ml (7.5 g a.i)/100 L	Different application methods used in Australia and overseas	Not at this time. Additional data may be required to support the use of the overseas use pattern in Australia

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Cyantraniliprole	United States	Exirel label, Du Pont, United States	Cyantraniliprole is a systemic insecticide that is used overseas to control ACP	Exirel (0.83lb. ai/gallon (~100 g a.i/L)) is used in the United States to control ACP when applied at a rate of 13.5 - 20.5 fl. oz./acre (986.5 - 1,498 ml (98.65 - 149.8 g a.i)/ha)	Exirel (100 g a.i/L) is used in Australia on citrus to control various pests when applied at a rate of 75 ml (7.5 g a.i)/100 L. A maximum of 3,000 mL (300 g a.i)/ha is permitted under the label	Australian and overseas use patterns comparable	Consider further
Cyfluthrin	United States	Tombstone, 2ee label. EPA REG No. 34704-912	Cyfluthrin is a contact, non-systemic insecticide that is used overseas for the control of ACP	Tombstone (2 lb. a.i/gallon (240 g a.i/L)) is used in the United States to control ACP when applied at a rate of 2 - 3.2 fl. oz./acre (146 - 234 ml (35 - 56 g a.i/ha)	Pesticide is used in Australia but is not used on citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Diflubenzuron	United States	Micromite 80 WGS label, MacDermid Agricultural Solutions, United States; Tiwari et al., (2012)	Diflubenzuron is a non-systemic insecticide that is used overseas for the control of ACP. Diflubenzuron kills nymphs and eggs. Adults that feed on sprayed plants produce fewer eggs but are not controlled by this pesticide (Tiwari et al., 2012)	Micromite 80 WGS (80% a.i) is used in the United States to control ACP when applied at a rate of 6.25 oz./acre (437.8 g (350.24 g a.i)/ha)	Pesticide is used in Australia but is not used on citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Dimethoate	United States	Dimethoate 400 label, Loveland Products, United States	Dimethoate is a broad-spectrum systemic insecticide used overseas for the control of ACP	Dimethoate 400 (4 lb. a.i/gallon (~480 g a.i/L)) is used in the United States to control ACP when applied at a rate of 1 pint/100 gallons (125 ml (60 g a.i)/100 L) of water, when applied using ground equipment, or 1 pint/10 gallons (1,250 ml (600 g a.i)/100 L) when applied aerially.	Various Dimethoate products, such as Dimex 400EC (400 g a.i/L), are used on Australian citrus to control various pests when applied at a rate of 75 ml (30 g a.i)/100 L	Concentration used overseas is higher than that used in Australia	Not at this time. Additional data would be required to support a permit application
Fenpropathrin	United States	Danitol 2.4 EC label, Valent, United States	Fenpropathrin is a non-systemic insecticide used to control ACP overseas. It is reported by Childers and Rogers (2005) as being very effective at controlling ACP	Danitol 2.4 EC (2.4 lb. a.i/gallon (287.6 g a.i/L)) is used in the United States to control ACP when applied at a rate of 16 fl. oz./acre (1,169.2 ml (336.3 g a.i)/ha)	Product is not used in Australia	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Fenpyroximate	United States	FujiMite XLO label, Nichino America, United States	Fenpyroximate is a non-systemic insecticide used to control ACP overseas	FujiMite XLO (0.4 lb. a.i/gallon (~48 g a.i/L)) is used in the United States to control ACP when applied at a rate of 2 - 4 pints/acre (2,338.5 - 4,677 ml (112.2 - 224.5 g a.i)/ha)	Product is not used in Australia	N/A	Not at this time
Flupyradifurone	United States	Sivanto 200SL label, Bayer United States	Flupyradifurone is a systemic insecticide used to control ACP overseas	Sivanto 200SL (1.67 lb. a.i/gallon (200 g a.i/L) is used in the United States to control ACP when applied to foliage at a rate of 10.5 - 14 fl. oz./acre (767.3 - 1,023 ml (153.46 - 204.6 g a.i)/ha) Sivanto 200SL is also used as a chemigation or basal drench to control ACP when applied at a rate of 21 - 28 fl. oz./acre (1,524.6 - 2,046.2 ml (304.92 - 409.24 g a.i)/ha)	Active ingredient has recently been listed in Australia but not yet labelled for use on citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Imidacloprid	India	Cohigan label, Adama, India	Imidacloprid is a systemic insecticide used overseas to control ACP. It is reported by Childers and Rogers (2005) as being very effective at controlling ACP	Cohigan (17.8% a.i) is used in India to control psylla (i.e. ACP) on citrus when applied at a rate of 50 ml (8.9 g a.i)/ha	In Australia Allez 350 SC (350 g a.i./L) is used to control various citrus pests when applied as soil drench or via micro-sprinkler or drip irrigation at a rate of 9ml (3.15 g a.i)/tree	Method of application varies between Australia and overseas	Not at this time. Australian and overseas use patterns differ. Additional data may be required to support future permit applications
Imidacloprid	Brazil	Winner label, Bayer, Brazil	Imidacloprid is a systemic insecticide used overseas to control ACP. It is reported by Childers and Rogers (2005) as being very effective at controlling ACP	Winner (200 g a.i/L) is used in Brazil to control ACP when applied as a soil drench at the base of each tree at a rate of 2.5 – 5 ml (0.5 - 1.0 g a.i)/tree	In Australia Allez 350 SC (350 g a.i./L) is used to control various citrus pests when applied as a soil drench, micro-sprinkler or drip irrigation at a rate of 9ml (3.15 g a.i)/tree	Australian rates greater than rates used overseas	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Imidacloprid	United States	Admire-pro label, Bayer United States	Imidacloprid is a systemic insecticide used overseas to control ACP. It is reported by Childers and Rogers (2005) as being very effective at controlling ACP	Admire-pro (4.6 lb. a.i/gallon (550 g a.i/L)) is used in the United States to control ACP in nurseries when applied as a soil application at a rate of 0.33 - 0.5 ml (0.18 - 0.275 g a.i)/"citra pot" = 0.1 cubic foot = 2.83 L) Admire-pro is applied to soil at a rate of 7 - 14 fl. oz./acre (511.5 - 1,023 ml (281.325 - 562.65 g a.i)/ha) to control ACP in citrus orchards Admire Pro is also used to control ACP in citrus orchards when applied as a foliar spray at a rate of 3.5 - 7 fl. oz./acre (255.8 - 711.5 ml (140.7 - 281.3 g a.i)/ha)	In Australia Allez 350 SC (350 g a.i./L) is used to control various citrus pests when applied as soil drench or via micro-sprinkler or drip irrigation at a rate of 9ml (3.15 g a.i)/tree	Method of application varies between Australia and overseas	Not at this time. Australian and overseas use patterns differ. Additional data may be required to support future permit applications

