Urban plant biosecurity: Using a foundational approach to understand emerging risks, support resilient cities and safeguard rural industry

December 2020

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This document should be cited as:

Lye J & McGregor H. (2020), APBSF Project Final Report, Urban plant biosecurity: Using a foundational approach to understand emerging risks, support resilient cities and safeguard rural industry.

Acknowledgment

The authors are grateful to the Australian Plant Biosecurity Science Foundation for funding of this study. The social research aspect was funded in part by the Federal Department of Agriculture, Water & Environment Young Researcher Award (CSIRO sponsored for the category of health and biosecurity). Acknowledgment also goes to Eva Wawrzynczak for diligent data sourcing and aggregation, Dr Paul Umina for support during the *Urban Green Series,* and Drs Elia Pirtle and Lizzie Lowe for guest speaker sessions during the series. The authors are also grateful to the Foodprint Melbourne research team for collaborative interest in the project and provision of spatial data.

Executive Summary

The concepts of 'urban greening' and 'urban rewilding' are becoming increasingly normalised in high-density urban areas, such as Australia's capital cities. The growing popularity of urban greening approaches has been supported by the growing need to find solutions for heat effects, storm water runoff, declining air quality, energy use, threats to food security, and maintaining social cohesion in rapidly expanding and diversifying societies (Oberndorfer et al. 2007; Pataki et al, 2011; Cao et al. 2014; Grebitus et al. 2020). In line with evolution of how many urban residents perceive local food production, green infrastructure and the potential for greater plant health stewardship in urban environments, is a growing pressure on the Australian plant biosecurity system. This is driven by increasing pathway risk, limited expansion of state and federal government resources, and changing international distributions of pests and disease (Srinivasan and Simpson, 2014; Paini et al. 2016; Craik et al. 2017; Inspector General of Biosecurity, 2018; Inspector General of Biosecurity, 2019; Inspector General of Biosecurity, 2020).

Exotic plant pest transmission pathways are often closely associated with the movement of people or products (Paini et al. 2016; Weeks et al. 2020; Inspector General of Biosecurity, 2020). High volume people and product movement from airports and seaports increase risks to nearby amenity, natural and production areas. Major Ports of Entry are associated with high density residential urban areas and arterials that provide direct routes from primary production regions to the port or urban centre and from ports to interim warehouses and distribution depots, while in waiting to be transported further afield. Major cities, such as Melbourne, are surrounded by high-value peri-urban agricultural food bowls (Carey et al. 2019) that stand to significantly benefit from plant health protection activities undertaken in adjacent urban environments. This makes urban and peri-urban regions particularly important zones for plant biosecurity engagement and plant health stewardship activities.

Concerns relating to growing disconnectedness between urban residents, food production, and plant biosecurity have been noted by the Australian government and associated organisations (Beale et al. 2008; Srinivasan and Simpson, 2014). However, correlation between lack of primary production knowledge and attitudes towards biosecurity is not well characterised. Importantly, shifting mindsets and ideals relating to the importance of plant health stewardship and, more broadly, access to green spaces and local grown products is increasingly being supported by community-led action and local policy setting. This green direction shift is likely to have substantial implications relating to plant health attitude and knowledge, and present important opportunities for supporting greater plant biosecurity engagement at a local level in urban environments.

In *Urban plant biosecurity: Using a foundational approach to understand emerging risks, support resilient cities and safeguard rural industry* we suggest a divergence from traditional approaches towards building biosecurity compliance and engagement, which rely on a top-down knowledge transfer approach. We outline a more sophisticated approach towards improving plant biosecurity outcomes in urban environments, that takes into consideration changing land use and socio-demographic value drivers in line with the growing popularity of urban greening and urban agriculture. We demonstrate how geospatial mapping of urban land use, key organisations, grey communication networks and planning frameworks, such as local policies and local support structures, can aid in identifying locations and communities where there are the greatest opportunities for supporting plant health outcomes in urban environments, and thus safeguarding adjacent high-value production areas. This report also fills an important information gap in relation to characterising urban resident attitudes towards biosecurity and willingness to report suspect exotic pests.

This work integrated a number of discipline areas, including social research, geospatial analysis, and community engagement, in a novel application framework to support development of targeted, local-level community-based engagement strategies in urban environments. The study has yielded the following key findings and insights in relation to attitude, engagement and motivations:

- Those engaged in primary production tend to have greater biosecurity and land management knowledge than non-farming community counterparts in peri-urban regions. However, based on the available literature willingness to improve land management practices among non-farming community members appears to be high and assumptions made about peri-urban lifestyle landholders and biosecurity risk do not appear to be made on a strong foundation of evidence.

- The use of informal (grey) networks is a key aspect of for building biosecurity awareness and capability among non-farming urban and peri-urban residents. These networks include local knowledge brokers, special interest group information platforms, and peers.

- Social capital is an indicator of community resilience and community ability to recover after upheaval (such as a biosecurity incursion). Directing engagement strategies towards strengthening of social capital among community groups will support improved plant health outcomes. Geospatial mapping and demographic analysis can be used to identify communities of high or low social capital.

- Across the entire dataset survey dataset of urban and rural residents (n = 456), the response average was between 'unsure' and 'likely', which indicates there is scope to increase overall willingness of residents to report. However, willingness to report a suspect exotic pest was in the majority, with 64% of survey respondents indicating they were likely or highly likely to report a suspect exotic plant pest.

- Likelihood of reporting a suspect exotic pest was not found to significantly differ based on current residential location (rural or urban) and setting of upbringing (rural or urban) and there is high alignment between rural and urban residents in relation to motivations that would drive reporting. Among 'high likelihood' exotic pest reporters, key motivators were moral duty, environmental protection, agricultural protection, and general awareness of risk.

- A lack of knowledge and confidence among potential reporters is potentially a major limiting factor in improving plant health outcomes in urban and rural environments. This barrier is unlikely to be appropriately addressed through traditional biosecurity outreach approaches that place an emphasis on providing direct information about priority pests. Rather, a more holistic process of building community social capital (strengthening informal networks) and empowering individuals and groups to become more familiar with their seasonal garden ecology will support longer-term positive outcomes.

In this report we also demonstrate that integration of geospatial mapping analysis into engagement planning affords an opportunity to take biosecurity engagement strategy to a more sophisticated level as it offers a method of conducting granular analysis of urban demographics and environments in order to direct strategic building and utilisation of social capital at a local or regional level. Overall, the report highlights that significant opportunities exist to use the described geospatial analysis and social research approach to investigate and pilot building of community level social capital among urban communities to improve biosecurity outcomes – an need that has also been highlighted by other studies in recent years (Klepeis and Gill, 2016; Sinclair et al. 2020).

Urban residents represent a potentially powerful pool of interested individuals if plant health training and engagement is offered in line with major motivators and values, and with a view to building community level social capital. This study highlights the importance of building confidence and knowledge among community members and taking an approach that supports potential exotic plant pest reporters in achieving a greater understanding of their garden ecosystem. As one proof of concept activity, the outreach component of this project, which was designed with a basis in our social research findings, was successful in increasing the confidence of participants based on feedback.

In future, biosecurity engagement should go beyond basic biosecurity awareness activities and should investigate activities that will build social capital within communities. An important factor in building social capital is fostering collaborations between groups and facilitating strengthened communication throughout horizontal (grey) networks.

Finally, biosecurity engagement in urban environments must be undertaken with consideration of the wider urban planning context. Continued strengthening of grassroots and policy supported urban greening directions at a local level will pose new opportunities for improving community plant health knowledge and stewardship, and strengthening of trusted plant health learning networks. Biosecurity organisations and affiliated groups may capitalise on a changing local context through targeted, data driven, pre-emptive engagement.

1. Introduction

The concepts of 'urban greening' and 'urban rewilding' are becoming increasingly normalised in high-density urban areas, such as Australia's capital cities. The growing popularity of urban greening approaches has been supported by the growing need to find solutions for heat effects, storm water runoff, declining air quality, energy use, threats to food security, and maintaining social cohesion in rapidly expanding and diversifying societies (Oberndorfer et al. 2007; Pataki et al, 2011; Cao et al. 2014; Grebitus et al. 2020). In line with evolution of how many urban residents perceive local food production, green infrastructure and the potential for greater plant health stewardship in urban environments, is a growing pressure on the Australian plant biosecurity system. This is driven by increasing pathway risk, limited expansion of state and federal government resources, and changing international distributions of pests and disease (Srinivasan and Simpson, 2014; Paini et al. 2016; Craik et al. 2017; Inspector General of Biosecurity, 2018; Inspector General of Biosecurity, 2019; Inspector General of Biosecurity, 2020).

While there is increasing global and local exploration and structured investigation into how an urban greening direction could be actioned, investigations relating to how plant biosecurity may be maintained in line with this direction is notably missing - to an extent at government policy and planning level, and definitely at the community enterprise level. However, herein lies an opportunity to explore how plant health and plant biosecurity conversations and knowledge brokering may be integrated into existing community networks.

1.1 Ports of entry and plant biosecurity

Exotic plant pest transmission pathways are often closely associated with the movement of people or products (Paini et al. 2016; Weeks et al. 2020; Inspector General of Biosecurity, 2020). High volume people and product movement from airports and seaports increase risks to nearby amenity, natural and production areas. Major Ports of Entry are associated with high density residential urban areas and arterials that provide direct routes from primary production regions to the port or urban centre and from ports to interim warehouses and distribution depots, while in waiting to be transported further afield. Major cities, such as Melbourne, are surrounded by high-value peri-urban agricultural food bowls (Carey et al. 2019) that stand to significantly benefit from plant health protection activities undertaken in adjacent urban environments. This makes urban and peri-urban regions particularly important zones for plant biosecurity engagement and plant health stewardship activities, particularly in the context of the many potential early detectors associated with these points of entry and sites of early establishment, such as warehouse and distribution centre workers, port officials, fresh produce establishments, tourist hotspots in close proximity to ports, and urban community groups that have an interest in green spaces and plant health stewardship.

Instances of exotic pest detection at ports of entry occasionally make it into the public sphere. In November 2018, a cargo ship originating in China was ordered to turn around without making port at Freemantle after an offshore inspection by federal Department of Agriculture and Environment biosecurity officers detected an infestation of brown marmorated stink bug (*Halyomorpha halys*) as well as other exotic species, were detected on board (Fresh Fruit Portal, 2018). In that same year the stink bug was found within Melbourne city limits, brought into the city on imported ceramics and machinery from Italy, which prompted an exotic pest eradication response, and Varroa mite was also detected at the Port of Melbourne in a shipment originating from the United States (Agriculture Victoria, 2020). In 2019, federal biosecurity officials detected exotic Heath snails in a large shipment of Mercedes-Benz cars (The Guardian, 2020).

The number of exotic pest interceptions at Australian ports between 2012 and 2018 has been reported as more than 104,000 linked to air cargo, and 35,800 linked to sea freight (Inspector General of Biosecurity, 2019). Between January 2014 to July 2016 imported cut flowers were affiliated with the highest number of exotic pest interceptions at Australian ports (Inspector General of Biosecurity, 2019). Exotic bees, Brown marmorated stink bug, and Giant African land snail comprise the majority of National Priority Plant Pest interceptions (Inspector General of Biosecurity, 2019). Notably, exotic bees, Brown marmorated stink bug (Fig 1.1) and Giant African snail all have the potential to significantly impact horticultural industries often affiliated with peri-urban production regions, including vegetables, stonefruit, berries, citrus and pome fruit. The Melbourne peri-urban agricultural zone is one example of a high value food bowl, that has the potential to supply the Greater Melbourne region with up to 41% of its fresh produce needs (Sheridan et al. 2015), yet is coming under increasing pressure from outer urban sprawl (Buxton and Butt, 2020).

Figure 1.1 Brown marmorated stink bug (*Halyomorpha halys*) is a frequent interception at Australian ports of entry and has the potential to significantly impact horticultural industries (source: U.S. Department of Agriculture)

1.2 Protection of the Greater Melbourne food bowl

Urban growth boundaries are set up to contain the outward growth of a municipality, with a key benefit being the continued protection of surrounding primary industries and a robust food supply chain. Green wedges are often allocated at the periphery of an urban growth boundary to conserve significant natural features, protect water supply catchments, and to provide urban residents with relief from high density environments.

There are currently 31 municipalities, plus part of Mitchell Shire, that sit within the Melbourne urban growth boundary. The Melbourne urban boundary intersects highly productive land, and thus there remains an intrinsic risk to the regional food bowl (Buxton and Butt, 2020). From a geographical and socio-economic perspective, Melbourne residents are well-placed to both support and benefit from increased plant health resilience across the wider Melbourne region. Peri-urban food bowl resilience supports shorter value chains, lower consumer costs, fresher produce and the opportunity to 'buy local'. While Melbourne peri-urban cropping is on average undertaken on a small spatial scale, production potential is notably higher on a per hectare basis compared with rural counterpart farming operations (Buxton and Butt, 2020).

Protection of Melbourne peri-urban agribusinesses is essential to maintaining a robust food supply chain for Melbourne city and limiting inflation of fresh food prices. This need has been acknowledged at a jurisdictional level and is articulated in *Plan Melbourne 2017-2050*, which commits to contain outwards growth of the urban sprawl in order to protect peri-urban agricultural zones. In 2019, The Victorian Department of Environment, Land, Water and Planning released a land capability assessment of Melbourne green wedge and peri-urban areas, and subsequently undertook community consultation in order to initiate planning for protection of Melbourne agricultural areas (Fig 1.2, Capire Consulting Group, 2019). However, national acknowledgement of the need to protect peri-urban food bowls surrounding Australian cities is lacking, as is a defined plan for doing so. As described by Buxton and Butt (2020), security of food production and supply at a national level is not under threat, however "*...at a local and city-region level the loss of production [through rezoning] and future adaptability of farming systems, particularly in areas of higher quality soils and those close to markets should be of concern to policy makers".*

Protection of these high-value, urban fringe agricultural areas does not only stem from planning-based protection mechanisms, such as constraints on urban growth boundary expansion. Border protection activities by the federal government, as well as exotic plant pest surveillance and containment measures undertaken by the state government plays a key role. Importantly, community-based mechanisms for facilitating plant health knowledge and stewardship in localities adjacent to production regions has significant potential to contribute to protection of these zones.

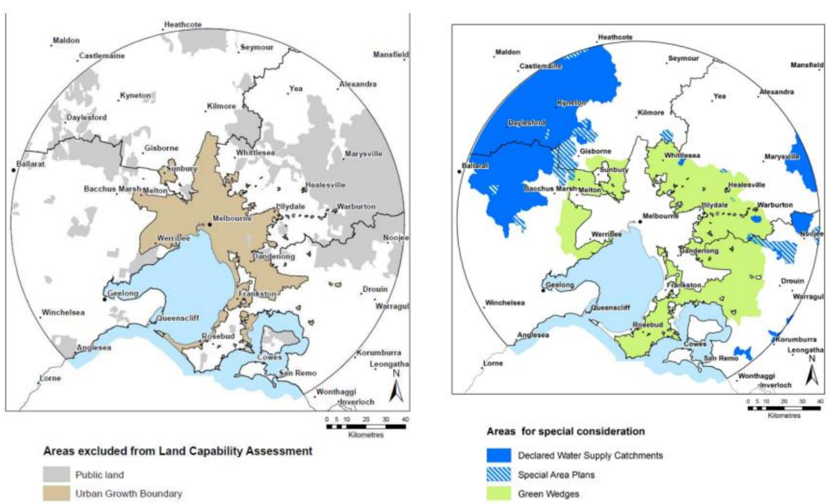


Figure 1.2 Greater Melbourne urban growth boundary (left), green wedge and supply catchments (right) (Source: Imhof et al. 2018).

1.3 Urban agriculture and community social capital

Concerns relating to growing disconnectedness between urban residents, food production, and plant biosecurity have been noted by the Australian government and associated organisations (Beale et al. 2008; Srinivasan and Simpson, 2014). However, correlation between lack of primary production knowledge and attitudes towards biosecurity is not well characterised. Importantly, shifting mindsets and ideals relating to the importance of plant health stewardship and, more broadly, access to green spaces and local grown products is increasingly being supported by community-led action and local policy setting. This green direction shift is likely to have substantial implications relating to plant health attitude and knowledge, and present important opportunities for supporting greater plant biosecurity engagement at a local level in urban environments.

The concepts of 'urban greening' and 'urban rewilding' are becoming increasingly normalised among urban societies. The link between urban green spaces and wellbeing is well demonstrated (Hartig et al., 2014; WHO Regional Office for Europe, 2016) and in a demonstration of international leadership, in 2017 the World Health Organisation released the action plan '*Urban green spaces: a brief for action*', which recognises the importance of instigating an urban greening direction in major cities.

The popularity of 'urban agriculture' either practiced by home gardeners, community groups or for commercial purposes, has experienced a marked increase over the past decade. In 2012, Guitart et al. reported that the Australian City Farm and Community Gardens Network website listed 240 community gardens across Australia. As of September 2020, the organisation (now known as Community Gardens Australia) lists 646 community gardens in its directory. While this directory is potentially an underestimate of actual garden numbers, and the increase in listed gardens may in fact be a product of increased awareness about the directory itself over the intervening period, the change in listings remains an indication of increased interest in urban agriculture in Australia.

Despite this growth there is a lack of scientific literature on the topic for the Oceania region. Overall, the status of urban agriculture in mega-cities (classed as having a population of more than 5 million people) have received less attention than smaller cities (Graefe et al. 2020). However, the total body of literature is growing in reflection of the popularity of this area (Guitart et al. 2012). Most research has focussed on benefits of urban agriculture from a social wellbeing and societal cohesion perspective (Guitart et al. 2012). While urban agriculture initiatives have been shown to be input inefficient (McDougall et al. 2019), motivations to grow food crops in an urban environment are less inclined towards financial benefit or cost savings, but rather, towards less tangible motivations such as environment, society and food attributes (Grebitus 2020).

Community gardens as a mechanism of improving community social capital has been a high focus of past research (Glover, 2004; Alaimo et al. 2010; Firth et al. 2011; Guitart et al. 2012). Social capital is characterised by the strength of informal networks, opportunities to improve skills and knowledge, and regularity of organisational collaborations by Klepeis and Gill, (2016), although there is no undisputed definition for this term and the meaning of 'social capital' does vary (e.g. Woolcock (1998) describes the concept as *"the information, trust, and norms of reciprocity inhering in one's social networks"* and Brehm and Rahn (1997) use the following definition of "*the web of cooperative relationships between citizens that facilitate resolution of collective action problems"*).

Building social capital with communities has been raised by several recent studies as a new objective to which biosecurity engagement activities should aspire. In a study of invasive weed management in the peri-urban Kiama Local Government Area of New South Wales, Australia, which is approximately 60km south of Sydney, Klepeis and Gill (2016) hypothesise that strength of community social capital is related to the ability of communities to withstand socio-ecological challenges, and enhances civic engagement and collective problem-solving capacity – all of which are important facilitators of biosecurity management. In an investigation of how social capital may be improved within groups for the purpose of strengthened biosecurity outcomes, Surata et al. (2010) describe use of a Biosecurity Ecoliteracy teaching method, which is described as "*transformative learning which employs basic concepts of ecology to promote in-depth understanding, creative thinking, critical reflection, social skills, and self-consciousness in managing plant living/health, animal (including human) living/health and issues associated with the environment*". This method of learning was found to align well with biosecurity principles and engagement as biosecurity management involves multiple stakeholders, is interdisciplinary, and the risk and impacts are dependent on social constructs and contexts.

Building social capital amongst community groups for the purpose of seeking improved plant health outcomes is also important to negate the demotivating effect of 'some in, some not'. This was highlighted by Kruger (2018): *"Some interviewees remarked that messages to backyarders to diligently manage Qfly are undermined when a lack of Qfly management close by is evident, such as on derelict orchards. Grower interviewees who personally requested neighbours to manage Qfly had limited success….it is unlikely that education and aware- ness-raising alone will elicit on-going strong community support."*

Community gardening as a mechanism to build social capital is well recognised and researched (Kingsley and Townsend, 2006; Kingsley et al. 2019; Scott et al. 2020). In a recent Melbourne based study, learning and engagement with other community members was found to be a strong factor in being a member of a community garden, with one interviewee indicating that peer-to peer knowledge channels held high importance when it came to learning about good growing practices – "*to be around other gardeners. Because it's so hard learning out of books*" (Kingsley et al. 2019).