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Imidacloprid + Beta-cyfluthrin	United States	Leverage-360 label, Bayer United States	Imidacloprid is a systemic insecticide and Beta-cyfluthrin is a non-systemic insecticide. Together these pesticides are used overseas to control ACP	Leverage-360 (2 lb. a.i Imidacloprid +1 lb. a.i Beta-cyfluthrin /gallon (~240 g a.i Imidacloprid +120 g a.i Beta-cyfluthrin/L)) is used in the United States to control ACP when applied at a rate of 6.4 fl. oz./acre (467.7 ml (112.25 g a.i Imidacloprid + 56.124 g a.i Beta-cyfluthrin)/ha)	Pesticide is used in Australia but is not used on citrus	N/A	Not at this time
Lambda-cyhalothrin	Brazil	Karate Zeon 250CS label, Syngenta, Brazil	Lambda-cyhalothrin is a non-systemic insecticide used overseas to control ACP	Karate zeon 250CS (250 g a.i/L) is used in Brazil to control ACP on citrus when applied at 3 - 4 ml (0.75 - 1 g ai)/100 L	Pesticide is used in Australia but is not used on citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Maldison (syn. Malathion)	Brazil	Malathion 1000EC label, FMC, Brazil	Maldison (syn. Malathion) is a non-systemic insecticide used overseas to control ACP ACP resistance to Maldison has been reported in Mexico (Pardo et al., 2018)	Malathion 1000EC (1000 g a.i/L) is used in Brazil ton control ACP when applied at a rate of 150 ml (150 g a.i)/100 L. The label recommends using 2,000 L/ha (which equates to 3,000 g a.i/ha)	Fyfanon 440 EW (440 g a.i/L) is used in Australia to control citrus pests when applied at a rate of 140 - 230 ml (61.6 - 101.2 g a.i)/100 L	Overseas rates are higher that Australian rates	Not at this time. Additional data may be required to support this use pattern
Naled	United States	Dibrom 8 Emulsive, 2ee permit. EPA REG No. 5481-479	Naled is a non-systemic insecticide that is registered for the control of ACP overseas. Naled is effective against adults and nymphs	Dibrom 8 Emulsive (7.5 lb. a.i/gallon (~900 g a.i/L)) is used in California and Arizona for the control of ACP when applied at a rate of 1 - 2 Pints/acre (1,169.24 - 2,338.49 ml (1052.3 - 2,104.6 g a.i)/ha)	This pesticide is not used in Australia	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Oxamyl	United States	Vydate L 2ee EPA REG No. 352-372	Oxamyl is a systemic and contact insecticide that is registered for the control of ACP overseas	Vydate L (2 lb. a.i/gallon (240 g a.i/L)) is used in the United States to control ACP when applied at a rate of 1 - 2 quart/acre (2,338.5 – 4,677 ml (561.2 - 1,122.5 g a.i)/ha)	This pesticide is used in Australia but not on citrus	N/A	Not at this time
Phosmet	United States	Imidan 70W 2ee EPA REG No. 10163-169, Gowan, United States	Phosmet is a non-systemic insecticide that is registered for the control of ACP overseas	Imidan 70W (70% a.i) is used in the United States to control ACP when applied at a rate of 1 - 3 lb./acre (1,120.82 - 3,362.55 g (784.6 - 2,353.8 g a.i)/ha)	This pesticide is used in Australia but not on citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Pyrethrin	United States	PyGanic EC 5.0 label, Valent, United States	Pyrethrin is a non-systemic insecticide that is registered for the control of ACP overseas. Note, pyrethrin is reported to offer no residual control of ACP but is compatible with organic production	PyGanic EC 5.0 (5 % ai) is used in the United States to control ACP on citrus when applied at a rate of 4.5 - 17 fl. oz./acre (328.8 - 1,242.3 ml (16.44-62.115 g a.i)/ha)	PyGanic insecticide (13 g a.i/L) is used in Australia on citrus for the control of Greenhouse thrips when applied at a rate of 150 ml (1.95 g a.i)/100 L	Assuming a typical water volume required to achieve run off in citrus of 3,300 L/ha, the rates used in Australia are comparable to the rates used overseas	Consider further
Spinetoram	United States	Delegate WG label, Dow Agro Sciences. United States	Spinetoram is a systemic insecticide that is registered for the control of ACP overseas	Delegate WG (35% ai) is used in the United States to control ACP on citrus when applied at a rate of 3 - 6 oz./acre (210 - 420 g (73.5 - 147 g a.i)/ha)	Success Neo (120 g a.i/L) is used in Australia to control various citrus pests when applied at rates of 10 - 40 ml (1.2 - 4.8 g a.i)/100 L	Assuming a typical water volume required to achieve run off in citrus of 3,300 L/ha, the rates used in Australia are comparable to the rates used overseas	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Spirotetramat	United States	Movento label, Bayer United States	Spirotetramat is a systemic insecticide that is registered for the control of ACP overseas	Movento (2 lb. a.i/gallon (240 g a.i/L)) is used in the United States to control ACP when applied at a rate of 8 - 10 fl. oz./acre (584.6 - 730.8 ml (140.3 - 175.4 g a.i)/ha)	Movento 240 SC (240 g/L a.i) is used to control various citrus pests when applied at a rate of 20 - 40 ml (4.8 - 9.6 g a.i)/100 L. A maximum of 4 L (960 g a.i)/ha can be applied	Maximum rates used in Australia are comparable to the rates used overseas	Consider further
Terpene Constituents of the Extract of *Chenopodium ambrosioides* near *ambrosioides*	United States	Requiem label, Bayer United States	This insecticide is a non-systemic, contact insecticide that is registered for the control of ACP overseas	Requiem (16.75% a.i) is used to control ACP in the United States when applied at a rate of 2 - 4 quarts/acre (4,677 – 9,354 ml (783.4 – 1,566.8 g a.i)/ha)	Pesticide is not used in Australia	N/A	Not at this time
Thiacloprid	Argentina	Calypso 48 SC label, Bayer, Argentina	Thiacloprid is a systemic insecticide that is registered for the control of ACP overseas	Calypso 48 SC (48 g/100 ml) is used in Argentina to control ACP when applied at a rate of 50 ml (24 g a.i)/100 L	Pesticide is used in Australia but not on citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Thiamethoxam	Argentina	Actara label, Syngenta, Argentina	Thiamethoxam is a systemic insecticide that is used overseas for the control of ACP. Reported by Childers and Rogers (2005) as being very effective at controlling ACP	Actara (25 % a.i) is used in Argentina to control ACP when applied at a rate of 1 g (0.25 g a.i)/plant. Assuming a planting density of 414 trees/ha (based on national area and number of trees as presented by USDA 2018), this equates to 103.5 g a.i/ha	Actara (250g a.i/kg is used in Australia to control citrus pests when applied at 20 - 30 g (5 - 7.5 g a.i)/100 L, the label allows up to 5,000 L/ha, which equates to up to 375 g a.i/ha	Method of application varies between Australia and overseas	Not at this time. Additional data would likely be required to support different use patterns
Thiamethoxam	Brazil	Actara 10GR label, Syngenta, Brazil	Thiamethoxam is a systemic insecticide used overseas for the control of ACP. Reported by Childers and Rogers (2005) as being very effective at controlling ACP	Actara 10GR (10 g a.i/kg) is used in Brazil to control ACP when applied at a rate of 75 g (0.75 g a.i)/plant. Assuming a planting density of 411 trees/ha (based on national area and number of trees as presented by USDA 2017), this equates to 308.25 g a.i/ha	Actara (250g a.i/kg is used in Australia to control citrus pests when applied at 20 - 30 g (5 - 7.5 g a.i)/100 L, the label allows up to 5,000 L/ha, which equates to up to 375 g a.i/ha	Method of application varies between Australia and overseas	Not at this time. Additional data would likely be required to support different use patterns

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Thiamethoxam	India	Suckgan label, Adama, India	Thiamethoxam is a systemic insecticide used overseas for the control of ACP. Reported by Childers and Rogers (2005) as being very effective at controlling ACP	Suckgan (25% a.i) is used to control psylla (ACP) on citrus when applied at a rate of 100 g (25 g a.i)/ha	Actara (250g a.i/kg is used in Australia to control citrus pests when applied at 20 - 30 g (5 - 7.5 g a.i)/100 L, the label allows up to 5,000 L/ha, which equates to up to 375 g a.i/ha	Overseas rates comparable to Australian rates	Consider further
Thiamethoxam	United States	Actara label, Syngenta, United States	Thiamethoxam is a systemic insecticide used overseas for the control of ACP. Reported by Childers and Rogers (2005) as being very effective at controlling ACP	Actara (25% ai) is used in the United States to control ACP when applied at a rate of 4 - 5.5 oz./acre (280.2 - 385.3 g (70.05 - 96.3 g a.i)/ha)	Actara (250g a.i/kg is used in Australia to control citrus pests when applied at 20 - 30 g (5 - 7.5 g a.i)/100 L, the label permits up to 5,000 L/ha, which equates to up to 375 g a.i/ha	Overseas rates comparable to Australian rates	Consider further