Informal knowledge and learning networks by which affiliates of grass-roots food gardening groups obtain information on best growing practices ('grey networks') are potentially highly influential channels of communication. In a study of community garden affiliates in North Queensland and their level of engagement with biosecurity risks, Curnock et al. (2020) found that "...*less formal institutional characteristics such as social networks played a greater role in shaping stakeholder engagement*" than other influential factors such as land tenure, policies or regulations. As we describe further throughout this report, there is indeed an opportunity to explore and trial a system of supporting urban plant health that perpetuates trusted knowledge and advice in a positive feedback cycle that continually educates and empowers food growing communities across a city region.

For the purpose of this study we use the following definition of community garden, as described by other studies (Holland, 2004; Pudup, 2008; Kingsley et al., 2009; Guitart et al. 2012): *'Community garden' refers to 'open spaces which are managed and operated by members of the local community in which food or flowers are cultivated'.* As shown on the Community Gardens Australia Directory, Melbourne is an Australian leader of community growing initiatives, accounting for 29% of national listings.

1.4 Opportunities in a greener Melbourne

In Melbourne, the past 5 years has seen the emergence and growth of an active and engaged urban agriculture and local food movement. The broader context due to COVID-19 has accelerated that growth since early 2020, outwardly represented in more people being aware and concerned about food security and supply resilience. The concept of urban agriculture is not new, with mature examples of its evolution and success globally. However, in most major cities in Australia, until more recently, it has been only a novel or boutique activity and conducted at mainly hobbyist scale.

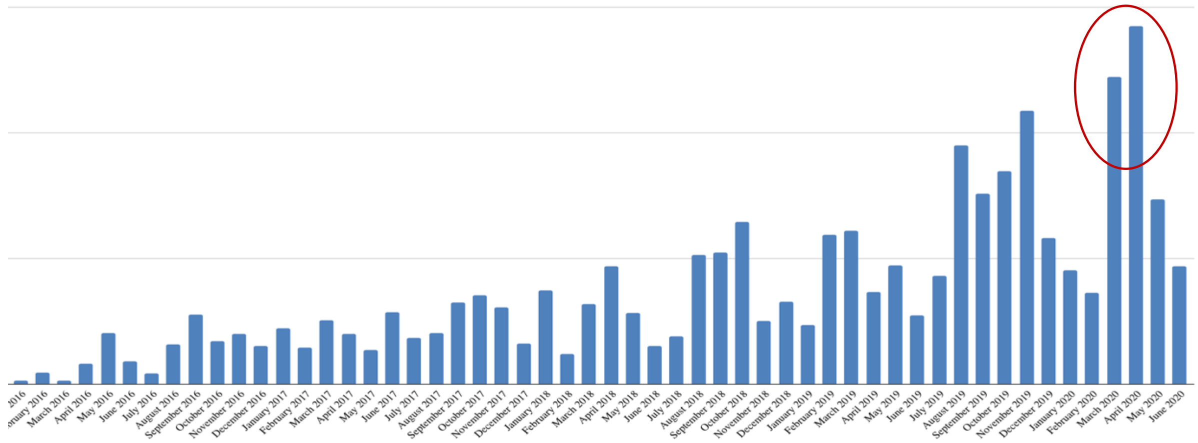
This has also been changing over time, with initiatives such as 'Farmer Incubator' programs, urban farming ventures supplying the restaurant and consumer trade and key organisations, such as 3000acres in Melbourne, facilitating access to urban land for growers previously limited by that opportunity. These communities and networks have grown, catalyzed by experienced and entrepreneurial actors, classified as 'influencers', and driven by new societal and philosophical drivers. Along with increased activity at a community level, the establishment of urban farms, growing at commercial scale have offered credibility to the concept of urban agriculture, beyond that of backyard production, and have established these 'influencers' as community champions, through whom many of the initiatives and programs run or are leveraged (Section 4.2 and 4.3.5).

These developing areas of food production and urban greening bring increased biodiversity, including a host of food plant species, and could therefore be perceived to potentially play a role in plant pest and disease transmission, through offering a suitable environment for establishment potential. However, they also afford the opportunity to create sentinel sites and pest containment zones that are actively stewarded through building critical social capital, to engage informed and interested groups (Fig 1.3). This current context offers a tangible and novel opportunity to explore more laterally, how plant health can be improved in cities, how these emerging and established influencers can be engaged to share their knowledge and how to create collaboration between urban, peri-urban and larger scale commercial growers.

These active and engaged urban and peri-urban gardening communities have already demonstrated their commitment to this cause, through their pursuit of these growing opportunities and the rehabilitation of areas that have previously fallen into disuse and/or are no longer actively monitored nor stewarded. (Examples of this are the rehabilitation of disused Victrack sites and vacant residential blocks, transformed into community gardens - Collingwood Fair Share and Luscombe Street Community Gardens).

The escalation in food growing activity in Melbourne can be further supported by the growth of businesses facilitating and educating the gardeners. This can be represented in a tangible sense through analysis of sales figures from a leading food garden landscaping business in inner Melbourne (Figs 1.4 and 1.5). Despite the broader societal and economic challenges of COVID19, their sales data shows not only a year on year increase of sales of equipment (garden beds and associated infrastructure) since 2016 but an above average increase in sales for the months of March and April 2020.

Figure 1.3 Greater urban food plant species diversity offers the opportunity for actively stewarded plant pest sentinel sites.



Figures 1.4 Total sales of equipment (e.g. garden beds and associated infrastructure) for backyard food production from May 2016-May 2020, sourced from an inner Melbourne garden and landscaping business (note sales peak over March-April 2020)

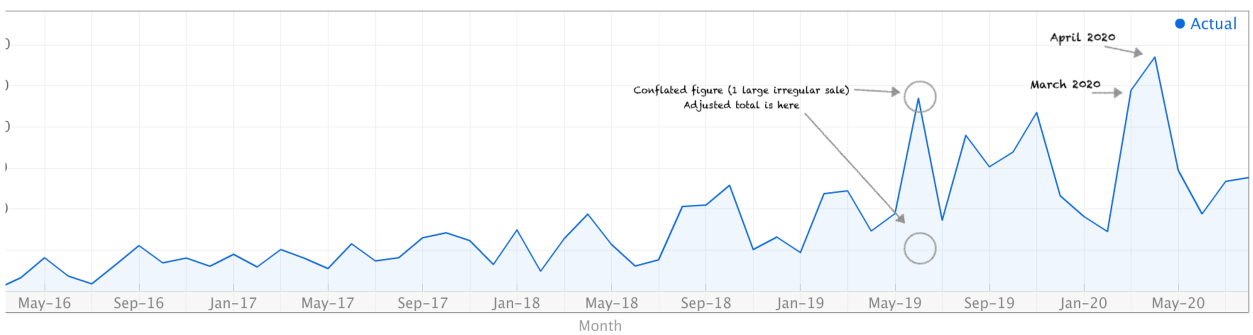


Figure 1.5 Total sales - income (garden beds and associated infrastructure) for backyard food production from May 2016-May 2020, sourced from an inner Melbourne garden and landscaping business (note sales peak over March-April 2020) - Note – the figures for June 2019 are adjusted as per the notation above, due to a single, large, irregular sale. The March and April 2020 figures are highlighted.

The commitment of the urban community to these activities was also more recently highlighted in the preliminary results from a survey '*Gardening in the Pandemic'* conducted by Sustain capturing over 9000 responses from across Australia, with Victoria and Melbourne well represented in the demographics. The initial results support that there is a broad, increasing awareness of food supply and security and interest in backyard or community food production. The survey was conducted between June and July 2020 and identified that across that time, over 60% of respondents had spent more time than previously gardening – specifically growing food. Many of the survey respondents (>50%) were experienced gardeners (with over 10 years' experience) reinforcing the capacity of the urban, backyard gardener communities to contribute significantly to plant health and surveillance outcomes. For the newer gardeners, their greatest needs were identified as access to land, mentoring and resources.

With a concurrent growing interest and engagement from local councils (as we show in this study), community groups and the potential to engage further with community champions and influencers, considerable opportunity exists to formalize and build on this existing social capital to better support these communities to build their knowledge and activity in the areas of plant health and biosecurity. This in turn supports commercial or larger scale growers through increased surveillance activity, early detection and reporting.

As legislation, planning policies and engagement materials are developed to support city-level and local level urban greening directions, and certain priority plant pests achieve a near global distribution, it is necessary to identify and quantify key community-based urban information networks and land use to provide a ground-truthed, granular exploratory framework that can underpin and inform national, jurisdictional and local plant health activities.

1.5 Project aims

A major theme throughout the investigation was improving plant health outcomes and boosting plant biosecurity awareness and activity in urban environments. The scope of this project was designed such that:

1. Findings will provide greatly needed context on the potential for plant health and general surveillance activities to be undertaken in a large Australian capital city, and identify less traditional but potentially powerful plant health information and learning networks (grey networks) that are largely unregulated, untracked and underestimated;
2. Findings will improve the collective understanding of how community groups and individuals could be empowered to improve urban plant health and plant biosecurity outcomes;
3. Needs and projections relating to plant health risks and urban plant biosecurity opportunities will be identified;
4. Identification of these needs and projections could be used by biosecurity authorities and agricultural industries (particularly those commonly adjacent to urban areas) to strategically direct plant health engagement and surveillance activities in urban environments; and
5. Activities will serve as a basis for exploring and documenting a replicable methodology to identify grey networks, as well as highlight spatial risk and opportunity areas in regard to supporting plant health activities and exotic pest reporting in a large city.

2. Evidence mapping of Australian urban biosecurity research

2.1 Introduction

This study has been undertaken within the context of both increasing urban greening priorities and directions within heavily urbanised centres, and an increasing risk of exotic pests entering through major Ports of Entry. While assessments of the knowledge levels, motivators and attitudes of individuals within the agricultural sector have been, and continue to be undertaken, it is unclear to what extent similar research has been conducted in urban and peri-urban environments.

Past research investigating the knowledge level, attitudes and awareness of Australian urban and peri-urban residents in relation to plant biosecurity was identified through an extensive online scientific literature search using an evidence mapping approach. Evidence mapping is becoming more frequently adopted by researchers as a method of systematically aggregating and analysing literature to produce a high-level overview of a topic. According to Miake-Lye et al. (2016) evidence mapping can perhaps best be described as "*a systematic search of a broad field to identify gaps in knowledge and/or future research needs that presents results in a user-friendly format, often a visual figure or graph, or a searchable database*."

By taking this evidence mapping approach we aimed to compile scientific literature that provided context to the following key research questions:

- What is the level of plant biosecurity awareness amongst urban or peri-urban populations?
- What is the level of plant biosecurity knowledge amongst urban or peri-urban populations?
- What are the motivations and barriers to increased pest reporting or implementation of good biosecurity practices amongst urban or peri-urban populations?

2.2 Methodology

Past research investigating the knowledge level, attitudes and awareness of Australian urban and peri-urban residents in relation to plant biosecurity was identified through an online scientific literature search.

Reference databases used for the study included the Mendeley database, Google Scholar, PubMed (NCBI), the Bielfeld Academic Search Engine (BASE), Semantic Scholar, the Social Science Research Network (SSRN), and Science Open. These databases were searched during October 2019-January 2020.

Studies identified through a preliminary search using primary search terms were triaged through a secondary search term filter. Screening of titles and abstracts against inclusion criteria and removal of duplicates reduced the list. Final studies were triaged by screening the full text against inclusion criteria. Search terms were:

- biosecurity AND (peri-urban OR urban)
- biosecurity AND cities OR city)
- biosecurity AND (attitud* OR behaviour)
- biosecurity AND urban AND value*
- biosecurity AND urban AND (knowledge OR awareness)
- biosecurity AND urban AND challenge*
- Australia OR Australian (used for triaging into a final list)

Inclusion criteria were set to determine which research papers would be included for final analysis. Those papers with study populations living in urban or peri-urban regions across Australia were included in the final research list. The study was required to have included study participants that did not make the majority of their income from primary production, and results for this sub-population was required to be clearly identifiable in the research paper. The study was required to have made use of social science methodology for testing hypotheses against a sample population (for instance, opinion papers or single case studies were not included in the final research list). Studies that had a focus on plant pest biosecurity were included in a final short list. Those studies focusing on weed biosecurity, invasive invertebrate biosecurity and animal health biosecurity were excluded from the final short list.

Apart from basic contextual information for each study, specific data was extracted and mapped to the following domains for analysis:

- Study design
- Reason for study
- Knowledge and awareness
- Attitudes and motivators
- Identified challenges
- Recommendations

2.3 Results

Final short list comprised of seven studies undertaken in Australia from 2005-2017. Case study regions across all seven studies that included a plant pest biosecurity focus were: the Yass region, ACT, the City of Swan, WA, the Barossa Valley and Adelaide Hills, SA, the City of Greater Bendigo, Victoria, and the Brisbane / Sunshine Coast Hinterland, QLD, the Yarra Valley, Victoria, and the Greater Perth region.

When weed, invasive species, or animal health related studies, where a peri-urban or urban population or sub-population data had been clearly evident were included the final expanded list reached 22 studies (Appendix 1). The expanded list comprises of studies that can be categorised as: Animal pest biosecurity (9), plant pest biosecurity (2), invasive weeds (4), invasive animals (2), and multi-focus studies (4). An additional nine reports were identified, which did not meet inclusion criteria, yet are pertinent to this field of work nonetheless. These additional reports include discussion papers, opinion pieces and economic analyses. They are referred to in the discussion section.

The multi-focus studies were comprised of four plant pest biosecurity studies (Aslin and Mazur 2005, Maller et al. 2007, Hollier et al. 2008, and Gilmour et al. 2011) that did not focus exclusively on plant biosecurity awareness and knowledge. Rather, these studies also included a focus on other topics of biosecurity, such as invasive weed management and animal biosecurity. Data collection across these four studies were undertaken within a similar time period (between 2003 and 2007), at a time period when government authorities had an interest in assessing biosecurity risk as it was related to the rapidly diversifying and fragmented peri-urban landscapes surrounding major cities. In all instances within these studies greater emphasis of the results and analyses was given to weeds and animal health. These four multi-focus studies made up the majority of studies included in table 2.1.

By including these additional studies and tracking publication dates, as well as data collection dates, it becomes clear that investigations into peri-urban and urban resident knowledge, attitude and awareness of animal or plant biosecurity has been funded over two distinct time periods since 2000: 2005-2009 and 2012-2017 (Fig. 2.1). Across the 22 studies there was a notable lag between data collection and publication of results, beyond what would be expected for peer reviewed research. The average lag time between data accrual and data publication was 3 years.

Table 2.1 Final list of identified studies that include an investigation of attitudes, knowledge and awareness of plant biosecurity amoung urban and peri-urban residents. Multi-focus studies are denoted by 'M'.

Authors	Title	Publication/publisher	Publication data
Aslin, H. J., Mazur, N. M	Biosecurity awareness and peri-urban landholders: A case study approach.	Bureau of Rural Sciences	2005
Arevalo-Vigne, M. L. I.	Community engagement in biosecurity: Evaluating the role of knowledge and incentives in the area wide management of Mediterranean fruit fly in Western Australia.	The University of Western Australia	2017
Curnock, M., Farbotko, C., Collins, K., Robinson, C. J., & Maclean, K.	Engaging with risk (or not): shared responsibility for biosecurity surveillance and the role of community gardens.	Geographical Research	2017
Gilmour, J., Beilin, R., & Sysak, T. M	Using stakeholder mapping and analysis with a mental models approach for biosecurity risk communication with peri-urban communities.	Journal of Risk Research	2011
Hu, X., Feng, Y., Santhanam-Martin, M & Nettle, R.	Assessment of industry and community awareness, understanding and control practices relating to Queensland fruit fly in the Yarra Valley: Implications for engagement strategies.	The University of Melbourne and the Box Hill Institute	2018
Hollier, C., Reid, M., Curran, E. et al. M	Small landholders: an assessment of potential biosecurity and land management risks.	Rural Industries Research and Development Corporation (Australia)	2008
Maller, C., Kancans, R., & Carr, A. M	Biosecurity and Small Landholders in peri-urban Australia.	Bureau of Rural Sciences	2007

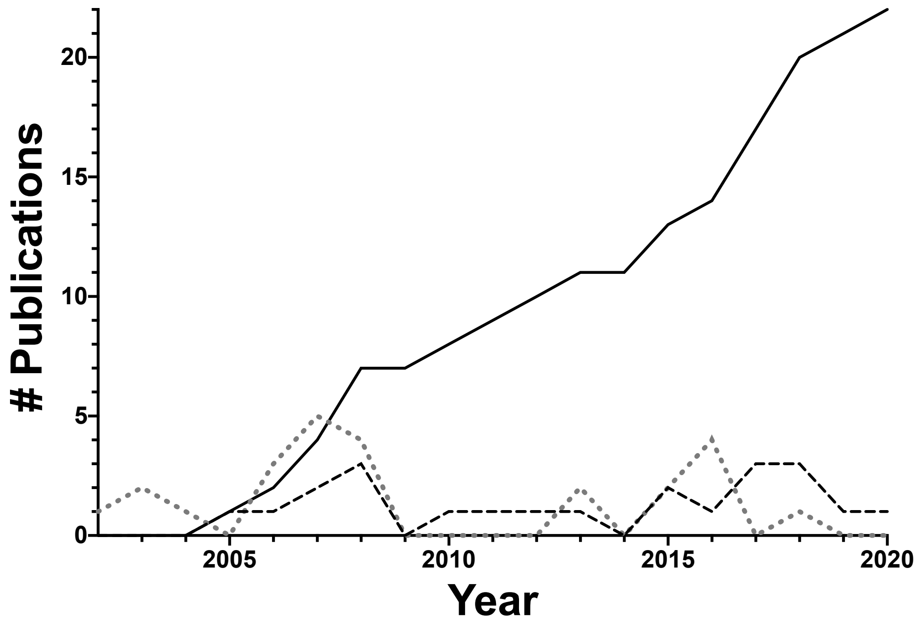


Figure 2.1 Evidence mapped studies published each year (thick dashed line), accumulative total of published studies (solid line), and dates of data collection (grey dashed line).

A subset of research questions across identified studies are included below.

- What is the current biosecurity and emergency animal disease knowledge of smallholder production in Australia and what are the relationships that exist between smallholders and the organisations and individuals from which they seek information, assistance and support? (Hayes et al. 2018)
- To better understand high risk peri-urban groups, what they do, what motivates them, and how to reach them (Aslin and Mazur 2005)
- Do rural lifestylers have the necessary motivation, capability and capacity to properly address existing and emergent NRM issues, particularly invasive weeds, on their properties, and do they have well developed networks that can be utilised to inform and disseminate important NRM information and messages on weeds through their peri-urban communities? (Choy and Harding 2009)
- What methodologies can be used to develop biosecurity communication strategies when stakeholders are diverse and knowledge level is uncertain? (Gilmour et al. 2011)
- What are the demographics, motivations, marketing strategies and rearing techniques of producers who trade pigs at livestock markets in eastern Australia? (Schembri et al. 2013)
- What is the knowledge, attitudes and practices in relation to zoonoses among metropolitan pet owners? (Steele et al. 2015)
- What are the main barriers that prevent Gold Coast peri-urban residents from reporting wild dog impacts to local government and what is their capability, opportunity and motivation to report wild dogs and their impacts to local government? (Hine et al. 2020)
- What are the challenges, knowledge level and training needs of veterinarians working within the peri-urban landscape? (Hayes et al. 2018)
- What are peri-urban landowner environmental ideologies, the degree to which they collaborate with one another, and their specific land-use practices when it comes to invasive weed management? (Klepeis and Gill 2016)
- What are the practices of small landholders in peri-urban areas that may give rise to exotic pests and diseases that are currently not established in Australia? (Maller et al. 2007)

- What are the social factors that influence the intention to control Mediterranean fruit fly (Medfly) at the property level? (Aravelo-Vigne 2017)
- What role can community gardeners play in relation to plant biosecurity, and what role do they play currently? (Curnock et al. 2017)
- To provide knowledge about small lifestyle landholder land use practice and biosecurity awareness to influence communication and skill development programs. (Hollier et al. 2008)
- To understand animal health and communication practices among smallholder livestock producers in Australia (Hernández-Jover et al. 2019)
- What is the capacity of different stakeholder groups to influence biosecurity outcomes for identified smallholder animal biosecurity issues and assess their success or failure to do so? (Hernández-Jover et al. 2012)
- What are the common husbandry and biosecurity practices of backyard, small-scale and large-scale Eastern Australian pig producers who trade pigs at sale yards? (Schembri et al. 2015)
- To investigate and understand longer term trends in public awareness and knowledge of weed impacts on agricultural enterprises, bushlands and other natural areas, and on the Australian economy (Fenton 2007)
- To benchmark community awareness, attitudes and beliefs in relation to NRM and the CMA (Collins 2008)

The Sydney and Greater Sydney region was the most well studied area in terms of the size of study populations and the number of studies conducted in the region (Fig 2.2). This was followed by the Cairns and Townsville regions of northern Australia. Sample populations surveyed across the expanded list were most commonly under 100 participants. Structured interviews were the most commonly employed technique (62% of studies from the expanded list) (Table 2.2).The second most common research methodology employed was the use of surveying of a sample study population in the region of interest, either by letter, phone, or online (59% of studies from the expanded list). While some studies attempted to identify high influence and high interest groups and identify the key communication channels through the consultation process, no studies merged a spatial analysis with social research analyses to understand risks and opportunities from a socio-geographic perspective.