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Thiamethoxam	United States	Platinum 75 SG label, Syngenta, United States	Thiamethoxam is a systemic insecticide used overseas for the control of ACP. Reported by Childers and Rogers (2005) as being very effective at controlling ACP	Platinum 75 SG (75% ai) is used in the United States to control ACP on citrus when applied as a drench, chemigation, or soil surface band at 1.83 - 3.67 oz./acre (128.2 - 257.1 g (96.15 - 192.825 g a.i)/ha)	Actara (250g a.i/kg is used in Australia to control citrus pests when applied at 20 - 30 g (5 - 7.5 g a.i)/100 L, the label allows up to 5,000 L/ha, which equates to up to 375 g a.i/ha	Method of application varies between Australia and overseas	Not at this time. Additional data would likely be required to support different use patterns
Thiamethoxam + Chlorantraniliprole	United States	Voliam Flexi label, Syngenta, United States	Thiamethoxam and Chlorantraniliprole are both systemic insecticides. Together these pesticides are used overseas to control ACP	Voliam Flexi (20% ai Thiamethoxam + 20% ai Chlorantraniliprole) is used in the United States to control ACP when applied at a rate of 5 - 7 oz./acre (350.26 - 490.37 g (70 - 98 g a.i Thiamethoxam + 70 - 98 g a.i Chlorantraniliprole)/ha)	This combination of pesticides is used in Australia but not on citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Thiamethoxam + Chlorantraniliprole	Brazil	Durivo label, Syngenta, Brazil	Thiamethoxam and Chlorantraniliprole are both systemic insecticides. Together these pesticides are used overseas to control ACP	Durivo (200 g a.i Thiamethoxam + 100 g a.i Chlorantraniliprole) is used in Brazil to control ACP on citrus when applied at a rate of 1 - 2 ml (0.2 - 0.4 g a.i Thiamethoxam + 0.1 - 0.2 g a.i Chlorantraniliprole)/ha for every 1 m of tree height	This combination of pesticides is used in Australia but not on citrus	N/A	Not at this time
Thiamethoxam + Lambda-cyhalothrin	Brazil	Engeo Pleno label, Syngenta, Brazil	Thiamethoxam is a systemic insecticide and Lambda-cyhalothrin is a non-systemic insecticide. Together these pesticides are used overseas to control ACP	Engeo Pleno (141 g a.i Thiamethoxam + 106 g a.i Lambda-cyhalothrin/L) is used in Brazil to control ACP when applied at a rate of 15 ml (2.115 g a.i Thiamethoxam + 1.59 g a.i Lambda-cyhalothrin)/100 L	Pesticide is available in Australia but not used on citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Zeta-cypermethrin	United States	Mustang, 2ee label. EPA REG No. 279-3126	Zeta-cypermethrin is a non-systemic insecticide that is registered for the control of ACP overseas	Mustang (1.5 lb. a.i/gallon (179.74 g a.i/L)) is used in the United States to control ACP when applied at 4.3 fl. oz./acre (314.2 ml (56.5 g a.i)/ha)	This pesticide is used in Australia but is not used on citrus	N/A	Not at this time
Zeta-cypermethrin	Brazil	Mustang 350 EC label, FMC, Brazil	Zeta-cypermethrin is a non-systemic insecticide that is registered for the control of ACP overseas	Mustang 350EC (350 g a.i/L) is used in Brazil to control ACP when applied to citrus at a rate of 5 - 10 ml (1.75 - 3.5 g a.i)/100 L	This pesticide is used in Australia but is not used on citrus	N/A	Not at this time