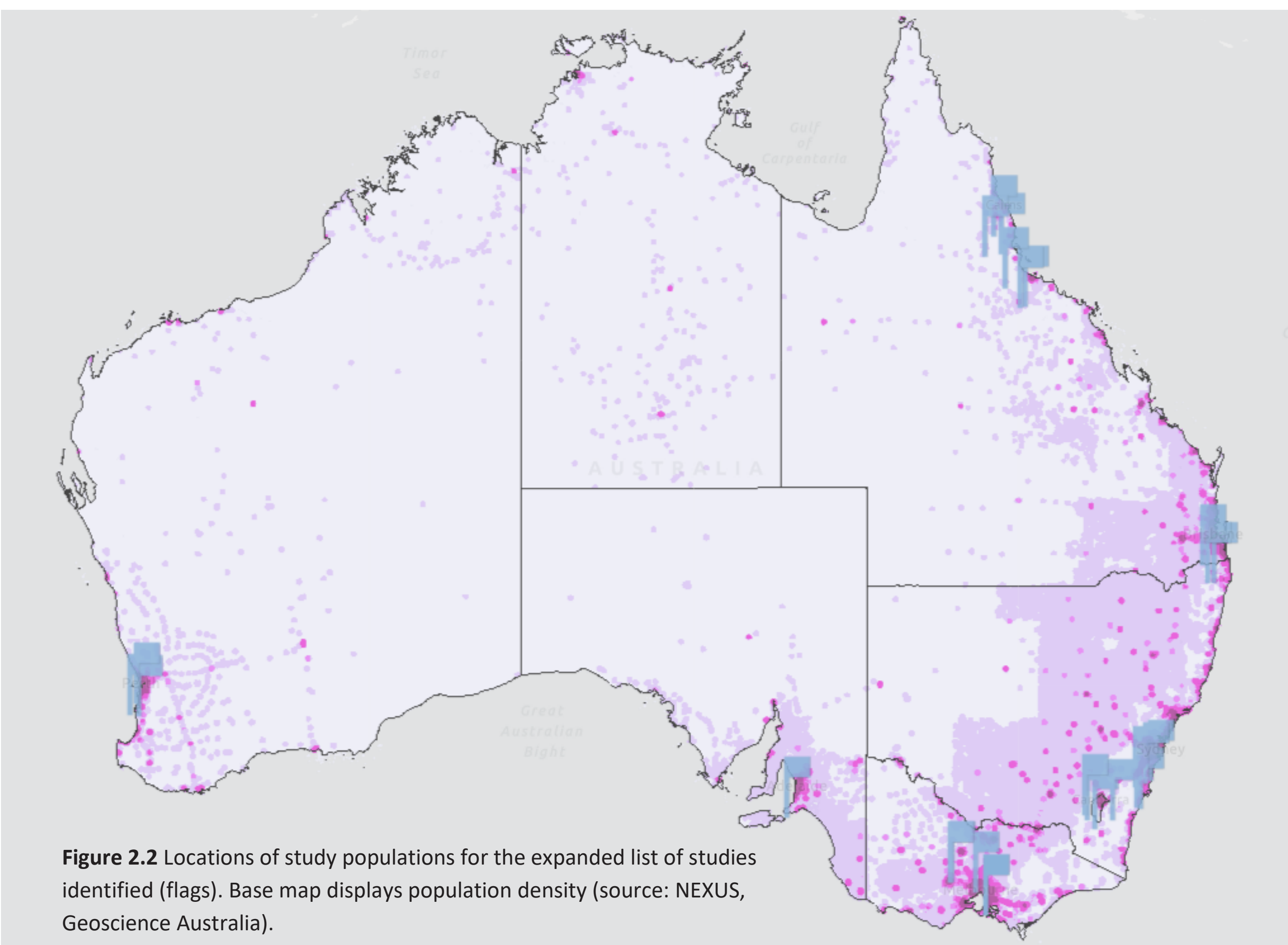


Figure 2.2 Locations of study populations for the expanded list of studies identified (flags). Base map displays population density (source: NEXUS, Geoscience Australia).

Table 2.2 Research methods mapped against category for the expanded list of studies identified. Proportions per row are calculated from the total number of publications that used that methodology type.

	Study category				
	Animal pest biosecurity	**Plant pest biosecurity**	**Invasive weeds**	**Invasive animals**	**Multi-focus**
Population survey					
Comparison of datasets					
Focus groups					
Interviews					
Literature review					
Stakeholder mapping					
Stakeholder issues mapping					
Audience segmentation analysis					
Regional case study					

<10%	10-25%	25-50%	>50%

Reasons for undertaking an investigation varied (Fig 2.3). The most common reason for initiating a study was the perception that the study population, which was most often peri-urban small landowners, represented a high biosecurity risk. This was cited as a reason across 10 studies. In these cases, studies attempted to validate or discount this hypothesis by posing questions that sought to determine willingness to implement biosecurity best practices, level of knowledge about exotic pests, what 'biosecurity' means to these populations, and level of awareness relating to biosecurity threats. Two other reasons emerged as common among studies. Firstly, five studies cited a lack of existing knowledge and a need to fill that knowledge gap. Secondly, five studies cited a need to create knowledge that would support more effective stakeholder engagement and communications for the purpose of better biosecurity in peri-urban areas.

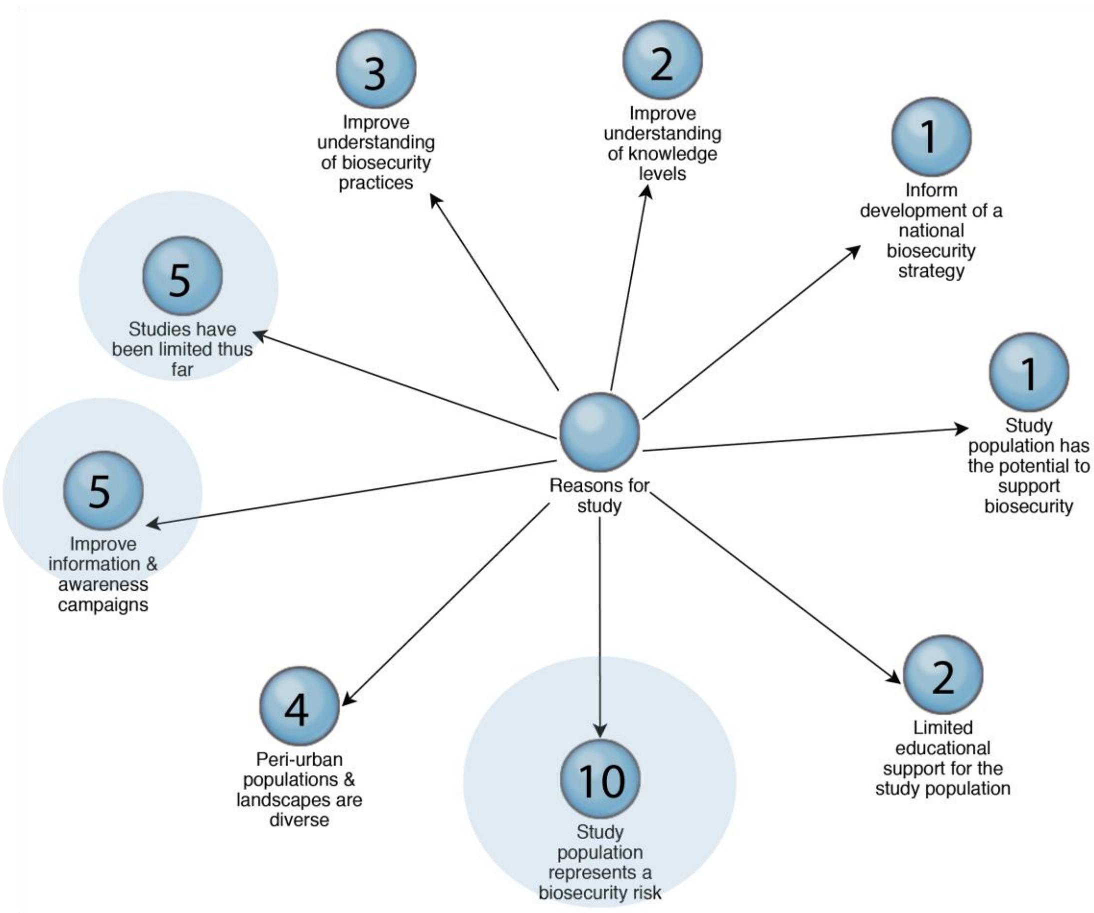


Figure 2.3 Reason for study by theme for the expanded list of studies identified. Overall 33 excerpts were extracted across 22 studies and coded to nine themes.

Table 2.3 Key findings were mapped against domains for the short-listed studies that included analysis of plant biosecurity awareness and knowledge in urban and peri-urban areas.

	Key findings
Communication	• Effective communication with peri-urban populations on the topic of biosecurity requires the communicator to be familiar with local knowledge networks (not invent new ones) and tap into these local networks. These networks are often relatively informal and are related to social/hobby interests (Aslin and Mazur, 2005). • Peri-urban landholders are motivated by 'neighbourliness' and good land management, and communication strategies should be designed to appeal to these values (Gilmour et al. 2011). • Biosecurity issues, such as raising awareness, should be addressed using local networks (horizontal communication), rather than by using top-down (vertical communication) approaches (Gilmour et al. 2011). • A single agency should be trusted with the lead communications to ensure joined up and consistent messaging. (This study found that the majority (51%) of the surveyed population would contact the Council if a QFF infestation was suspected, with the home gardener sub-population demonstrating a higher likelihood of taking this approach). • Levels of engagement are influenced at a local level based on communication among peers (community other gardeners) and softer less formal social networks (non-institutional) were found to foster greater biosecurity engagement amongst community gardeners (Curnock et al. 2017).
Knowledge	• Biosecurity knowledge among community gardeners correlated with levels of social capital (social network sophistication) (Curnock et al. 2017). • Not all community gardeners were 'knowledgeable or engaged' when it came to plant biosecurity (Curnock et al. 2017). • Agricultural knowledge and awareness of biosecurity risks (especially related to pest transmission) amongst peri-urban hobby farmers is low (Aslin and Mazur, 2005). • Gilmour et al. (2011) found no major difference in biosecurity knowledge and awareness between peri-urban landholders of different sized holdings. • Knowledge levels are higher amongst people involved in agriculture and horticulture than amongst the general community. In the general community, knowledge is higher amongst those who identify as home gardeners (Hu et al. 2018). • Lack of knowledge of the threat (QFF) and how they can help manage it appeared to limit higher adoption of control measures (Hu et al. 2018).
Attitude	• Community gardeners classed as 'unengaged' in biosecurity showed a positive attitude towards learning about the topic, but typically had low social capital (social network sophistication) (Curnock et al. 2017). • Disengagement with biosecurity amongst community gardeners was linked to negative experiences with authorities, e.g. inability to source information (Curnock et al. 2017). • Enthusiasm to learn and improve practices is high amongst peri-urban lifestyle landholders (Maller et al. 2007). • Motivators were tied to peri-urban land-holder size, e.g. fiscal motivators for larger holdings, and practice of good farm management for smaller holdings) (Gilmour et al. 2011). • There was a high willingness among community members to comply the right actions for QFF control and a very high willingness (98% of respondents) to report (Hu et al. 2018).
Behaviour	• Adoption of plant pest control options amongst community members (gardeners and producers) has a basis in knowledge of pest biology as much as confidence in using control technology (Arevalo-Vigne, 2017). • Knowledge and awareness are important factors that influence biosecurity best practice behaviour amongst peri-urban landholders (Gilmour et al. 2011). • No difference in risk posed by peri-urban landholders based on property size or source of primary income within the study population was identified by Gilmour et al. (2011). • Overall, Maller et al. (2007) found that small peri-urban lifestyle landholders are likely to pose a biosecurity risk, mainly due to biosecurity not being front of mind amongst this population type. However, Maller et al. (2007) also notes that larger landholders may also represent a risk due to low knowledge and awareness and small lifestyle landholder may pose no greater risk than other population segments. • Hu et al. (2018) found that current adoption of key management practices for QFF in the Yarra Valley was low overall, and lower for people outside the agriculture/horticulture industries.

2.4 Discussion

Evidence mapping methodology enabled the study to identify what investigatory work had been conducted in urban and peri-urban areas on the topic of biosecurity awareness and engagement until this point. Several studies found during mapping represented a 'first'. For example, Schembri et al. (2015) noted that it was reporting on the first dataset describing the on-farm biosecurity practices of small-scale and peri-urban producers, in eastern Australia while research by Aslin et al. (2005) and Gilmour et al. (2011) were the first biosecurity awareness investigations to be undertaken in regions such as Yass, Greater Bendigo, and the City of Swan. The study by Curnock et al. (2017) represents the first research study to attempt to characterise influencers on biosecurity engagement amongst community gardeners in Australia.

Past research has placed an emphasis on understanding risks and opportunities associated with peri-urban zones, rather than high density urban areas. Only two studies investigated biosecurity awareness and knowledge in high density metropolitan areas – Curnock et al. (2017) undertook some consultation in Cairns and Townsville, while Steele et al. (2015) tested pet owner knowledge of zoonotic disease transmission pathways by using a Sydney based veterinary clinic as a case study. This lack of emphasis on applying similar research questions and methodologies to adjacent, higher density urban areas is interesting and highlights an important gap, since urban areas are usually located in closer proximity to high volume ports of entry and the high density of properties results in a plethora of plant diversity and abundance within a small area.

A common challenge raised in relation to improving biosecurity engagement and practice in peri-urban zones is the fragmented and diverse nature of these landscapes, from both a social and geographical perspective. In recent years out migration from urban to peri-urban areas has increased and these ex-urbanites, amenity-migrants, or tree-changers have diverse interests and land uses (Gilmour et al. 2011). However, high density urban landscapes are even more fragmented and are presumably subject to an even higher diversity of uses, based on the mix of demographics that can be found in city environments. Therefore, while efforts to support improved engagement in peri-urban environments should not be ignored, as these regions are often sympatric with important production areas, there is a clear need to gain an improved understanding of knowledge, awareness and motivations in high-density city environments.

2.4.1 Defining research populations

The majority of studies identified during evidence mapping focused on residents in peri-urban regions around Australia. Hollier et al. (2008) notes that peri-urban areas are a dynamic urban-rural 'confluence' and small lifestyle landholders bring a diversity of interests, values, and intentions that contribute to creation of a complex community that is becoming increasingly difficult to characterize. Findings across the expanded list of identified studies served to emphasize the fragmented, eclectic and dynamic nature of residents and land uses in these zones. Attempts to categorize and describe the type of stakeholder found in a peri-urban region were made in several studies. Populations segments described across studies included:

- Absentee landowners, second and holiday homeowners, people from both English and non-English speaking backgrounds who have a suspicion of authority (Aslin et al. 2005);
- Downshifters, seachangers, treechangers, small lifestyle farmers, and hobbyists (Hollier et al. 2008)
- Ex-urbanites (Klepeis and Gill, 2016);
- Amenity migrants / tree-changers (Gilmour et al. 2011); and
- Lifestyle agrarian, regenerative, conservationist (Klepeis et al. 2011).

Apart from identifying a variety of categories by which studies have sought to describe peri-urban stakeholder types this review has highlighted the need to achieve a level of consensus among the research community when describing stakeholder types in these regions so that research findings may be more effectively compared. Sinclair et al. (2020) suggests a more standardized approach of using Groth's four-category landholder typology that has a basis in the theory of occupational identity. This stakeholder mapping framework allows for the sub-categorization based on factors such as enterprise type, knowledge and skills, and levels of engagement or trust. An example of how this stakeholder categorization process has been used is shown in table 2.4.

At this point in time definitions of 'peri-urban' vary across the research literature however, and until there is consensus on what constitutes a peri-urban region, effectively categorizing, describing, and thus understanding stakeholder groups will be difficult.

Table 2.4 Example application of Groph's framework for categorising stakeholders (from Sinclair et al. 2020)

Cohort[a]	Occupation	Area (ha)	Ties to land	Herd size	Income source
FTF, "cattlemen"	Beef producer	200–1000	Strong, generational, mostly purchased	300–1000	Farm sole income
FTF, dairy farmers	Dairying	200	Strong, mostly generational, mostly purchased	255 milkers	Farm sole income
FTF, "semi-commercial"	Beef producer	120+	Strong, recently purchased	120	Off-farm income, investments, one partner works full time on-farm
FTF, "wheelers & dealers"	Beef trader	Variable	None, mostly leased	400–700	Farm only
NF, "absentee"	Business investor	Variable	None, purchased	Variable	Off-farm income, investment
PTF, "retirees/ lifestylers"	Retiree	40–50	Varies, purchased	30	Off-farm income
PTF, "younger generation"	Professional, trade	80–100	Varies, recent purchase	50–60	Off-farm income, both work
PTF, "next generation"	Professional, trade	120	Strong, generational, purchased	120	Off-farm income, both work

2.4.2 Risk or opportunity?

The majority of studies identified in the extended list had a focus on knowledge, attitude and awareness in the peri-urban landscape, as opposed to high density city environments. This is unsurprising when considering the rate at which peri-urban landscapes are changing, both in geography, as well as ecology and demographics (The Melbourne urban growth boundary has been expanded several times over the past three decades). In 2007, Maller et al. highlighted research gaps in regard to small landholders in peri-urban regions of Australia. They included: behaviours and attitudes, knowledge of biosecurity, land use practices, location, numbers of small holders, and membership of networks / knowledge sources.

Previously, peri-urban landholders have been much maligned as posing natural resource management and biosecurity risks to surrounding primary production industries. This is likely due to the perception that these populations are ill-informed and lacking appropriate skills and motivation to provide regular and consistent land stewardship. In a Kiama LGA case study, Klepeis and Gill (2016) note that the farming community think of ex-urbanite landholders as "interlopers or uneducated" on the topic of natural resource management. A 2003 Review of the National Landcare Program indicated that small landholders in peri-urban regions are knowledge and motivation poor when it comes to natural resource management (Department of Agriculture Fisheries and Forestry 2003). Arevel-Vigne (2017) discusses changing risk in peri-urban landscapes in relation to Medfly, and notes that "*urban expansion, the subdivision of agricultural land into 'hobby farms' and changes to climate patterns have an effect on native and exotic species' invasiveness by changing the geographical patterns of natural distribution', spread and establishment, and removing natural predators and control barriers*."

Perceived risk is supplied as a reason for launching an investigation in almost half the studies reviewed (Fig 2.3), however only one study (Choy and Harding 2010) cited the potential of the study population to support biosecurity campaigns as a specific reason for undertaking research. The opportunities represented by peri-urban and urban residents who are largely unaffiliated with large scale commercial primary production, yet take part in private and collaborative land management to varying degrees is an under-represented and untapped research and activity area.

Several studies highlight the opportunity for raising levels of plant biosecurity engagement among non-farming urban and peri-urban communities. Hollier et al. (2008) notes that small holders in peri-urban areas maintain a curiosity and interest in developing skills in resource management, while investigations by Klepeis and Gill (2016) show that peri-urban lifestyle landholders have a significant overlap in natural resource management ideology in relation to invasive weeds. However, this study also collected data on key indicators related to differences in natural resource management. Seventy percent of commercial farmers were found to undertake weed management on property within the previous three years in comparison to 19.4% of lifestyle hobby farmers.

In a study by Choy and Harding (2010) a high number of survey respondents indicated that before purchasing a peri-urban hobby farm their natural resource management knowledge was poor. This was in comparison to post-purchase, when property owners who perceived their knowledge to be low was in the minority. Overall respondents exhibited a high motivation to improve their land management practices. Klepeis and Gill (2016) highlights the potential for trans-property collaborative management of weeds between lifestyle landowners and commercial farmers, however this study also indicates that these groups do not regularly interact with each other.

A 2018 study by Hu et al. on community knowledge and awareness of Queensland fruit fly (*Bactrocera tryoni;* QFF) has yielded interesting insights into knowledge levels and awareness in one peri-urban region – the Yarra Valley. Knowledge levels were found to be higher amongst people involved in primary production than amongst the general community. Among the general community sub-population, knowledge was found to be higher amongst those who identify as home gardeners.

Sub-population analysis by Hu et al. (2018) highlights the importance of taking an audience segmentation approach when developing stakeholder engagement plans. For instance, they found that respondents under 40 were more likely to not be familiar with QFF in comparison to those of an older age group, and community members in an urban setting (a town or suburban area) were more likely to be unfamiliar with the name in comparison to rural residents.

Klepeis and Gill (2016) investigated potential weed biosecurity risk posed by ex-urbanite peri-urban lifestyle landholders through the lens of social capital found in the case study region of Kiama LGA. This study noted that social capital at a local level is built through opportunities to get to know one's neighbours, to build skills and knowledge within the community, and having good communication between community groups. Klepeis and Gill (2016) suggest that absenteeism among ex-urbanite lifestyle landholders, a reduced tendency to undertake skills training, and the tendency for the farming community and lifestyle landholders to be found in different social circles results in weak social capital in amenity landscapes, thereby reducing the resilience of these communities in the face of changes and impacts (e.g. fire, or biosecurity response). However, Klepeis and Gill (2016) also note that, while social capital in these landscapes was hypothesized to be weak, it remained higher than expected due to some overlap identified between farmer and lifestyle landholder networks.

Access to trusted information about biosecurity and natural resource management is a notable point of difference between commercial farming communities and non-farming landholders that will have a large influence on the potential of each group to be biosecurity engaged and to undertake land management best-practices. Gilmour et al. (2011) highlights that biosecurity capacity building support is available to commercial and large-scale farming enterprises, with industry bodies and state agricultural agencies having provided a focus for supply of biosecurity information. Arguably, peri-urban lifestyle landholders should be viewed as a part of the local agricultural community, however, biosecurity information more broadly, land management information is not easily accessible to this group.

Aslin and Mazur (2005) makes reference to a national audit at the time looking at existing educational materials for landholders, although this report could not be sourced. However, research outside of this evidence mapping exercise has revealed that outreach in this topic area has increased over 2019-2020, to encompass initiatives such as ExtensionAUS. However, the importance of the social research that should underpin these campaigns cannot be understated.

Overall, results from the evidenced mapped studies did indicate that those engaged in primary production tend to have greater biosecurity and land management knowledge than non-farming community counterparts in peri-urban regions. However, willingness to improve practices among non-farming community members appears to be high and assumptions made about peri-urban lifestyle landholders and biosecurity risk do not appear to be made on a strong foundation of evidence. Maller et al. (2007) notes that the concept of 'peri-urban biosecurity risk' remains ambiguous, yet there are practical initiatives that may help to better understand potential risk and to support peri-urban populations in addressing risk. These include establishment of relationships between these landholders and knowledge brokers, the holding of local information forums, and development of local networks for information exchange about local land management.

Despite the existence of some cross-sectoral data on knowledge and attitude in relation to plant biosecurity as identified in this evidence mapping exercise, the effect of an increase in peri-urban geography surrounding major Australian cities over time (Buxton and Butt, 2020) on plant biosecurity risk and opportunities remains poorly understood. Importantly, studies conducted thus far have not been longitudinal in structure. Therefore, it is difficult to deduce changes in attitude and knowledge in context with the high rate of change in relation to Australian urban infrastructure and urban spread.

2.4.3 Communication networks

Across several studies that included a focus on plant biosecurity there was an emphasis on the importance of grey (informal) networks, particularly local networks, for building levels of engagement with biosecurity, and for building knowledge. Curnock et al. (2017) hypothesized that levels of engagement are influenced at a local level among community gardeners. This study suggested that an individual's informal communication networks (termed 'softer' networks) and less formal institutional arrangements (such as guidelines for garden management, and local policies) at the level of community gardens in particular are likely influencers of the level of biosecurity engagement among garden associates. Formal institutional arrangements (such as management structures, and land tenure) were less influential.

Similarly, findings by both Aslin and Mazur (2005) and Hollier et al. (2008) support the concept that small lifestyle landowners tend to use horizontal not vertical networks for information sharing and knowledge accrual, the former being described as "… *relatively informal networks that reflect their voluntary interests and do not relate to formal industry structures*". Several other studies emphasize the importance of using existing, local networks (formal or informal) for effective biosecurity engagement with non-farming peri-urban community members. Gilmour et al. (2011) states "*Biosecurity issues, such as raising awareness, should be addressed using local networks, rather than by using top-down approaches*." Since study populations across identified literature tended to be characterized by community members who managed land yet did not derive primary financial income from the land, information networks that aligned with values and species interests of community members were often described as being particularly important (Aslin et al. 2004; Aslin and Mazur 2005; Hollier and Reid 2007; Choy and Harding 2010).

After surveying 115 community members of the Murrumbateman and Wamboin regions in NSW on the topic of invasive weed management, Choy and Harding (2010) also recommend that engagement activities should not be restricted to well respected groups such as Landcare, but also make use of information hubs linked to the personal interests of landowners. In Gilmour et al. (2011) assessment of major information networks in peri-urban case study regions revealed that the rural fire service and Landcare were two commonly reported information channels for residents looking for land management advice, while other less formal networks, such as friends and neighbours, and special interest groups, such as pony clubs, were also important sources of information. In response to these findings Gilmour et al. (2011) state:

> *"Communication about biosecurity risk therefore needs to be multi-layered, looking across the landscape to see how, through a number of different communication networks, all categories of landholder are likely to be reached. As our data showed, people are linked across a diverse network of organisations and interests. They access their information from an equally diverse network of sources…The focus for an effective communication strategy needs to be on bringing together these different resources to integrate local networks, so they can be activated to respond to particular situations that might arise."*

Supporting groups across landscapes characterized by variable use patterns, such as urban areas, to collaboratively work towards improved plant health outcomes may also move beyond simply accessing and providing information to informal communication channels. The concept of strengthened social capital at a community level has a basis in communication and collaboration between individuals and groups. High social capital within a community is important for buffering communities in the face of change and challenges. In an example of how local level social capital may be strengthened, Klepeis and Gill (2016) suggest that stakeholder groups that may inherently be disengaged from each other, due to differing values or cultures for instance, may be brought together to address key areas of consensus (e.g. achieving improved vegetable crop quality), whereby interactions may 'spill over' into other areas, such as pest management and invasives.

Overall, in order to better understand and support this sector (peri-urban residents) in becoming more biosecurity engaged the following recommendations were made by the six plant biosecurity studies found to have some focus on plant biosecurity:

- Resource extension officers who can build relationships and trust with community gardeners and respond to suspect exotic plant pest reports.

- Take steps to better understand and acknowledge conflicting interests of different stakeholders so that communication activities and materials can be tailored to suit the needs of community garden groups and build trust.
- Acknowledge the growing importance of lifestyle landholders in peri-urban zones as members of local agricultural communities.
- Build biosecurity awareness strategies that are designed to tap into, and appeal to the values of this sub-population of the agricultural community (because agricultural productivity is not the main driver of change).
- Do not stigmatise this sub-population as posing higher biosecurity risk than other populations.
- Trial a 'participatory' approach among this sub-population to improve biosecurity awareness and capability, involving technical coaching, through raising understanding, promoting trials, and adoption.
- Government should assess how it can better communicate with this sub-population.
- Raising biosecurity awareness and best-practice in peri-urban areas will rely on a landscape level approach.
- Collect baseline data on the knowledge, behaviours, and attitudes of peri-urban small holders in relation to plant biosecurity.

2.4.4 Current and future activities

A large-scale, multi-institution study, '*Change and continuity in peri-urban Australia'*, initiated in 2006 aimed to better understand the peri-urban zone, why it is growing, demographic and landscape characteristics, and projections on growth for the future. This program of works published a large number of academic papers, reports and book chapters that provide insight into the factors that a common in the peri-urban zone. However, it is notable that in depth analysis into the peri-urban has been lacking since the '*Change and continuity in peri-urban Australia'* program concluded.

Based on the evidence mapping exercise it would appear that the challenges outlined for biosecurity in peri-urban areas remain unchanged from almost two decades past. They are:

- Understanding the attitudes of peri-urban landholders towards biosecurity;
- Understanding the land use practices and level of land management knowledge of peri-urban landholders;
- Characterising the actual risk posed by peri-urban (and urban) landholders in relation to biosecurity;
- Understanding the opportunities to support plant health outcomes by working with peri-urban and urban landholders; and
- Clarifying the definition of 'peri-urban'.

Importantly, new questions, challenges and opportunities have emerged since many of these studies were undertaken. The urban greening direction of many cities, or zones within cities, and the rapid increase in community gardening as a social exercise, as well as environmental stewardship of natural remnant areas, will change the risk and opportunities associated with maintaining plant health in these communities. However, both natural resource management related studies and biosecurity related studies undertaken in large Australian cities are few. On the question of biosecurity risk represented by urban residents in high density residential areas, no assumption can yet be made.

More recently Buxton and Butt (2020) have published '*The Future of the Fringe*', which investigates the risks associated with peri-urban expansion through the lens of recent state and local government planning policies. In 2013 the first conference focussing on peri-urban regions, 'Beyond the Edge', was hosted by LaTrobe University, and the biennial urban agriculture forum, run by SUSTAIN is yet another recently launched initiative through which urban biosecurity awareness and engagement may continue to be investigated. Further, a research group located at RMIT in Melbourne (the Centre for Urban Research) and at the University of Melbourne (the Victorian Eco-Innovation Lab) in particular continue to produce analysis and reports on per-urban planning, risk, influences, and environment. Thus, it is possible that further insights into opportunities relating to supporting plant biosecurity in cities will drop out from current research that is taking an urban planning and policy focus.

If this is the case, future findings and recommendations relating to plant biosecurity engagement may be closely linked to land use and policy, at a state or local level, which represents a potentially higher impact direction of research that can more effectively inform where, when and how stakeholder engagement should occur as a priority. At the time of writing, no studies had been found that investigate green city design and impact on biosecurity risk and no studies that have made use of GIS based mapping to visually represent and understand biosecurity risk as linked to land usage and local communication network potential. Indeed, almost a decade ago Wadsworth and Choy (2011) had pointed out that assessment of biosecurity issues are rarely considered with land use patterns and land use planning in mind, both in rural areas and on the rural-urban fringe.

This analysis has raised questions about how far qualitative social research can take us when it comes to gaining insight into biosecurity risk and opportunity at a peri-urban or urban community level given the changing nature of these landscapes and the uniqueness of communities at a regional and local level. In terms of geography, past case studies have included the Yass Region, ACT, the Swan Region, WA, Townsville, Cairns and the Sunshine hinterland, QLD, Murrumbateman and Wamboin, NSW and Greater Bendigo, Victoria. However, any extrapolation from previous investigations to other regions should be made with an acknowledgment of how unique that these regions can be from each other.

Almost 15 years ago Houston (2005) had noted that assumptions about the make-up of peri-urban communities are too often made based on course population change data rather than using more strategic, predictive and granular data, such as building approvals. Such geospatial quantitative data may be used to complement qualitative, social research derived data to better understand such environments (Black et al. 2000). A discussion paper by Wadsworth and Choy (2011) highlights the potential benefits of considering geospatial data and predictions in this sense, and also point out the disconnection between biosecurity planning and current land use, as well as planning frameworks that dictate urbanization of rural areas. They suggest that biosecurity may be improved in landscapes undergoing a rural to urban transition by:

- Build land use activity and pattern data into biosecurity decision-making;
- Raise biosecurity engagement and awareness through land use regulation (hard mechanism) and integrating information into property titles, and development application processes (soft mechanisms); and
- Integrating biosecurity science principles in land use planning processes.

Sinclair et al. (2020) adds to this proposed approach by suggesting that biosecurity authorities may consider mechanisms for identifying property ownership transfer and use that timeframe as an entry point to engage in biosecurity awareness activities.

Collection of current baseline data on peri-urban and urban demographics from a land use and location perspective will be an important aspect of understanding the level of land management knowledge and practices undertaken by different land-holder types, proximity to commercial production areas, and importantly, will further consolidate understanding of how these communities can be empowered to steward plant health through effective communication strategies that make use of ‘grey’ networks (described as ‘horizontal’ communication networks in Aslin and Mazur (2005) and as ‘soft’ communication networks in Curnock et al. (2017)). Future investigations may become more sophisticated and predictive by combining qualitative social research insights with analysis of geographical factors, such as location, land use and demographics, as well as institutional planning frameworks, and local policies, and local support structures.

Section 4 of this report explores integration of geographical factors into biosecurity analyses further and demonstrates what insights such as analysis may uncover. It also trials a method of interrogating local greening direction planning policies and supports, and mapping of informal networks (termed ‘grey’ networks in this report) to better understand community level plant health stewardship opportunities.

3. Social study of urban and rural residents

3.1 Introduction

A key factor in design of stakeholder engagement strategies during an exotic plant pest incursion response or for preparedness purposes is taking an audience segmentation approach and determining best actions to engage each group. In the case of plant pest incursions in urban areas, audience segmentation and development of engagement tactics can become complex and difficult to execute due to geographic, demographic and land use variation, as well as difficulties with land access.

Understanding the level of willingness to report an exotic pest, and well as motivators and barriers to reporting is an important aspect of designing an effective stakeholder engagement plan. Understanding how motivators, attitudes and knowledge may converge or diverge from those who class themselves as 'rural residents' can also contribute to more effective, audience segmented engagement during responses that must take into account both high density urban environments and low-density rural areas.

Additionally, understanding how current residence (urban or rural living) and past residence (upbringing in an urban or rural environment - ex urban or ex rural) may influence likelihood of reporting, as well as the motivators for making a report has similarly not been previously investigated in Australia. Having an understanding of how spatial, demographic and value factors influence likelihood of reporting can lead to the following benefits:

- Improvement in judging actual biosecurity risk and opportunity posed by demographic groups living in different settings;
- More effective stakeholder engagement campaigns that are audience segmented and are designed with a basis of appealing to audience motivations; and
- Improved prediction of what sub-populations are likely to be early adopters of biosecurity training and strong supporters of knowledge transfer (therefore training resources may be developed and delivered to suit and appeal to those sub-populations).

While metrics on land management knowledge may be gained by accessing numerous past investigations in the Natural Resource Management space (at least for peri-urban residents), data on attitudes and motivations are severely lacking, particularly in the case of urban residents living in a city or high-density housing suburban environment.

In the study described here, Melbourne and rural Victorian residents were surveyed in order to explore the following research questions:

1. Is there a relationship between social capital and likelihood of reporting a suspected exotic plant pest?
2. Is there a relationship between knowledge level (of food production), and likelihood of reporting?
3. Is there a relationship between strength of relationship to region, and likelihood of reporting?
4. Is there a difference in likelihood of reporting between urban residents and rural residents?
5. Do motivators and barriers to reporting align or diverge between rural and urban populations?

Research questions 4 and 5 were the focus of analysis in this report.

3.2 Methodology

3.2.1 Data collection

A survey was undertaken between the 12th of October 2019 and the 18th of October 2019. In collecting survey responses there was a risk that only highly engaged individuals with high social capital may undertake the survey, or that only respondents already engaged with the surveyor (**cesar**) would be more likely to undertake the survey due to the use of familiar distribution channels. To avoid these biases a survey panel service (PureProfile) was used. Pureprofile is an ASX listed international market data service that provides an independent interface for distributing surveys to target audiences. PureProfile panellists receive monetary and gift-based rewards for undertaking surveys. Therefore, reducing the likelihood that high social capital is influencing likelihood of responding. Individuals reported to live in Victoria were targeted. This was the only parameter set for identifying survey candidates.

3.2.2 Survey design

Responses to potential influencing factors were recorded on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). Data on residential times were collected as time ranges (<1 year, 1-5 years, 5-10 years, 10-20 years, >20 years). Likelihood of reporting was also captured on a 5-point scale (1 = highly unlikely, 2 = unlikely, 3 = unsure, 4 = likely, 5 = highly likely). The survey structure is displayed in Table 3.1.

Table 3.1 Influencing factors investigated and supporting questions

Influencing factor	Question	Answer choice
Residential affiliation	In what setting were you raised?	Urban
		Rural
	In what setting are you living now?	Urban
		Rural
Relationship to region	How long have you lived in your current area?	Less than one year
		1-5 years
		5-10 years
		10-20 years
		Over 20 years
	How closely do the following statements apply to you?	
	I intend to live in this area long term (over 20 years).	1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, 5 = strongly agree
	I try to buy locally grown produce local when possible (grown within 50km).	1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, 5 = strongly agree
	I feel emotionally invested in the area in which I live.	1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, 5 = strongly agree

Knowledge level	I have a good understanding of where and how the food I buy is grown.	1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, 5 = strongly agree
	I have a good understanding of what food crops are grown in my region (within 50km).	1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, 5 = strongly agree
Social capital	I often contribute to community groups or events.	1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, 5 = strongly agree
	Scenario: You have found a pest species that you suspect is exotic to Australia.	
Likelihood of reporting	What is the likelihood that you would report this detection to the appropriate authority?	1 = highly unlikely, 2 = unlikely, 3 = unsure, 4 = likely, 5 = highly likely
Additional data		
Location	What is your postcode?	Open-ended
Reason for answer to 'likelihood of reporting' question	Why/why not?	Open-ended

3.2.3 Data analysis

Any individual who reported that they did not live in Victoria were re-routed to a survey end page and this data was not included in the analysis. For the purpose of analysis, the dataset population was segregated into those who currently affiliate as living in a rural or urban area.

Short answer questions were submitted by respondents to explain why they gave their answer on likelihood of reporting. These short answers were coded by theme using NVivo qualitative analysis software. This method of categorizing responses allows a qualitative dataset to be converted into a semi-quantitative indicator of gaps and areas of greatest outreach need in relation to improving likelihood of reporting.

3.3 Results

After exclusion of non-Victorian residents and incomplete surveys, the total number of responses was 456. Overall, the proportion of respondents raised in a rural setting was 34% (n = 157) while the proportion raised in an urban setting was 66% (n = 299). This included respondents who had remained in those settings and those who had subsequently moved to the alternate setting. Current urban residents equated to 66% (n = 300) and current rural residents equated to 34% (n = 156). Interestingly, mapping of postcodes contributed by respondents indicated that perceptions on urban and rural residency vary, with some technically peri-urban residents indicating that they are rural residents and others indicating they are urban residents (Fig 3.1) (for the purpose of this study, results have been analysed within the context of 'perceived' residency status). There was high similarity of ex-urban and ex-rural respondents across the entire dataset, indicating that consistent proportions (10%) of current rural and urban residents had been raised in the alternate setting (Table 3.2).

These results indicate that willingness to report a suspect exotic pest is high, with 64% of respondents overall likely or highly likely to report a suspect exotic plant pest (Fig 3.2, Fig 3.3). Likelihood of reporting based on current residential location and setting of upbringing was similar between sub-populations. Across the entire dataset, the response average was 3.76. This value sits between 'unsure' and 'likely', which indicates that there is some general willingness to contribute to exotic pest surveillance, however there is definite scope to increase the willingness of residents to report. The sub-population with the highest likelihood of reporting were long-time rural residents (average response of 3.99 - 'likely') and the sub-population with the lowest likelihood were urban residents who had been brought up in a rural environment (average of 3.58 - unsure/likely). Overall, rural residents were more likely to report a suspect exotic pest, regardless of the setting in which they were raised. However, no sub-population displayed a significant difference and therefore these results must be interpreted with caution.