PESTICIDE	OVERSEAS COUNTRY USING CHEMICAL TO CONTROL PEST	RELEVANT REFERENCE/ PERMIT	COMMENTS	OVERSEAS USE PATTERN	AUSTRALIAN USE PATTERN	SIMILARITY BETWEEN OVERSEAS AND AUSTRALIAN USE PATTERNS	CONSIDER FOR PERMIT APPLICATION?
Zeta-cypermethrin+ Avermectin	United States	Gladiator label, FMC, United States	Zeta-cypermethrin is a non-systemic insecticide. Avermectin is a systemic insecticide. Together these pesticides are used overseas to control ACP	Gladiator (0.172 lb. a.i Zeta-cypermethrin + 0.078 lb. a.i Avermectin/gallon) (20.6 g a.i Zeta-cypermethrin + 9.3 g a.i Avermectin/L) is used in the United States to control ACP when applied as a foliar spray at a rate of 4.75 fl. oz./100 gallons (37.1 ml (0.76 g a.i Zeta-cypermethrin + 0.345 g a.i Avermectin)/100 L) applied at a rate of 1000 gallons/acre (i.e. 9353.96 L/ha = 1927 g a.i Zeta-cypermethrin + 87 g a.i Avermectin g a.i/ha)	This combination of pesticides is not used in Australia	N/A	Not at this time

Control of Pomelo psyllid (*Cacopsylla citrisuga*)

Pest information

Pomelo psyllid (*Cacopsylla citrisuga*) is reported to vector the Asiatic strain of Huanglongbing (‘*Candidatus* Liberibacter asiaticus’) in China (Cen et al., 2012).

Chemical control options used overseas

No chemical control options have been identified specifically for this pest. It is highly likely that the chemicals used to control the Asiatic citrus psyllids and the African citrus psyllid would also be effective for this species. However, further work would be required to confirm this.

Control of Black psyllid (*Diaphorina communis*)

Pest information

Black psyllid (*Diaphorina communis*) in Bhutan was reported to contain the Asiatic strain of Huanglongbing (‘*Candidatus* Liberibacter asiaticus’) (Donovan et al., 2012). Transmission studies have yet to confirm the vector status of this species.

Chemical control options used overseas

No chemical control options have been identified specifically for this pest. It is highly likely that the chemicals used to control the Asiatic citrus psyllids and the African citrus psyllid would also be effective for this species. However, further work would be required to confirm this.

Chemicals to consider further

As summarized in Table 19 and Table 21, several pesticides have been identified as suitable for the control of the various psyllid vectors of HLB. based on the similarity of the overseas and Australian use patterns. A summary of these pesticides is provided in Table 22 below.

Table 22 Summary of pesticides identified as suitable for the control of HLB. psyllid vectors in the event of a pest incursion

PESTICIDE	ASIATIC CITRUS PSYLLID	AFRICAN CITRUS PSYLLID	POMELO PSYLLID	BLACK PSYLLID
Abamectin	✓		No controls identified	No controls identified
Carbaryl	✓			
Clothianidin	✓			
Chlorpyrifos	✓	✓		
Cyantraniliprole	✓			
Dimethoate		✓		
Imidacloprid	✓	✓		
Pyrethrin	✓			
Spinetoram	✓			
Spirotetramat	✓			
Thiamethoxam	✓	✓		

Concluding remarks

Based on the discussion presented above the following chemicals appear to have potential for the control of Huanglongbing and its psyllid vectors:

- Abamectin
- Carbaryl
- Chlorpyrifos
- Clothianidin
- Cyantraniliprole
- Dimethoate
- Imidacloprid
- Pyrethrin
- Spinetoram
- Spirotetramat
- Thiamethoxam

These chemicals have been selected as their use overseas is very similar to the existing use patterns used in Australia. This means that these pesticides are good candidates for future permit applications.

Summary

A summary of the control options used overseas and those that are suitable for further consideration is presented in Table 23.

Table 23 summary of control options for exotic citrus pests

PESTICIDE	PESTS CONTROLLED USING THIS PESTICIDE (SEE ABOVE TABLES)	PESTS CONTROLLED BY THE PESTICIDE THAT SUITABLE FOR FUTURE PERMIT APPLICATIONS[9] (SEE ABOVE TABLES)
Abamectin (MOA 6)	*Brevipalpus* mites that vector Citrus leprosis virus; Asiatic citrus psyllid (Vector of HLB)	Asiatic citrus psyllid (Vector of HLB)
Abamectin + Thiamethoxam (MOA 6 + 4A)	Asiatic citrus psyllid (Vector of HLB) Glassy winged sharpshooter	
Acetamiprid (MOA 4A)	African citrus psyllid (Vector of HLB); Asiatic citrus psyllid (Vector of HLB) (**suppression only**); Glassy winged sharpshooter	
Aldicarb (MOA 1A)	Asiatic citrus psyllid (Vector of HLB)	
Azadirachtin (MOA Unknown)	Asiatic citrus psyllid (Vector of HLB) (**suppression only**)	

[9] ie that permits may be possible to develop based on a similarity of Australian and overseas use patterns.

PESTICIDE	PESTS CONTROLLED USING THIS PESTICIDE (SEE ABOVE TABLES)	PESTS CONTROLLED BY THE PESTICIDE THAT SUITABLE FOR FUTURE PERMIT APPLICATIONS[9] (SEE ABOVE TABLES)
Beta-cyfluthrin (MOA 3A)	Asiatic citrus psyllid (Vector of HLB); Glassy winged sharpshooter	
Bifenthrin (MOA 3A)	Asiatic citrus psyllid (Vector of HLB); *Brevipalpus* mites that vector Citrus leprosis virus; *Oncometopia facialis* a vector of Citrus Variegated Chlorosis	
Bifenthrin + Imidacloprid (MOA 3A + 4A)	Asiatic citrus psyllid (Vector of HLB); Glassy winged sharpshooter	
Buprofezin (MOA 16)	Glassy winged sharpshooter	Glassy winged sharpshooter
Carbaryl (MOA 1A)	Asiatic citrus psyllid (Vector of HLB)	Asiatic citrus psyllid (Vector of HLB)
Chlorantraniliprole + Lambda-cyhalothrin (MOA 28 + 3A)	Asiatic citrus psyllid (Vector of HLB)	

PESTICIDE	PESTS CONTROLLED USING THIS PESTICIDE (SEE ABOVE TABLES)	PESTS CONTROLLED BY THE PESTICIDE THAT SUITABLE FOR FUTURE PERMIT APPLICATIONS[9] (SEE ABOVE TABLES)
Chlorpyrifos (MOA1B)	African citrus psyllid (Vector of HLB); Asiatic citrus psyllid (Vector of HLB); Exotic thrips (**suppression only**); Glassy winged sharpshooter	African citrus psyllid (Vector of HLB); Asiatic citrus psyllid (Vector of HLB); Exotic thrips (**suppression only**); Glassy winged sharpshooter
Chromobacterium subtsugae strain PRAA4-1T and spent fermentation media (MOA Unknown)	Glassy winged sharpshooter	
Clothianidin (MOA 4A)	Asiatic citrus psyllid (Vector of HLB)	Asiatic citrus psyllid (Vector of HLB)
Copper – as Copper hydroxide (M1 Fungicide)	Citrus canker (**suppression only**)	Citrus canker (**suppression only**)
Copper – as Copper sulfate pentahydrate (M1 Fungicide)	Citrus canker (**suppression only**)	
Copper – as Cuprous oxide (M1 Fungicide)	Citrus canker (**suppression only**)	Citrus canker (**suppression only**)