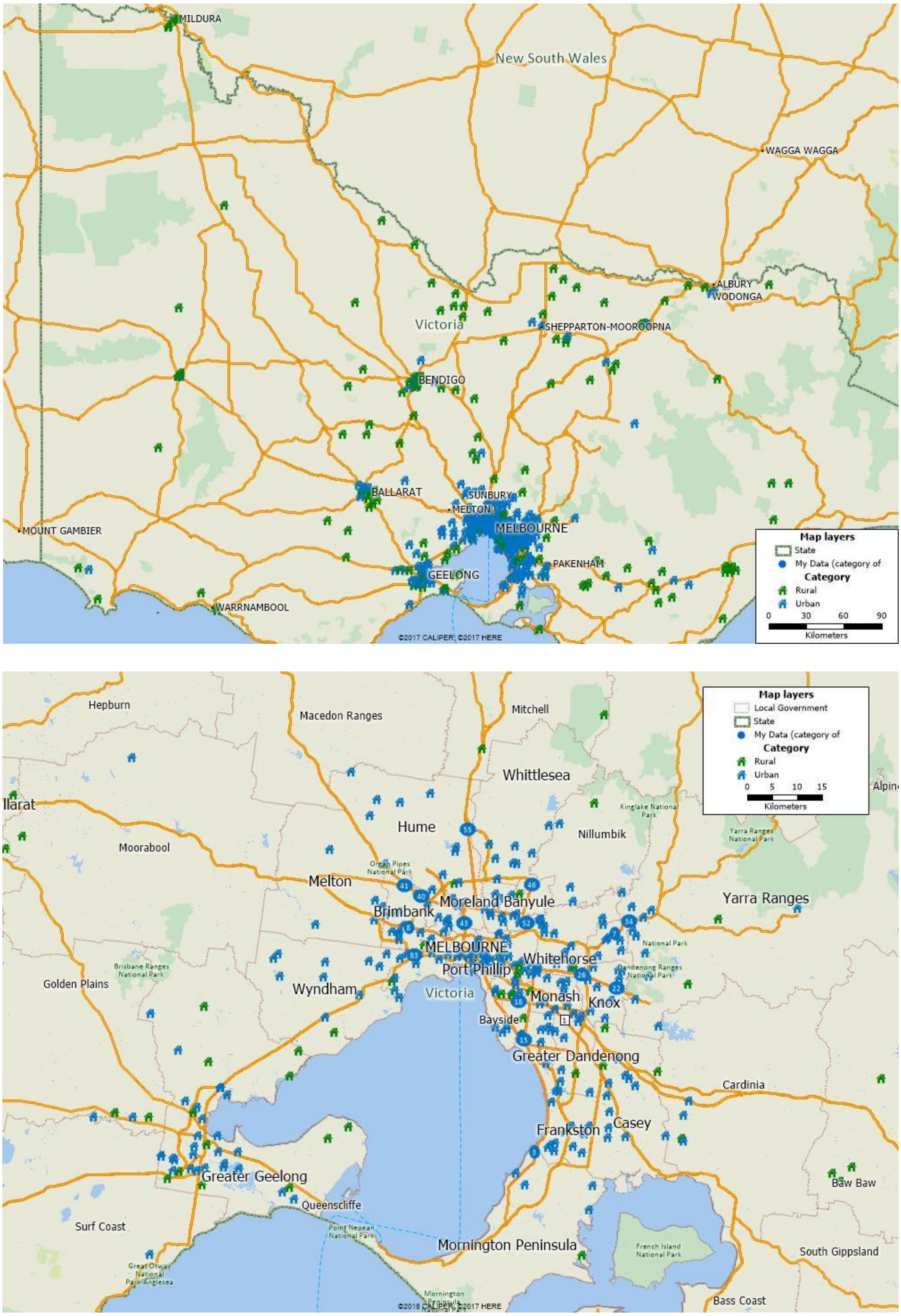


Figure 3.1 Location of survey respondents across Victoria (top) and across Melbourne (bottom). Six postcodes were not mapped due to typographical error.

Table 3.2 Residential affiliation of those who participated in the survey. 'Ex-urban' and 'ex-rural' indicates upbringing in a different environment to current residency.

Sub-population	Description	Proportion (%)
Urban	Upbringing and current residency in urban environment	56%
Rural	Upbringing and current residency in rural environment	24%
Ex Urban	Urban upbringing and current rural residency	10%
Ex Rural	Rural upbringing and current urban residency	10%

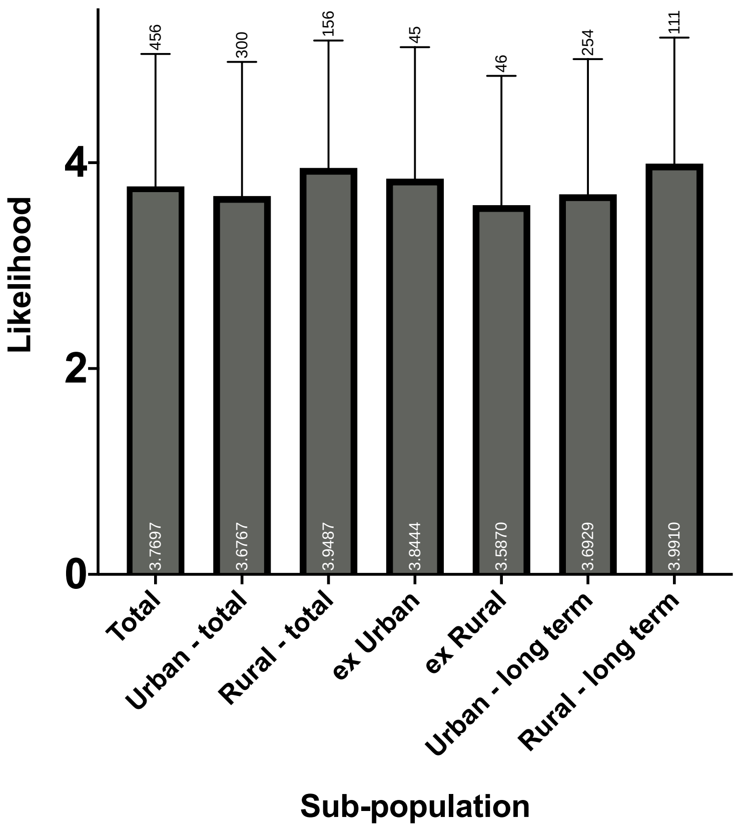


Figure 3.2 Likelihood of suspect exotic pest reporting based on current and past residence (total n = 456).

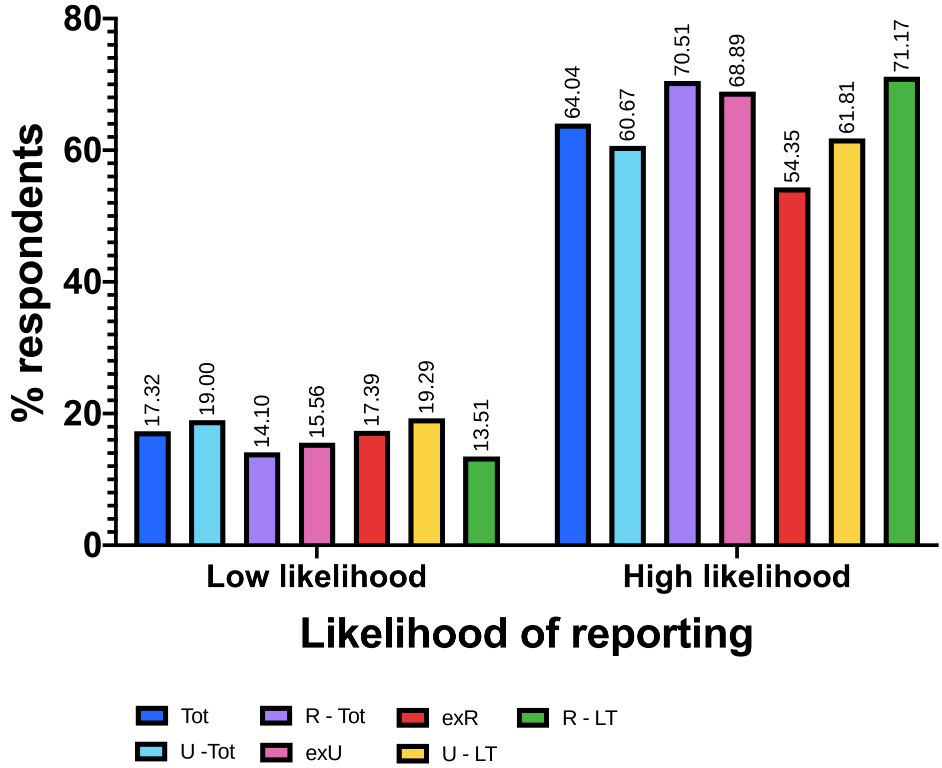


Figure 3.3 Proportion of respondents who indicated a low or high likelihood of reporting a suspect exotic pest per sub-population. Sub-populations: Tot (Total), U - Tot (Urban - Total), R - Tot (Rural - Total), exU (ex Urban), exR (ex Rural), U - LT (Urban - long term), R - LT (Rural - long term). 'Low' includes highly unlikely and unlikely, while 'high' includes likely and highly likely (total n = 456).

Rural and urban residents were further split into 'likely reporters' and 'unlikely reporters'. Coding of open-ended responses resulted in identification of motivations and barriers to reporting for each group. Examples of those open-ended answers coded under major themes are included in table 3.3.

Results indicated that there are three dominating factors that motivate high likelihood reporters among urban residents: moral duty, environmental protection, and having a general awareness of risk. Motivating factors aligned closely with reasons provided by rural residents, with the highest three being environmental protection, agricultural protection, and general awareness of risk. Although not ranked amongst the top three most common motivating factors, 'moral duty' was still a common theme amongst rural residents, as was 'agricultural protection' amongst urban residents. Amongst the high likelihood reporters a barrier common to both groups was 'lack of knowledge'.

Lack of knowledge was also the most common barrier submitted by unlikely reporters, with over 50% of urban and rural resident unlikely reporters have answers coded to this theme. The two key sub-categories to the 'lack of knowledge theme' related to not knowing how to report (most appropriate channel) and not being confident in detecting something that is exotic. Coding results are displayed in tables 3.4-3.7 and figures 3.4-3.7

Table 3.3 Examples of open-ended answers coded to major themes.

	Example response	
Theme	**Urban residents**	**Rural residents**
Agricultural protection	*Pests can ruin crops so it is important they are controlled.* *Australia needs to protect its crops and food sources.* *I know that exotic species to Australia can decimate our local crops - it puts our industries in jeopardy, I feel protective of our Australian farmers so would have no problem reporting.*	*Because it would affect the local produce economy if it were to infect.* *If I knew about it, it's important for reporting to keep our crops healthy and safe.* *It could have devastating effects on further crops if its a pest and nit reported*
Environmental protection	*To protect Australia's unique biodiversity.* *To protect the indigenous plants and animals.* *Ecosystem is too fragile to mess around with.*	*I don't want it to damage the eco system of my area.* *It is important we all contribute to a healthy environment.* *To protect the future viability of our unique environment.*
General awareness of risk	*If left not reported its only going to get worse and then harder to control.* *Invasive species are a huge problem globally.* *I wouldn't want the pest to spread and do more damage.*	*Because it is important to catch it early.* *Because it could be a danger to our way of life.* *Must stamp them out before they cause harm.*
Moral duty	*it is the proper thing to do.* *It's my responsibility to protect our land Australia.* *Obligation.*	*The right to do in a situation like that.* *My duty.* *Right thing to do.*
Lack of knowledge	*I am unfamiliar with what qualifies as a pest so wouldn't know when to report such a thing.* *I don't feel confident about which authority to contact.*	*I don't know enough about the damages that could be caused.* *I don't really know much about pests and where to report.* *I would probably assume someone would have already done that as I'm less experienced with insects and animals than others.*

Table 3.4. Rural residents who reported they are likely or highly likely to report a suspect exotic pest. Themes were derived from 103 open responses coded 212 times to 12 themes. The majority of the themes were motivators for reporting, although one theme was a barrier.

Theme	Proportion of coded items
Agricultural protection	29%
General awareness of risk	19%
Environmental protection	17%
Moral duty	13.5%
Influenced by experience or connections	6%
Country protection	6%
Lack of knowledge	5%
Access to an easy reporting process	3%
The 'experts' should be told	2%
Financial gain	1%

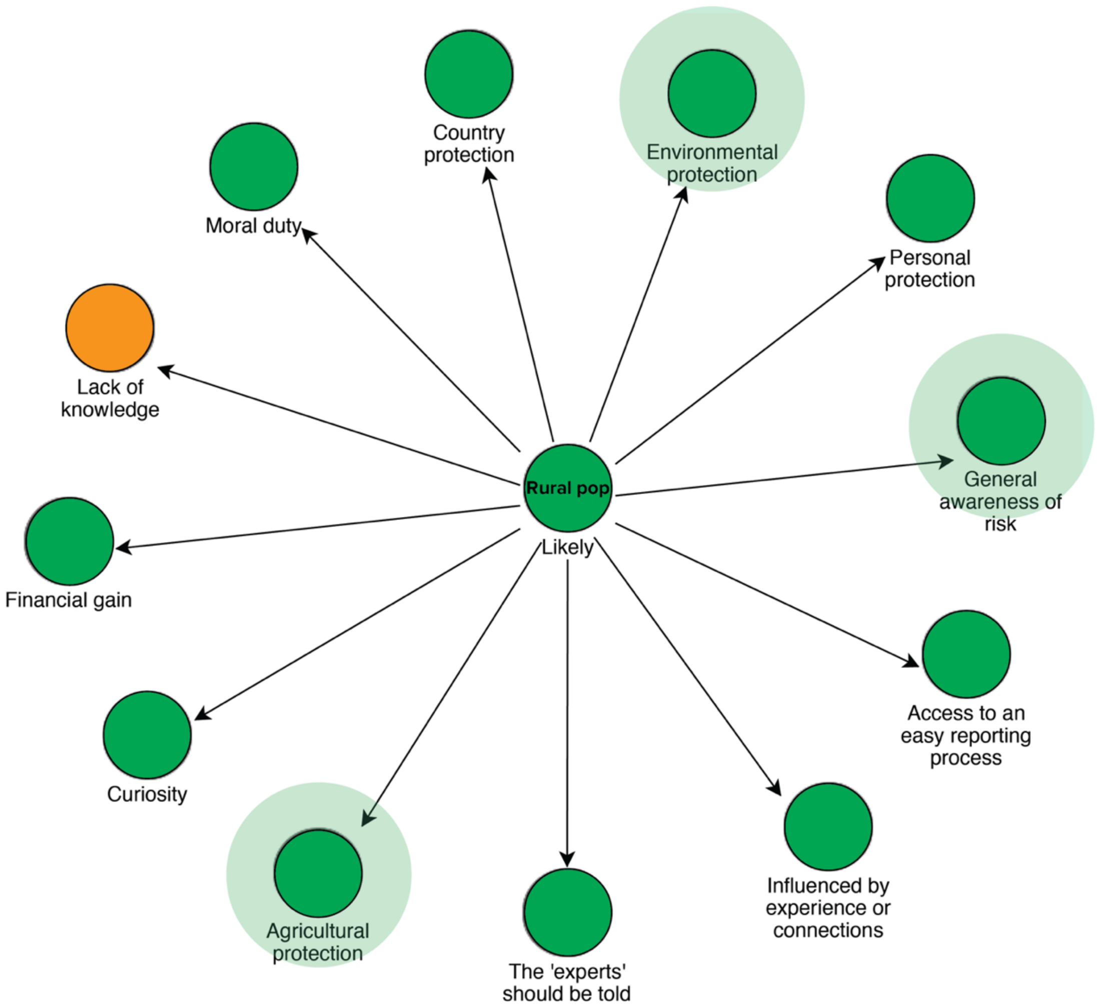


Figure 3.4 Motivators (green) and barriers (orange) to reporting a suspect exotic pest among rural residents who reported they are likely or highly likely to report a suspect exotic pest.

Table 3.5 Rural residents who reported they are unlikely or highly unlikely to report a suspect exotic pest. Themes were derived from 20 open responses coded 40 times to 6 themes.

Theme	Proportion of coded items
Lack of knowledge	55%
Not front of mind	20%
Concern about humane treatment of pest	10%
Assumption that somebody else will	5%
May not be taken seriously	5%
Physically unable	5%

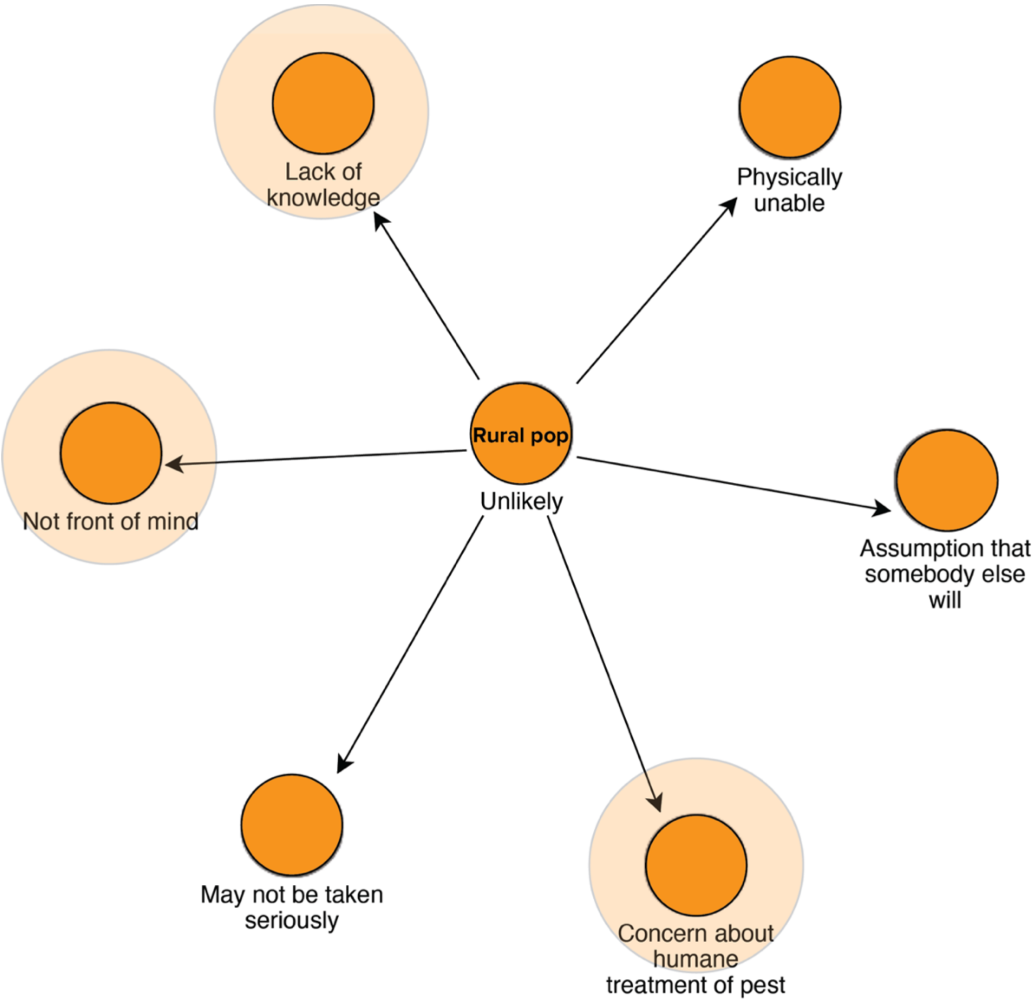


Figure 3.5 Barriers (orange) to reporting a suspect exotic pest among rural residents who reported they are unlikely or highly unlikely to report a suspect exotic pest.

Table 3.6 Urban residents who reported they are likely or highly likely to report a suspect exotic pest. Themes were derived from 169 open responses coded 322 times to 12 themes. The majority of the themes were motivators for reporting, although one theme was a barrier.

Theme	Proportion of coded items
Environmental protection	18%
Moral duty	16.5%
General awareness of risk	15%
Agricultural protection	13.5%
Country & community protection	11%
Lack of knowledge	2%
Relationship to area	2%
Dislike of pests	0.5%
The 'experts' should be told	0.5%

Figure 3.6 Motivators (green) and barriers (orange) to reporting a suspect exotic pest among urban residents who reported they are likely or highly likely to report a suspect exotic pest.