PESTICIDE	PESTS CONTROLLED USING THIS PESTICIDE (SEE ABOVE TABLES)	PESTS CONTROLLED BY THE PESTICIDE THAT SUITABLE FOR FUTURE PERMIT APPLICATIONS[9] (SEE ABOVE TABLES)
Cyantraniliprole (MOA 28)	Asiatic citrus psyllid (Vector of HLB)	Asiatic citrus psyllid (Vector of HLB)
Cyflumetofen (MOA 25A)	*Brevipalpus* mites that vector Citrus leprosis virus	
Cyfluthrin (MOA 3A)	Asiatic citrus psyllid (Vector of HLB); Glassy winged sharpshooter	
Deltamethrin (MOA 3A)	*Oncometopia facialis* a vector of Citrus Variegated Chlorosis	
Dicofol (MOA Unknown)	*Brevipalpus* mites that vector Citrus leprosis virus	*Brevipalpus* mites that vector Citrus leprosis virus
Diflubenzuron (MOA 15)	Asiatic citrus psyllid (Vector of HLB)	
Dimethoate (MOA 1B)	African citrus psyllid (Vector of HLB); Asiatic citrus psyllid (Vector of HLB); *Bucephalogonia xanthophis* a vector of Citrus Variegated Chlorosis; Citrus aphids, vectors of Citrus tristeza virus Exotic thrips	African citrus psyllid (Vector of HLB) Citrus aphids, vectors of Citrus tristeza virus (**note no permit required, already registered in Australia**)

PESTICIDE	PESTS CONTROLLED USING THIS PESTICIDE (SEE ABOVE TABLES)	PESTS CONTROLLED BY THE PESTICIDE THAT SUITABLE FOR FUTURE PERMIT APPLICATIONS[9] (SEE ABOVE TABLES)
Fenbutatin-oxide (MOA 12B)	*Brevipalpus* mites that vector Citrus leprosis virus	*Brevipalpus* mites that vector Citrus leprosis virus
Fenpropathrin (MOA 3A)	Asiatic citrus psyllid (Vector of HLB); Glassy winged sharpshooter	
Fenpyroximate (MOA 21A)	Asiatic citrus psyllid (Vector of HLB); *Brevipalpus* mites that vector Citrus leprosis virus	
Flupyradifurone (MOA 4D)	Asiatic citrus psyllid (Vector of HLB); Citrus canker (**suppression only**)	
Gamma-cyhalothrin (MOA 3A)	*Oncometopia facialis* a vector of Citrus Variegated Chlorosis	*Oncometopia facialis* a vector of Citrus Variegated Chlorosis
Hexythiazox (MOA 10A)	*Brevipalpus* mites that vector Citrus leprosis virus	
Imidacloprid (MOA 4A)	African citrus psyllid (Vector of HLB); Asiatic citrus psyllid (vector of HLB); Black citrus aphid a vector of Citrus tristeza virus *Bucephalogonia xanthophis* a vector of Citrus Variegated Chlorosis; Glassy winged sharpshooter; *Oncometopia facialis* a vector of Citrus Variegated Chlorosis	African citrus psyllid (Vector of HLB); Asiatic citrus psyllid (vector of HLB); Black citrus aphid a vector of Citrus tristeza virus (**note no permit required, already registered in Australia**); Glassy winged sharpshooter; *Oncometopia facialis* a vector of Citrus Variegated Chlorosis

PESTICIDE	PESTS CONTROLLED USING THIS PESTICIDE (SEE ABOVE TABLES)	PESTS CONTROLLED BY THE PESTICIDE THAT SUITABLE FOR FUTURE PERMIT APPLICATIONS[9] (SEE ABOVE TABLES)
Imidacloprid + Beta-cyfluthrin (MOA 4A + 3A)	Asiatic citrus psyllid (Vector of HLB)	
Imidacloprid + Cyfluthrin (MOA 4A + 3A)	Glassy winged sharpshooter	
Lambda-cyhalothrin (MOA 3A)	Asiatic citrus psyllid (Vector of HLB); *Bucephalogonia xanthophis* a vector of Citrus Variegated Chlorosis; *Dilobopterus costalima* a vector of Citrus Variegated Chlorosis	
Maldison (Syn. Malathion) (MOA 1B)	Asiatic citrus psyllid (Vector of HLB); Carambola fruit fly; Citrus aphids, vectors of Citrus tristeza virus Exotic thrips; Oriental Fruit fly; Mexican fruit fly	Citrus aphids, vectors of Citrus tristeza virus (**note no permit required, already registered in Australia**); Exotic thrips; Oriental Fruit fly; Mexican fruit fly
Methidathion (MOA 1B)	Black citrus aphid a vector of Citrus tristeza virus; *Brevipalpus* mites that vector Citrus leprosis virus (**suppression only**)	Black citrus aphid a vector of Citrus tristeza virus (**note no permit required, already registered in Australia**); *Brevipalpus* mites that vector Citrus leprosis virus (**suppression only**)