Table 3.7 Urban residents who reported they are unlikely or highly unlikely to report a suspect exotic pest. Themes were derived from 56 open responses coded 110 times to 10 themes.

Theme	Proportion of coded items
Lack of knowledge	59%
Not front of mind	9%
Lack of interest	7%
Uncertain why they would be 'unlikely' to report	7%
May not be taken seriously	5%
Assumption that somebody else will [report]	2%
Lack of time	2%
Never experienced it	2%
No relationship to region	2%
Unaware of obligation	2%

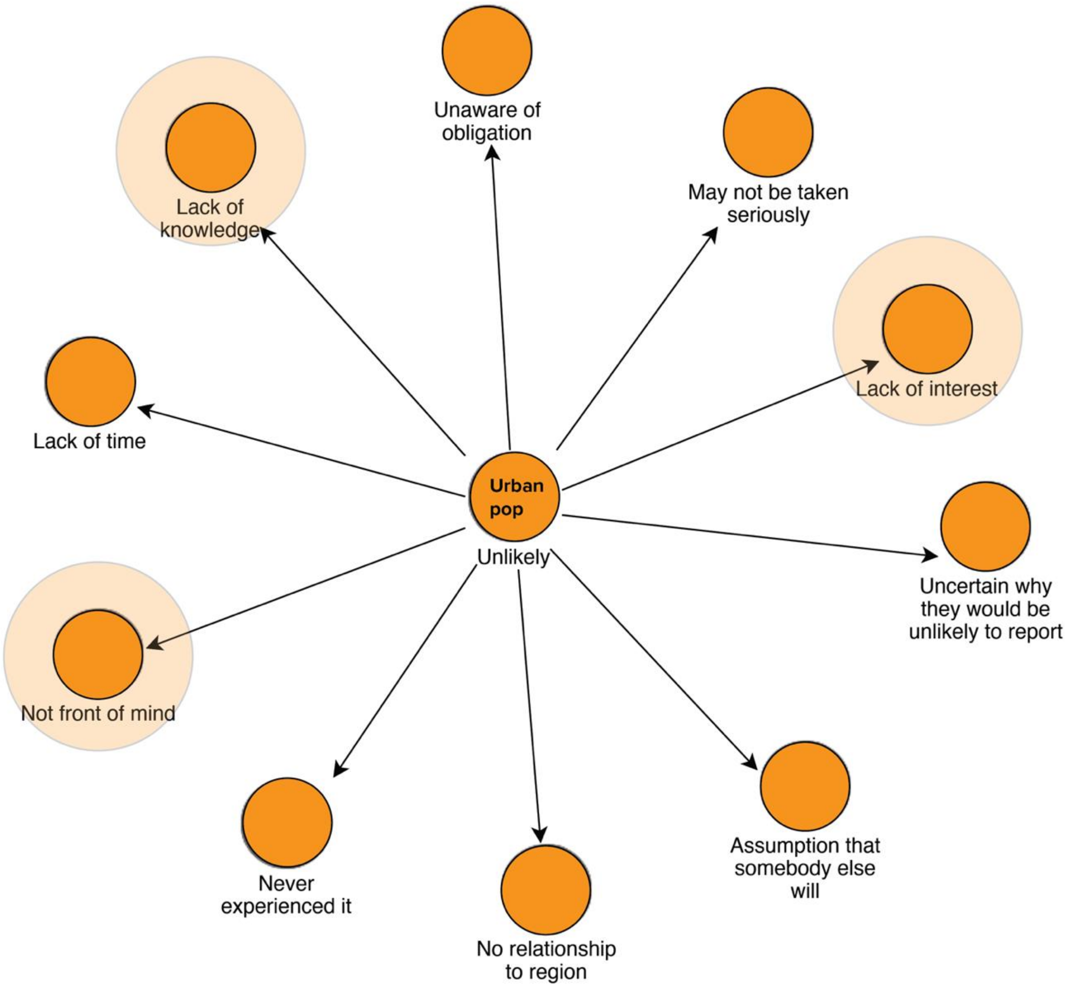


Figure 3.7 Barriers (orange) to reporting a suspect exotic pest among urban residents who reported they are unlikely or very unlikely to report a suspect exotic pest.

3.4 Discussion

As was shown in the evidence mapping, past studies have commonly been undertaken due to the assumption that the demographic groups in peri-urban areas represent a high biosecurity risk due to a lack of natural resource management and production knowledge among landholders, and a lower awareness and motivation to ascribe to biosecurity best practices. However, this assumption has not been verified by past studies, and some studies have indicated that groups such as peri-urban rural lifestyle small-holders are in fact highly motivated to improve knowledge and follow best practices and share aligned land management ideology with commercial farmers on certain topics (Hollier et al. 2008; Klepeis and Gill, 2016).

These survey results indicate that among the population tested there is consistency in likelihood of reporting a suspect exotic pest, with the majority of respondents being 'likely' or 'highly likely' reporters regardless of current residency or upbringing. Any slight differences between sub-groups would require further investigation, particularly since some sub-groups contained low numbers of respondents. For instance, the lower likelihood of urban residents who had been brought up in a rural setting was based on a relatively small sample size of 46 respondents. Overall, this result corresponds with recent survey data published by Hu et al. (2018), which indicated that 98% of community members living in the Yarra Valley, Victoria, would report a suspected QFF infestation.

The concept that those living in city environments are 'disconnected' from food and fibre production has previously been raised as a barrier to raising biosecurity awareness in these environments (Srinivasan and Simpson, 2014). However, these survey results highlight that even for urban-based individuals who were brought up in an urban environment biosecurity is deemed as important. In addition, thematic coding of open-ended answers also highlighted there is high alignment of motivators between urban and rural residents, with 'agricultural protection' being noted among the top four reasons for reporting. These results contrast with the perception that urban residents are spatially as well as mentally removed from primary production, and that this removal will affect importance that these populations place on biosecurity.

However, there was some divergence in motivators that should be noted as they indicate what each group perceives to be *most* important. While environmental protection was a universally strong motivator and was mentioned by similar proportions of respondents across both groups, agricultural protection was more prevalent a motivator among rural respondents. In this case 29% of rural residents noted that agricultural protection was a reason why they would report, compared to 13.5% of urban residents. A motivator that was mentioned at similar proportions across both groups was the theme of 'moral duty', which is interesting given the context of the general biosecurity obligation introduced as a regulatory requirement in some Australian states. In addition, urban residents were more likely to be unsure about why they would report, therefore demonstrating good intentions, but not necessarily able to articulate why they would be motivated to report.

This survey has also highlighted the barrier that 'lack of knowledge' represents. While willingness to report is high, improving community member confidence in identifying what may constitute as unusual, and improving community understanding about the most appropriate processes to report will be an important aspect of improving reporting rates from community members. While lack of time has previously been reported as a major factor that limits invasive weed management by peri-urban landholders (Choy and Harding, 2010), this was not given as a reason by respondents, even those who are unlikely to report.

These insights become important when developing effective extension strategies with the aim of changing attitudes and practices. Interestingly, the motivation of environmental protection aligns with a major motivation for becoming involved with urban farming, as investigated in the USA by Grebitus et al. (2020)

Several questions included in the survey will also enable subsequent analysis of several other factors that may influence likelihood of reporting, although they are not analysed here. These are: social capital, knowledge of region, and relationship to region. Based on evidence mapping in section 2 the level of influence that these factors have on the likelihood that an urban resident will report a suspect exotic plant pest has never been investigated. Social capital, which is increased at a community level through communication networks, access to training, and collaboration between groups, is one concept in particular that may be used as an indicator of community engagement and knowledge in urban and peri-urban areas (Kelpeis and Gill 2016; Curnock et al 2017).

Several studies indicate that building community and individual social capital will be increasingly important in building biosecurity capability. Based on a case study conducted throughout parts of Queensland, Curnock et al. (2017) notes that informal networks are particularly important to members of community gardens classed as 'engaged' in biosecurity. Klepeis and Gill (2016) found that the farming community of one peri-urban region (Kiama LGA) demonstrated higher social capital than lifestyle landholders in the same region and tend to engage in more natural resource management issues. In a study of commercial and lifestyle hobby farmer approaches towards tick management in the Northern Rivers region of NSW, Sinclair et al. (2019) suggests that improvements in landholder responsibility towards more effective biosecurity practices will require a move towards building social and human capital, rather than limiting engagement to simply raising of awareness of best-practices.

Amongst urban specific social research, Curnock et al. (2017) identified that respondents interviewed in regard to community gardens and biosecurity risk fell into the categories of 'engaged' (high awareness and interest), 'unengaged' (limited knowledge and awareness, but interested in learning more), and 'disengaged' (low awareness and low interest in becoming engaged). Similarly, Hine et al. (2020) identified two types of non-reporters in a study investigating motivators for wild dog reporting in a peri-urban of Queensland. They are reluctant stakeholders ("perceived no benefits of reporting; too much effort; believed the dogs should be left alone") and receptive stakeholders ("acknowledged wild dogs were a threat and understood the benefits of reporting").

As shown through evidence mapping, past studies of biosecurity knowledge and awareness among urban residents has been disparate – both in time and space – and there is much scope to expand this current investigation to reveal further insights. Additional surveying to compare urban and rural resident motivations and likelihood of reporting could delve deeper and investigate possible differences further by restricting rural respondents to those involved in farming, thereby allowing a measure of differences and similarities between the farming community in rural areas, the non-farming community in rural areas, and the non-farming community in urban areas. Based on the continued importance of peri-urban food bowls as a source of produce for adjacent cities, and increasing interest in urban agriculture, a further study may also incorporate the farming community in urban and peri-urban areas. If further surveying were to demonstrate differences in likelihood of reporting, the influencing factors for this would require exploration. In this case a lower chance of reporting may be a product of many factors, including age, education, financial circumstances, cultural background, to name some possibilities.

These survey results indicate that urban and peri-urban residents represent a potentially powerful pool of interested individuals if biosecurity training and engagement is offered in line with the major motivators of urban and peri-urban sub-populations. It also indicates that there is a general willingness to be engaged, although as noted by Sinclair et al. (2019) this engagement should go beyond basic biosecurity awareness activities and investigate activities that will build social capital within these communities. An important factor in building social capital is fostering collaborations between groups and facilitating strengthened communication throughout horizontal (grey) networks. This concept is explored further in section 4.

4. Geospatial analysis

4.1 Introduction

In Australia there currently exists an opportunity to connect the emerging and growing urban agriculture communities with regional commercial growers, through shared accountability for plant health surveillance and outcomes. Traditionally, these communities have been considered as separate, with different values and beliefs that inform practice and behaviours (Srinivasan Simpson 2014). However, it is possible that the urban and peri-urban food gardener communities could offer considerable support and intelligence to regional and peri-urban commercial growers, through being empowered to participate in activities that slow down or stop the movement of plant pests and diseases through early detection and appropriate management. The most impactful places to conduct these activities may be along commodity distribution routes or 'most-likely' transmission routes for exotic pest species. Other target areas could include areas in close proximity of ports or transfer locations, or high density commercial growing areas.

The ability to identify and understand the gardener communities in these areas, who could support sentinel detection, testing and awareness activities, offers an opportunity to apply a novel approach to pest and disease surveillance and support plant biosecurity activities.

In addition, boosting the capability of urban and peri urban community groups to participate in, and build knowledge in these areas, would not only support their own local plant health and productivity goals, but would also increase broader production industry understanding of how urban community groups and individuals could be empowered to improve wider plant health and plant biosecurity outcomes.

4.2 Methodology

Understanding your stakeholder communities and audience is a critical component in the development of extension programs. The concept of stakeholder analysis is well defined with a range of tools and processes described to facilitate that process (Peterson 2013). This methodology offers a novel and powerful approach to collect and analyse data that offers insight into who the stakeholders and audience are (urban and peri-urban community gardeners), what their drivers and values for decision making are likely to be and what engagement strategies would be most effective in any given context – for example in early detection of an exotic pest, or in collaboration for regional endemic disease control.

The case study examples provided in this report (section 4.5) offer insight into the practical application of this methodology and the broader understanding generated from the work in from this project. Further validation and ground truthing of this methodology is also possible through collaborations already identified by the project team (section 5.2)

To validate this approach, a desktop study was undertaken to define these urban and peri-urban networks (stakeholder communities and audiences) and how they may be engaged in extension and surveillance activities in plant health and biosecurity. The data collected also identified examples of communities close to routes and ports for establishment and transmission of pest species and offered an understanding of how land management and policy overlays could also contribute to or support the development of engagement strategies and surveillance activities. The project activity also sought to identify high risk activities, or sites for exotic pest and disease transmission (e.g. large scale, international importation and distribution networks or key hubs for produce distribution (referred to as 'Distribution') (Schembri 2019)) and to identify examples of key actors in the urban gardening and food growing communities who could act as community champions and educators (identified as 'Influencers' in Fig 4.2a 4.2b and 4.3.5).

As such, the project team accessed and collated data from a range of sources (Appendix 2) resulting in the development of a large multi-component dataset that includes:

- Community garden group locations across Melbourne and Greater Melbourne;
- Estimations and classification of social capital for each group, using:
    - social media reach into the community and potential for community engagement,

    - local demographic and physical networks,
    - estimation of connectedness of groups and networks based on spatial analysis, using the key indicators of garden size, main activities, demographic overlays and local policy frameworks;
- An assessment of ‘greening direction’ for each local council; and
- A case study examination of land use data for agriculture across Melbourne and Greater Melbourne

An adjunct set of data was collected for environmental group locations across Melbourne and Greater Melbourne. This was compiled for 163 'place-based' environmental groups in the metro Melbourne area that are estimated to collectively provide environmental stewardship of approximately 19,000 Ha of remnant bushland, grassland, wetland and foreshore ecosystems across the city. Although the analysis of this data is beyond the scope of the current study it offers a future opportunity to further examine the spatial relationships between environmental groups, their networks and common areas of high biodiversity value.

Whilst the data sets compiled are representative of the key attributes and actors involved in this network mapping, they are by no means exhaustive nor specific to any one case example. As such, the methodology applied and data collected to date in this project offers an in-principle demonstration of an approach that can be refined, contextualized and further applied. A further series of future case studies is proposed to refine and better understand the application of this approach using key pest species or commodity examples (e.g. a case study for Brown Marmorated Stink Bug (BMSB) or for key threats to the citrus industry) and identify the resources required to actualize the use of this framework at a local, regional and sectoral basis.

Data sets used to examine spatial relationships were mapped in Maptitude™ 2020 GIS software (Calliper Corporation, USA) using schematic representation of data. The mapped data uses a universal base map and the software offers the opportunity to export data captured in the spatial analysis, for more sophisticated statistical analysis of key components. A good example of this capability is in the assessment of demographics likely to engage with a community garden based on their proximity to the garden, and therefore are more likely to be engaged by activities there, or by outreach offered by the garden. Analysis of demographic data such as age, gender, household income, occupation, ethnicity can inform the most appropriate engagement strategies, including for example if extension is required in multiple languages.

Presentation and detailed statistical analysis of spatial data at this level was considered beyond the scope of this project, but it is proposed that it would be included as a routine part of any future application of this work (section 7).

4.3 Methodologies and key outcomes by data classification

4.3.1 Community gardens networks

Data was captured from a total of 231 urban (176) and peri-urban (55) gardens across 28 metropolitan council areas, representing over 40 more gardens identified and described than in any current community gardens database.

This dataset was compiled from open source, individual community garden data, local council data and national and institutional databases, such as those compiled by key organizations supporting community garden networks and urban agriculture (e.g. Australian Community Gardens Association and local council databases). A full list of data sources is available in Appendix 2. As such, this offers the opportunity for replication of this methodology across other urban contexts in Australia with access to comparable data sources. To our knowledge, this dataset represents the largest city-level compilation of community gardens location, size, activity and social capital/networks of any study to date, as well as the largest compilation of locations, engagement channels and reach for place-based environmental groups.

Data for each garden was classified against key elements to support the geospatial mapping and analysis. As part of the data capture, a novel methodology was applied to objectively classify garden size and reach into the community, to better understand the potential for information extension via these engaged community networks. The role of community champions and trusted networks in supporting extension and behavioural change is well established in in extension theory and other sectors, therefore, this dataset also captured associated networks and gardeners who are growing at scale or with commercial outputs in urban areas (e.g. Spoke and Spade, Melbourne Food Hub, local organizations supporting garden activity e.g. Ceres, 3000 Acres). These key actors are referred to as 'Influencers' in the mapping outputs.

4.3.2 Community garden location

The location for each garden was captured in Excel and then mapped based on postal location. Location data was available for 168 urban and 52 peri-urban gardens. Where exact postal location was not available, location was determined in the mapping software by cross referencing alternative location data (street, suburb, postcode, state). All garden locations are believed to be accurate and representative of garden location for the purposes of this analysis.

The map shows location of gardens classified by local council (colour), key arterial routes in the region and state and local government boundaries. The spatial distribution of the gardens demonstrates a higher density of gardens in urban areas and discrete pockets of garden activity on the urban fringe and in peri-urban areas. Clear 'hot' and 'cold' spots can also be identified with areas such as Port Phillip, Frankston and the Inner North being highly represented and gardens in Cardinia, Moorabool and Murrindindi, appearing to be present at lower densities. The council policy overlay, helps identify numbers of gardens that may be influenced by policy, such as for land access or water use. The possibility of a role of local councils in engagement can also be explored where they may work to support the development of engagement networks. Garden location offers insight into the most appropriate sites for sentinel surveillance activities for example servicing adjacent agricultural regions or in close proximity to key transmission or distribution routes or centres. A deeper understanding of the infrastructure (garden size and reach) and community (garden demographic) of these 'hotspots' and 'coldspots', in combination with local land use and demographic mapping, would further support identification of high risk areas for plant health management and biosecurity reporting, which the authors suggest are most likely to be sites of low community cohesion (social capital), knowledge and information transfer (such as new suburbs and residential developments) rather than sites where there is a high level of activity from a food gardening perspective.

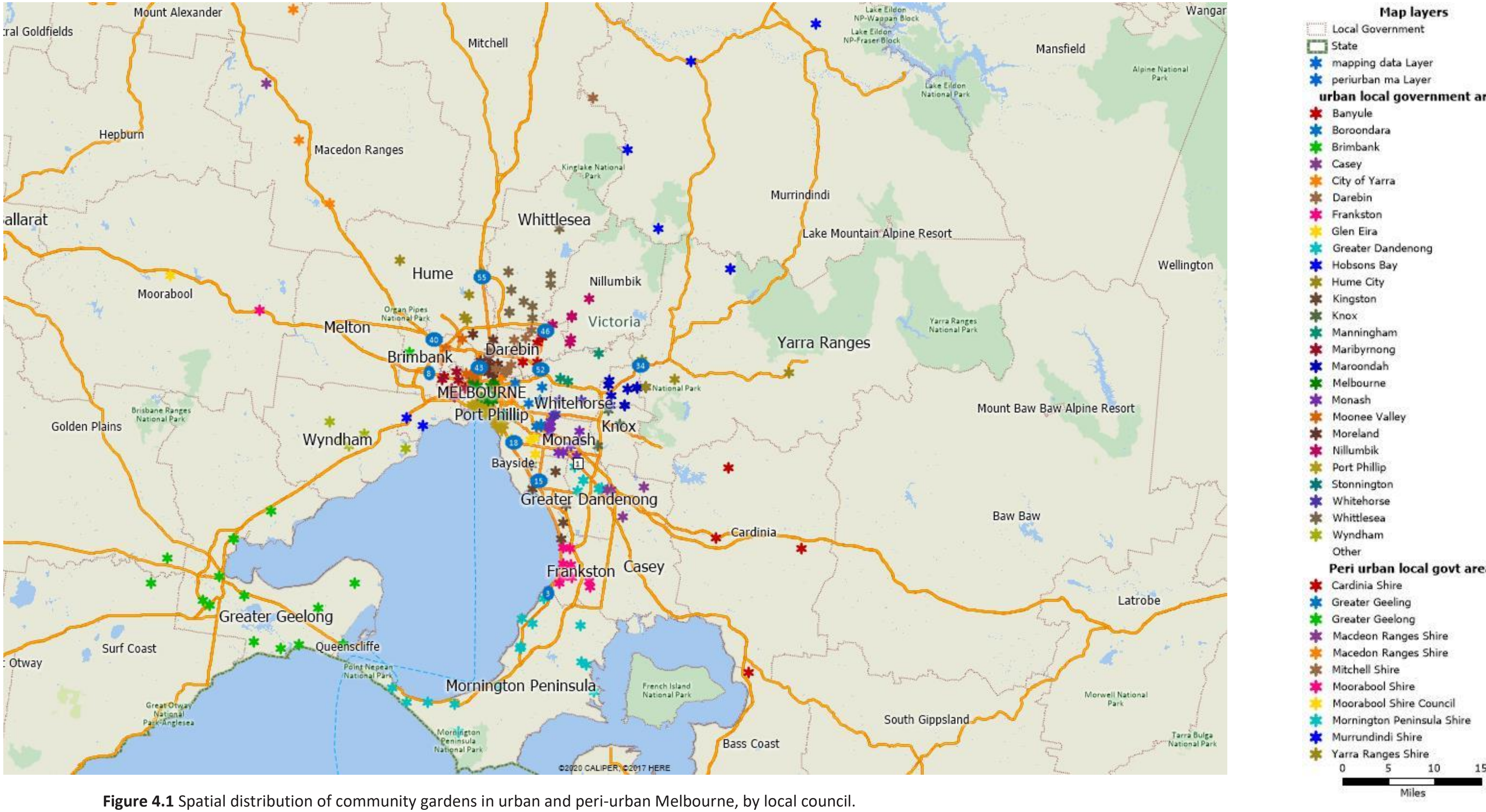


Figure 4.1 Spatial distribution of community gardens in urban and peri-urban Melbourne, by local council.

4.2.3 Community garden size

Community gardens were classified by size, to examine if there was any correlation between garden size, location and associated or potential networks. Size was determined through applying an objective score (1-10) which captured the following garden attributes;

- garden footprint (area);
- number of garden beds and/or area in food production;
- number and type of internal (membership based) activities conducted in the garden (e.g. composting, worm farms, propagation, workshops and working bees); and
- their current membership.

This classification was then ground-truthed against a subset of gardens (10) that represent the range of classifications, are known by the authors and/or represent key gardens in the Melbourne networks. Whilst this approach offers some indication of relative size of gardens, the main intention was to assess if there were potential correlations between garden size, location and spatial relationship to other key actors, in regard to distribution or surveillance networks (mapped as 'Influencers and distribution centres' in Fig 4.2b and detailed in sections 4.2 and 4.3.5) or large commercial growing areas (section 4.3.7).

There is considerable variation in garden size, however there is a propensity for gardens to be classified as 'larger' (score >5) in inner urban areas. Key findings are the frequency of location and larger size of gardens in areas such as Port Melbourne and Frankston where there are significant distribution or port activities and hence increased transmission risk, or in the East and North Eastern suburbs where there is geographical relationship with commercial growers, offering a key site for sentinel activities. (section 4.3.7). Garden size supports a greater variety of plant species and more community activity, and hence offers both a potential for increased risk for a wider variety of pest and disease species establishment (biodiversity) and transmission (activity), but more importantly offers a physical node and cohesive community for sentinel activity. The absence of gardens in some areas, or single gardens of small size, identifies that if community engagement is to be sought, connection with backyard growers or more diverse demographics without common drivers for plant health, may be more challenging. The significance of this will be further discussed in relation to case study opportunities (4.5 and sections 5 and 7).

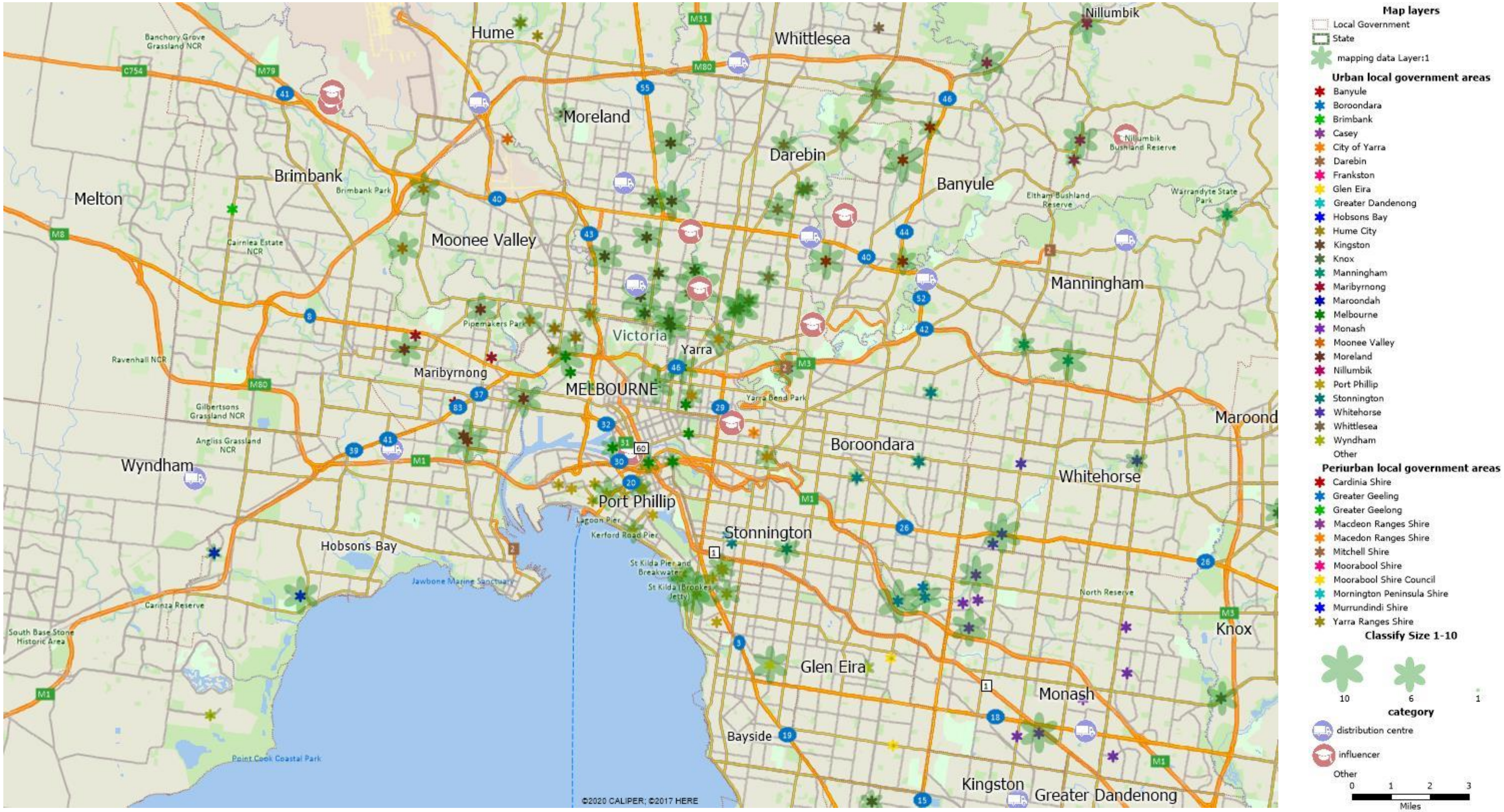


Figure 4.2 a) Garden size and location for urban gardens (with influencers and distribution) across Melbourne

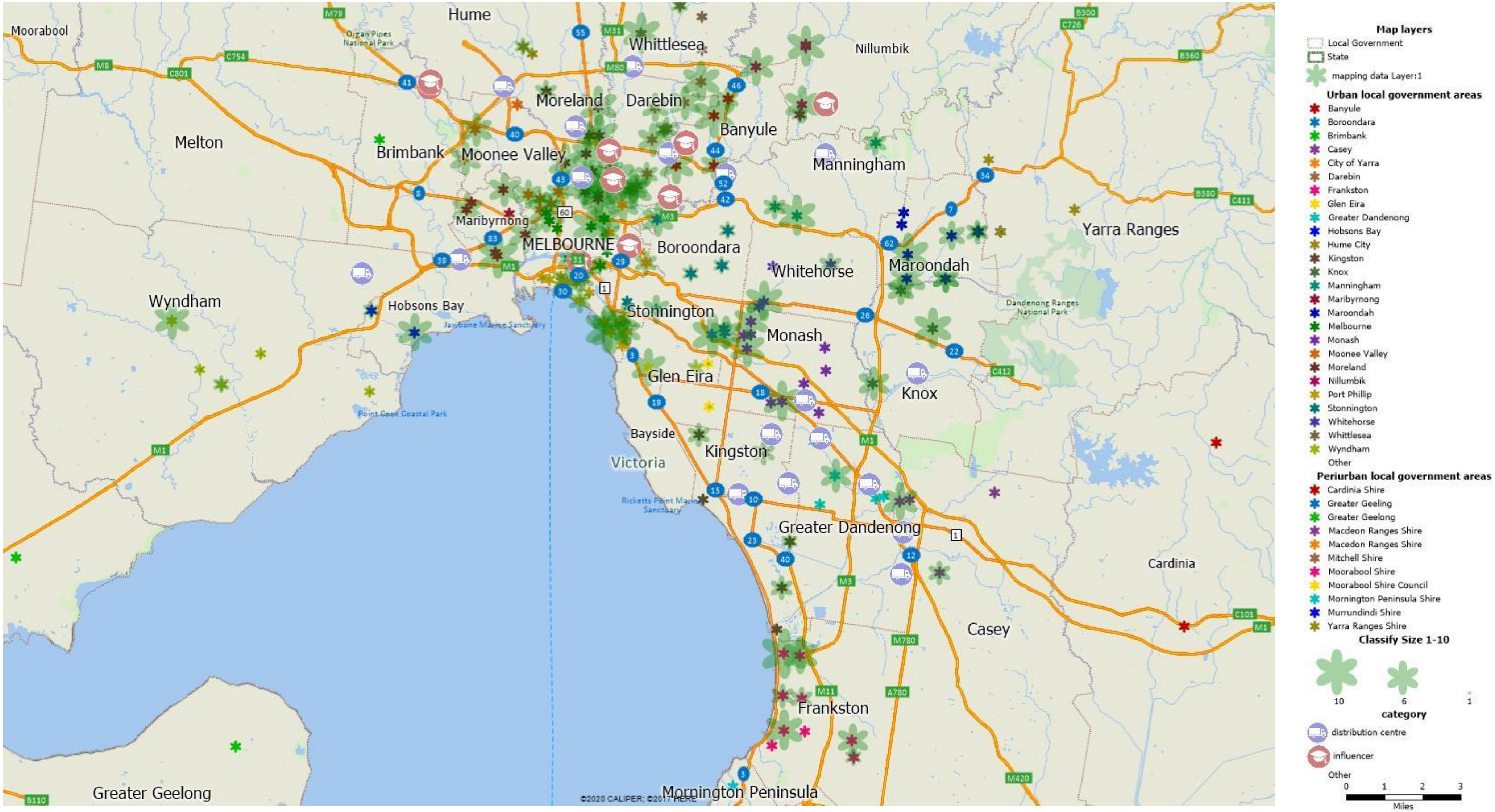


Figure 4.2 b) Garden size mapped against key influencers and international produce distribution centres for inner metro Melbourne.

4.3.4 Garden 'Reach' classification

'Reach' classification was generated to apply an objective measure of the potential social capital for community engagement associated with each garden and then collectively by suburb or local council area. Reach classification was applied using a numerical classification system against key garden attributes and activities, and is therefore comparable in application to the methodology for classification of garden size.

The attributes incorporated into the classification were size (section 4.3.3) and community engagement via garden activities with an outreach component (workshops, speakers, community events, engagement or presence in local networks), social media and other none physical forms of engagement (newsletter production and frequency, signs or leaflet distribution in the local community). Social media activity and followership was a key aspect of this classification, offering insight into the extent of the community garden networks, beyond their physical presence.

Objective capture of the social media following identified potential communities that are both interested in garden activities and are also well positioned to engage with outreach and extension. Facebook was the most common platform used, with 110 of the 231 (48%) gardens managing an active Facebook profile. This offered a total of 173,159 Facebook followers across all gardens, with 141,603 followers of the urban gardens and 31,556 followers of peri-urban gardens. Twitter and Instagram were used by some gardens (6 and 39 respectively) but followership and activity were much less than for Facebook in all cases. Use of social media was greater (activity, number of platforms and followership) in general for larger gardens and those in urban (compared to peri-urban) areas. However, as supported by the reach classification mapping (Fig 4.3) there exists significant potential for community engagement based on understanding what contributes to a garden's reach, regardless of garden location or size. It was also noted that there is little integration of garden networks or communities, either with one another or with local council, state or federal organisations.

The result of mapping the 'reach' classification for urban and peri-urban gardens is shown in Fig 4.3. A density mapping application was applied to visually demonstrate 'reach' for individual and combinations of gardens (by postcode), identifying areas of high coverage and activity (e.g. Port Phillip, Stonington, Yarra) and clear regions where, despite the presence of clusters of gardens, their current outreach potential is relatively less (e.g. Maribyrnong, Darebin, Maroondah). In a case study context, the 'reach' classification can quantify the effectiveness or potential the garden community offers for extension activities and inform potential pathways for engagement (eg via social media platforms) identify the broader communities associated with the garden (numbers of followers in social media compared to number to garden member numbers) and support the development of a tailored engagement strategy, utilizing multimedia approaches (social media, garden activities, local leafleting).

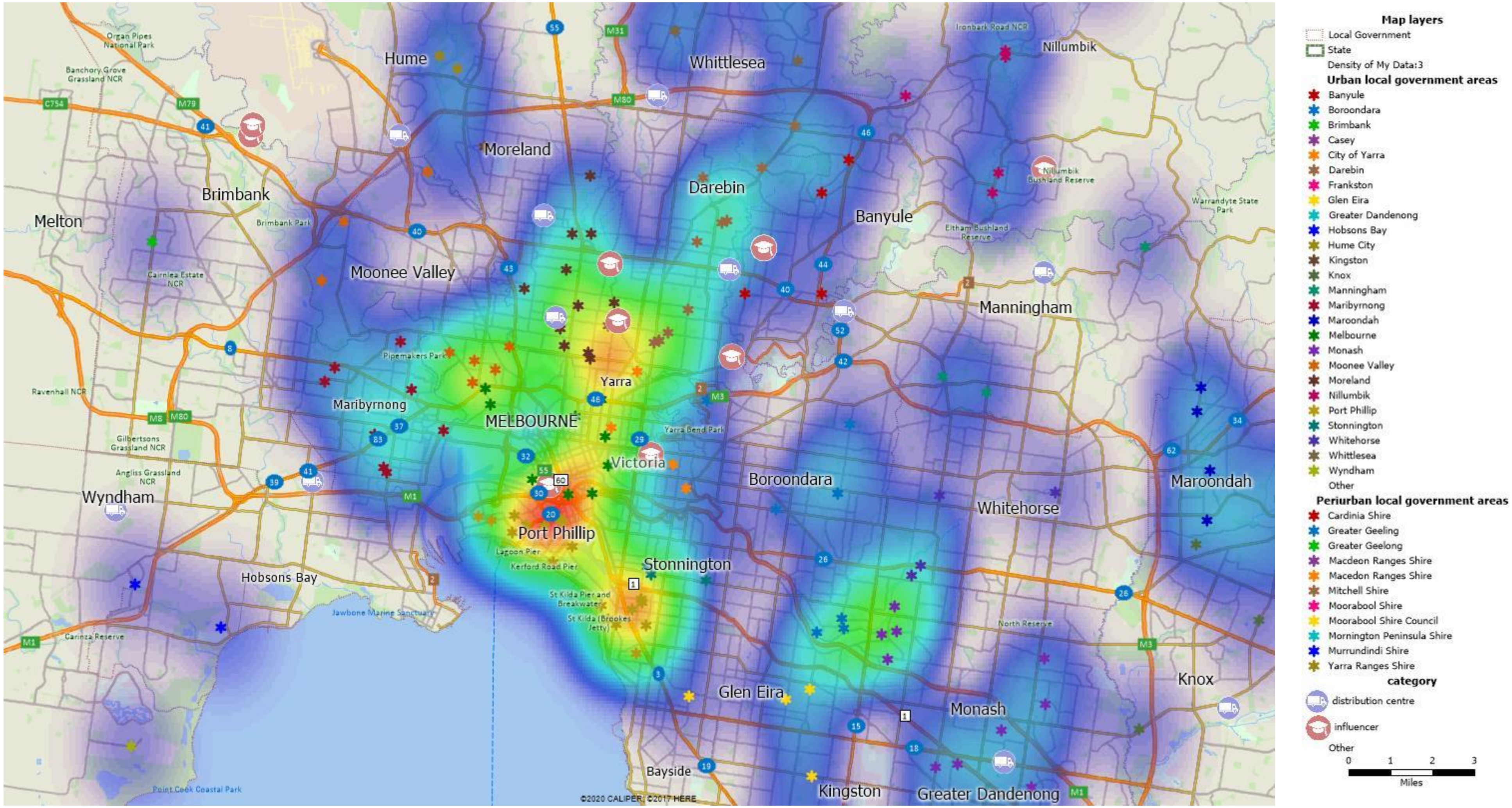


Figure 4.3 Community garden location, reach (density) and distribution networks and Influencers for gardens in Melbourne's inner and urban fringe areas (hot spots are highlighted in red and yellow hues, while areas where current outreach potential is relatively less are shown in blue and green hues)

4.3.5 Identifying risk nodes, pathways, and key 'influencers' for knowledge transfer

A proof of concept approach was applied to this aspect of the data collection by mapping the location of centres unpacking and distributing imported food products (distribution) and examples of key actors involved in urban agriculture, termed 'Influencers'. For this example, 'Influencers' are people or groups growing food commercially in urban areas in Melbourne, who are identified as potential key sources of knowledge and mentoring for urban growers (Fig 4.4 and section 4.2). Other key influencers could include organisations, groups, communities and institutions providing education, resources, support (e.g. financial) or access to land for urban food growing.

For each context in which this methodology is applied, there will be different Influencers and risks (such as distribution centres in this example), with varying levels of impact. Therefore, for each case the 'Influencers' can be identified, mapped and potentially further classified based on importance or significance for that case. Developing an understanding of the networks with which the Influencers engage, could add further layers of understanding for stakeholder assessment and development of engagement strategies.

The insight that facilitates collection and appropriate application of this data is also likely to be generated through developing an understanding of each case context, and the subsequent assimilation of both evidence-based and anecdotal information. As such, the relative value of this data will be highly variable between situations. However, these data types, applied judiciously and in context, may greatly assist in developing an understanding of risks for transmission, establishment and impact and how communities can be supported, mentored and empowered by Influencers, for participation in best practice management in food production and sentinel surveillance activities.

Relative distribution of garden location and proximity to the distribution centres ('distribution') and urban farms owned or managed by the 'Influencers' is shown in Fig 4.4. Where gardens are in close proximity to distribution centres, these may be identified as key sites and communities for extension and engagement activities, particularly for pest species that are likely to 'hitchhike' along transportation routes (e.g. Brown marmorated stink bug). The location of an 'Influencer' may offer an opportunity to engage directly with this person or group as a trusted adviser or community champion. The Influencers may also act as 'information nodes' or hubs, be able to assist in community education and oversight of sentinel activities, or extend broader support and engagement to the garden communities in the area. The opportunity for reporting through a trusted advocate has been established as a gap in the communication networks supporting identification and reporting of suspected pests and disease in grower communities (Schembri and McGregor 2019).