PESTICIDE	PESTS CONTROLLED USING THIS PESTICIDE (SEE ABOVE TABLES)	PESTS CONTROLLED BY THE PESTICIDE THAT SUITABLE FOR FUTURE PERMIT APPLICATIONS[9] (SEE ABOVE TABLES)
Methomyl (MOA 1A)	Thrips species not specified	Thrips species not specified
Naled (MOA 1B)	Asiatic citrus psyllid (Vector of HLB); Oriental Fruit fly	
No chemical options identified	*Bactrocera kandiensis;* *Bactrocera occipitalis*; Citrus fruit borer; Citrus stubborn disease; New Guinea fruit fly	
Oxamyl (MOA 1A)	Asiatic citrus psyllid (Vector of HLB)	
Phosmet (MOA 1B)	Asiatic citrus psyllid (Vector of HLB)	
Piperonyl Butoxide + Pyrethrins (MOA 3A + 3A)	Bean thrips Black citrus aphid a vector of Citrus tristeza virus	Black citrus aphid a vector of Citrus tristeza virus (**note no permit required, already registered in Australia**)
Pirimicarb (MOA 1A)	Citrus aphids, vectors of Citrus tristeza virus	Citrus aphids, vectors of Citrus tristeza virus (**note no permit required, already registered in Australia**)

PESTICIDE	PESTS CONTROLLED USING THIS PESTICIDE (SEE ABOVE TABLES)	PESTS CONTROLLED BY THE PESTICIDE THAT SUITABLE FOR FUTURE PERMIT APPLICATIONS[9] (SEE ABOVE TABLES)
Profenofos (MOA 1B)	African citrus psyllid (Vector of HLB)	
Propargite (MOA 12C)	*Brevipalpus* mites that vector Citrus leprosis virus	
Pyrethrin (MOA 3A)	Asiatic citrus psyllid (Vector of HLB); Glassy winged sharpshooter	Asiatic citrus psyllid (Vector of HLB); Glassy winged sharpshooter
Spinetoram (MOA 5)	Asiatic citrus psyllid (Vector of HLB)	Asiatic citrus psyllid (Vector of HLB)
Spinosad (MOA 5)	Mexican fruit fly; Oriental Fruit fly	Mexican fruit fly; Oriental Fruit fly
Spirodiclofen (MOA 23)	*Brevipalpus* mites that vector Citrus leprosis virus	
Spirotetramat (MOA 23)	Asiatic citrus psyllid (Vector of HLB);	Asiatic citrus psyllid (Vector of HLB);
Sulphur (MOA Unknown)	*Brevipalpus* mites that vector Citrus leprosis virus	*Brevipalpus* mites that vector Citrus leprosis virus

PESTICIDE	PESTS CONTROLLED USING THIS PESTICIDE (SEE ABOVE TABLES)	PESTS CONTROLLED BY THE PESTICIDE THAT SUITABLE FOR FUTURE PERMIT APPLICATIONS[9] (SEE ABOVE TABLES)
Terpene Constituents of the Extract of Chenopodium ambrosioides near ambrosioides (MOA unknown)	Asiatic citrus psyllid (Vector of HLB)	
Thiacloprid (MOA 4A)	Asiatic citrus psyllid (Vector of HLB); *Dilobopterus costalima* a vector of Citrus Variegated Chlorosis; *Oncometopia facialis* a vector of Citrus Variegated Chlorosis	
Thiamethoxam (MOA 4A)	African citrus psyllid (vector of HLB); Asiatic citrus psyllid (Vector of HLB); *Bucephalogonia xanthophis* a vector of Citrus Variegated Chlorosis; Glassy winged sharpshooter; *Oncometopia facialis* a vector of Citrus Variegated Chlorosis	African citrus psyllid (vector of HLB); Asiatic citrus psyllid (Vector of HLB); Glassy winged sharpshooter
Thiamethoxam + Chlorantraniliprole (MOA 4A + 28)	Asiatic citrus psyllid (Vector of HLB); Glassy winged sharpshooter	
Thiamethoxam + Lambda-cyhalothrin (MOA 4a + 3A)	Asiatic citrus psyllid (Vector of HLB); *Dilobopterus costalima* a vector of Citrus Variegated Chlorosis; *Oncometopia facialis* a vector of Citrus Variegated Chlorosis	

PESTICIDE	PESTS CONTROLLED USING THIS PESTICIDE (SEE ABOVE TABLES)	PESTS CONTROLLED BY THE PESTICIDE THAT SUITABLE FOR FUTURE PERMIT APPLICATIONS[9] (SEE ABOVE TABLES)
Zeta-cypermethrin (MOA 3A)	Asiatic citrus psyllid (Vector of HLB); Exotic thrips; Glassy winged sharpshooter	
Zeta-cypermethrin + Avermectin (MOA 3A + 6)	Asiatic citrus psyllid (Vector of HLB); Glassy winged sharpshooter	

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