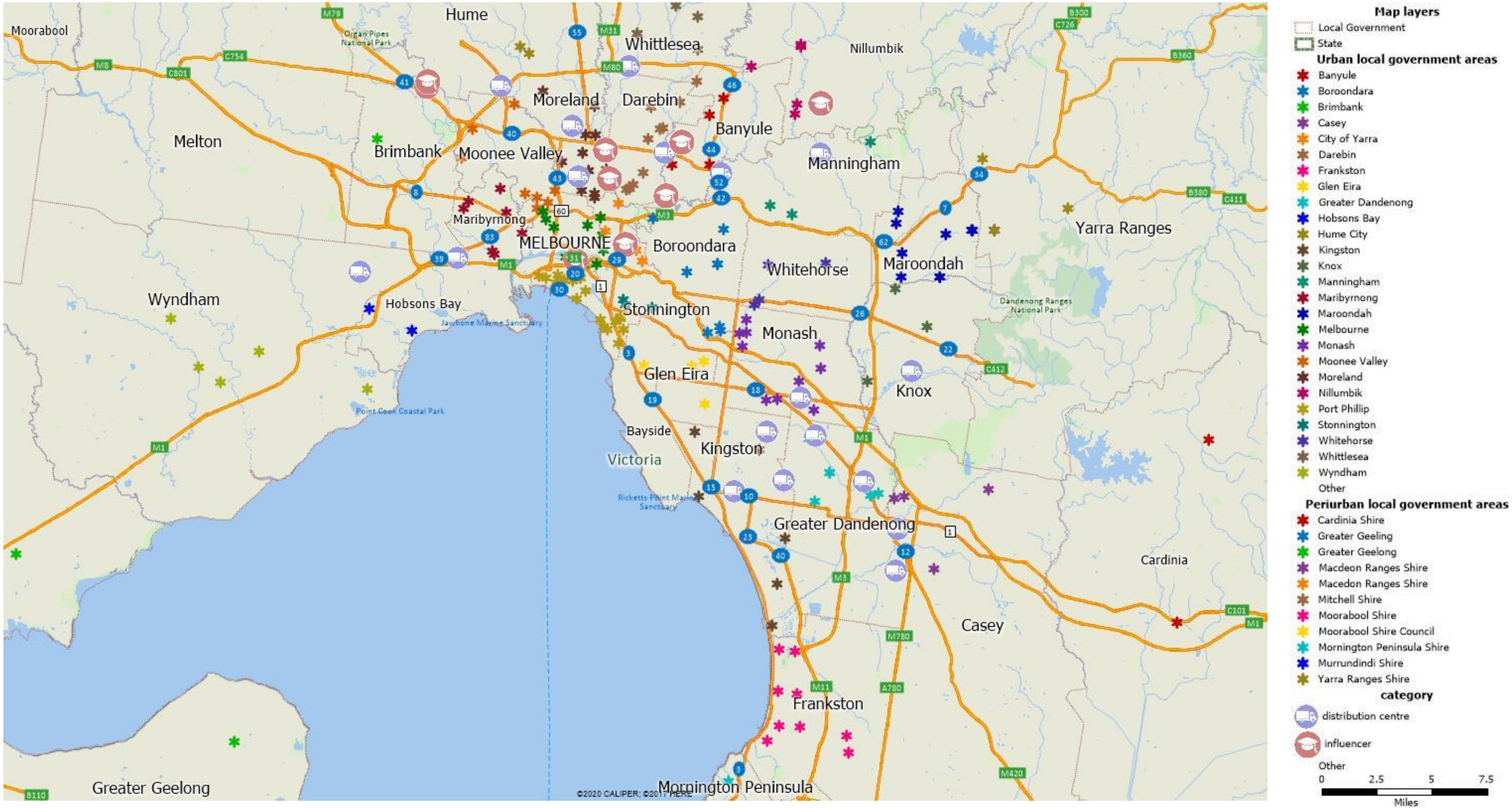


Figure 4.4 Examples of location mapping and projected transmission routes, and key influencers, for assessment of spatial risk (distribution) and opportunities (engagement leveraged through Influencers).

4.3.6 Capturing demographic and community data

It is possible to gain considerable insight into the demographics involved with and engaged by community gardens and their extended activities. The community gardens in Melbourne have discrete and also sometimes overlapping demographics due to the broader context, suburb, social and cultural, and ethnic aspects of the communities and their drivers for growing food (for example access to land, food security, income, health). Demographics can be examined and understood at a number of levels; by local council (constituents – often driven by values and political alignment), suburb (place based, economic, social) or based on measures such as age, gender or ethnicity.

A classification unique to, and valuable for, assessment of engagement strategies for community gardens is based on the common application of a radius ‘capture’ for garden membership. That is, gardens prioritise membership for people who live within a particular radius of the garden, to support regular activity in the garden, easy access for people without transport and the opportunity to engage with those communities through the physical presence of the garden, leaflet drops or local community communication networks (e.g. a notice board). The physical proximity of community to a garden is also likely to support community coherence and means a garden can tailor its activity and growing opportunities to those demographics (for example cultural preference for certain food). Hence this offers another focused lens through which to apply the most appropriate plant health engagement strategies.

Fig 4.5 demonstrates the capacity of the mapping methodology used in this work to capture the resident population within a pre-determined radius of each garden (1km in this example), nuanced by applying this as a travel time and route analysis, rather than as a ‘as-the-crow-flies’ measurement. The varied coloured areas identify these ‘membership captures’ for each garden, and the areas of black infill (street scape) identify demographics (residential areas) not eligible for membership or less likely to engage with a garden based on this spatial relationship. For any given context this offers the opportunity to not only better understand the garden membership demographic but to determine if any garden differs greatly to that of the broader population (by suburb or local council) and identify opportunities for gardens to form networks and collaborations, extending their community reach and presence. In turn, this may also identify if gardens are operating in isolation, or at extended distances from one another and across different demographics, restricting information and knowledge transfer.

The demographic data captured for each garden or across garden communities (for example based on location, size, reach) is drawn from the most recent Australian census data (2016) and can be generated as a table of values. Based on the aims of a particular case study, this data can then be filtered for key factors that are considered of importance for the context (e.g. age, ethnicity, gender, income) and subject to further statistical analysis. The application of this technique in a case study context is further described in section 5 of this report.

The power in this novel approach to data capture for assessing social capital is supported by its tailored nature, determining key aspects of any demographic (e.g. age, gender, income, ethnicity etc) and place (e.g. housing density, number of occupants per household, renter or owner demographics etc.) and examining this alongside factors such as garden size, reach, support from council policy, access to mentoring and support. The capture and analysis of this data offers the opportunity to identify areas of low social capital and high social capital when it comes to plant health knowledge and practice, and apply an integrated or holistic lens to determine how to engage grower and community demographics.

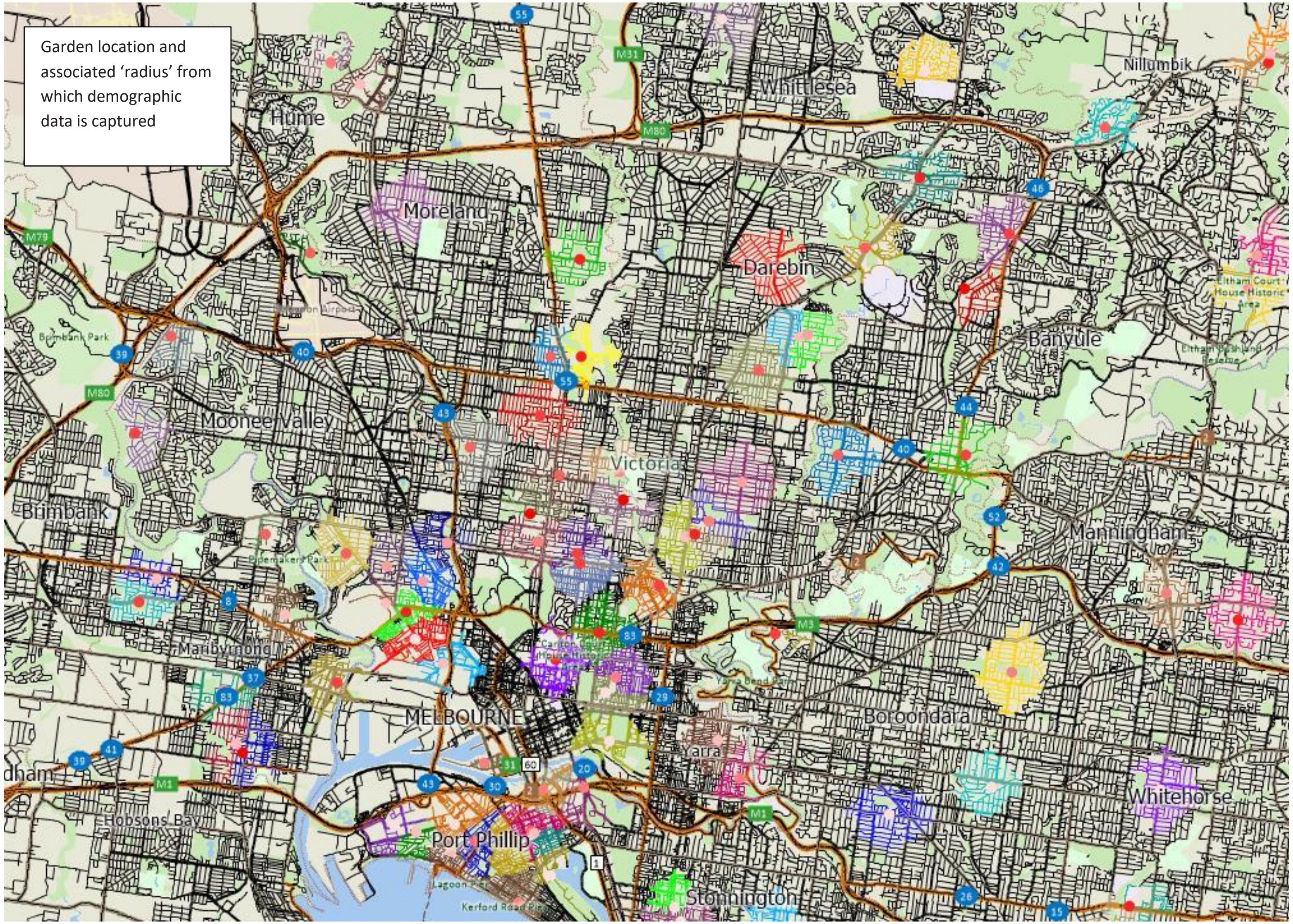


Figure 4.5 Demonstration of the application of mapping capability to capture demographic located within a pre-determined radius (1km) of the garden.

4.3.7 Geospatial relationships between community gardens and commercial growing areas on Melbourne's fringe

A critical component of this work was the assessment of the spatial and risk relationships between urban, or garden-based communities and those growing at commercial scale on Melbourne's fringe. One study objective was to explore the opportunity that strong social capital and associated community and communication frameworks offer for increased integration and collaboration between regional and urban grower communities. The use of spatial data assists in defining areas of high risk for pest and disease transmission and establishment, and relative opportunity for detection and management through engagement with both urban and commercial grower communities, towards a shared outcome.

We are also able to assess the potential in existing networks and better determine their support needs through targeted demographic analyses. Where networks exist, an assessment can be applied to determine their potential for sentinel garden activity to support a particular production sector (particularly with respect to detection of emergency plant pests for that industry), which may be in turn supported by a targeted and tailored extension and engagement program, using approaches described in earlier sections of this report. Drawing on the local government policy frameworks for these communities (section 4.3.8) may also offer insight into how to leverage or lobby for support and resources for engagement and extension activities or to support commercial grower and garden communities in best practice pest and disease management.

For the purposes of assessing the validity of this methodology, spatial data for two commodities was translated and adapted from a large and complex data set, shared with the project team by Food Print Melbourne (Sheridan and Kaemmerling 2019), Foodprint Melbourne GIS map data (data source - ABS 7121.0 - Agricultural Commodities, Australia, 2015-16), University of Melbourne). For insight into growing areas by commodity for the Melbourne food bowl, the full Foodprint Melbourne GIS map can be viewed here.

To offer a demonstration of how this data may be utilized, yield data for pome fruit and berries was mapped by location. Schematic quantification of yield values offers a visual and relative representation of this data and identifies the main growing areas (Fig 4.6). Overlaying community garden location and 'reach' starts to build an understanding of how these data may be integrated into more sophisticated, targeted case study analyses.

The example in Fig 4.6 clearly demonstrates the significance of the spatial relationships between community gardens on Melbourne's fringe and the commercial activities in these areas. The reach classification applied offers insight into existing potential networks for engagement and activity and where collaboration could be fostered between these growing communities for the purpose of maintaining plant health and contributing to pest surveillance. The fact that community gardens are sited within these key growing areas, offers a physical location and existing community for targeted sentinel activities for any pest or disease of high risk for the produce grown in those areas. Further identifying 'Influencers' and high risk centres or routes for the same case context (pest or disease) and relevant for the commodity value chain, will start to build a deep understanding of key factors for consideration in determining and communicating risk and what monitoring, extension and engagement activities are possible and most appropriate.

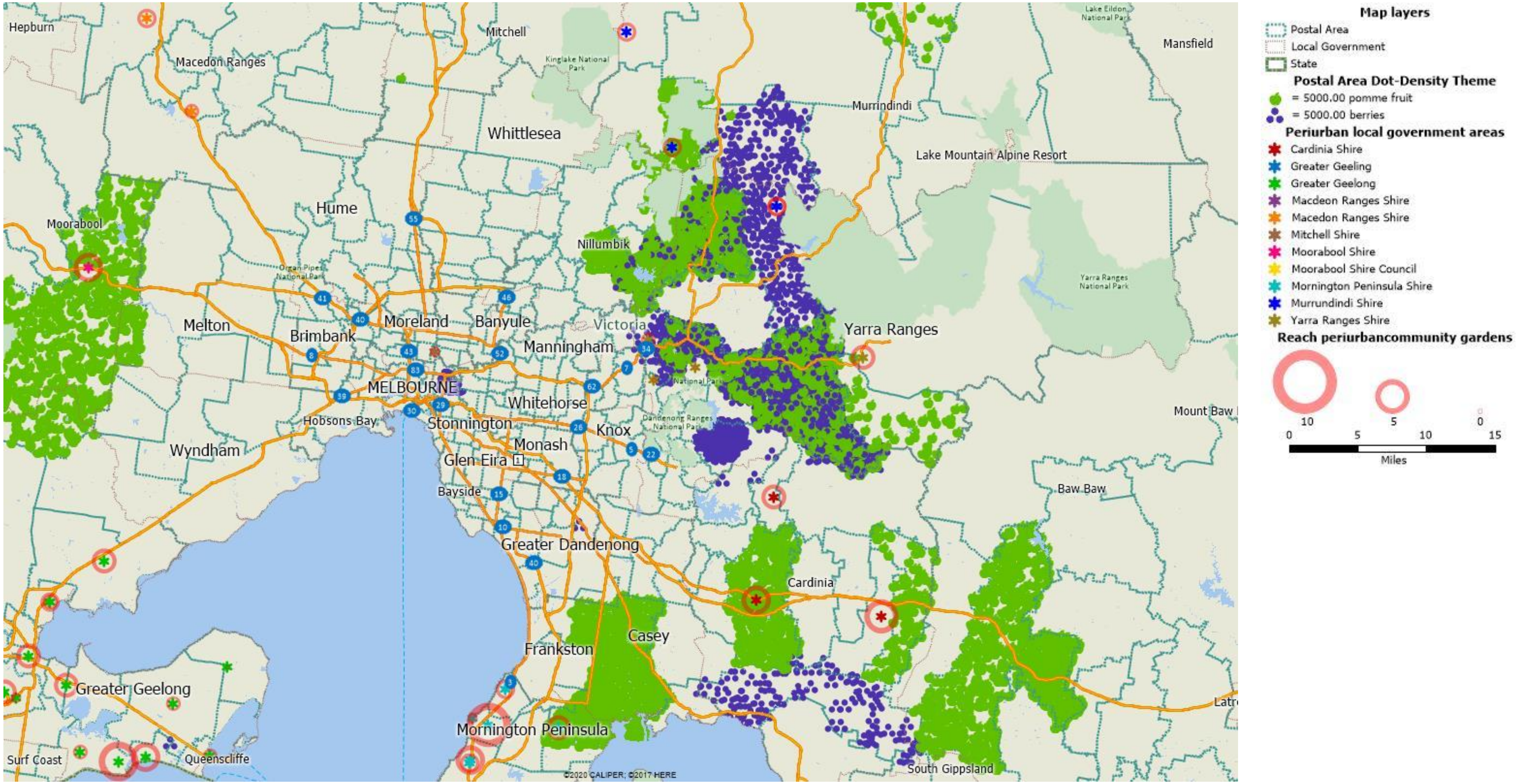


Figure 4.6 Commodity yield (two commodities) schematically represented against community garden location and reach.

4.3.8 Local government policy

Local policy frameworks supporting or limiting urban agriculture and urban greening directions have been open to a great deal of scrutiny and with the recent increase in activity in this space, are likely to be further assessed and developed. To determine the implications of local council policy for plant health, biosecurity and community garden establishment and activity, policy documentation from 28 local councils was assessed against key indicators. The key indicators examined included (but were not limited to):

- biosecurity and urban agricultural policy;
- green wedge management policy;
- food production and related activities;
- land access and food security; and
- urban greening.

Search terms were applied to each policy document to identify the frequency of use of these terms and in what context they were being used. An objective measure of frequency and context was applied to generate a score for each term, policy and council against the key themes (table 4.1). The time since creation and review of the documentation was also captured along with the number of revisions.

Table 4.1 A score of 1-5 as applied to each term

Score 1	term appears < 10 times in the document and is only referred to in passing
Score 2	term appears numerous times 10-20 but is not associated with a stand-alone section or policy
Score 3	term appears > 20 times but is not associated with a standalone policy or section
Score 4	term appears as part of a separate or stand-alone section
Score 5	term has own policy, manifesto or similar.

Low scores were returned against most search terms suggesting that either the terms applied in this project were not being commonly utilized in council policy and discussion, or that there was broadly low-level engagement with these areas of activity.

Specific policy existed for support of urban agricultural or community driven food growing activities in 6 of 28 councils, captured in 1 or 2 policy documents in each. The term 'biosecurity', or exploration of that concept appeared in 24 of 26 sets of council documents examined, which suggests that there is an understanding of the concept and use of consistent terminology. However, in all cases, this only returned a low score (score 1 across all documents examined). In all councils, the focus in the policy documentation was on biodiversity, ecological and green wedge management and land use.

Given the findings related to motivators for reporting of suspect exotic pests in section 3, which indicated that environmental protection is the primary motivator among urban residents, strong council focus on environmental stewardship is a potentially powerful basis for beginning biosecurity related discussions with community groups.

The application of this methodical, objective measure of council policy provided insight into the level that current policy frameworks support urban food production, plant health and biosecurity in Melbourne, as well as key limiting factors identified in social research to date, namely land access, resources, mentoring and support (e.g. knowledge transfer). These findings also offer the opportunity to identify gaps in policy development or execution for key councils that may form case studies in future analyses (section 5 and 7).

An example of the broad application of this data is the comparative assessment of policy for a council in the outer Western suburbs, with a high density of market gardens and commercial vegetable production. This local council returned high score (4 or 5) against the following search terms; biodiversity, community engagement, urban forest, green wedge and community gardens but has only a few small gardens with limited 'reach'. This context is compared to a local council area in the East of Melbourne with a larger number and higher density of gardens and larger size and reach, but with low scores against all but one of the same search terms. In such situations, policy analysis can expand demographic analyses and limit the potential for incomplete datasets to bias conclusions.

Developing an understanding of correlations between council policy, existing garden hotspots or cold spots, and risk factors such as the spatial proximity to adjacent growing regions, key transport routes or risk nodes such as distribution centres, will help inform if and how to engage at a local government level for support in extension and engagement programs.

Alternatively, this approach may identify disparity between policy development and community greening activities, for example identifying areas with strong greening support but low garden activity informing an opportunity for pre-emptive community engagement on the topic of plant health, thereby setting the culture of the gardens at an early stage.

4.4 Discussion

The development and testing of this methodology supported identifying elements of risk for plant health and disease transmission for both community gardens and commercial growers, and the potential for growth and development of community networks and champions for biosecurity extension and sentinel activity. There exists an opportunity to further validate this approach and ground truth it, using both known and projected examples with different contexts and risks, and for different communities and local government overlay.

For example, in relation to the port based and transport route risk for transmission or establishment of Brown marmorated stink bug in commercial grower regions this methodology could be applied to identify and classify risk locations and activities (e.g. distribution centres, transport hubs), determine their proximity to both community gardens and commercial growing areas and examine the stakeholder groups and communities associated with those areas and locations. This data would in turn inform the most appropriate and effective sentinel locations and activities, what resources would be required for the program and how to engage and educate key stakeholder groups and the extension community (community garden members and their associated networks) based on a clear understanding of these demographics. The local government policy overlay supporting or limiting these activities and communities could also be assessed and avenues for engagement and extension determined e.g. (social networks, social media). This tailored approach to engagement will generate more effective outcomes with efficient use of resources.

Ultimately, having an understanding of how spatial and demographic factors and values-based motivators influence the likelihood of community engagement, surveillance activity and likelihood of reporting, can lead to the following benefits:

- Improvement in judging actual biosecurity risk posed by demographic groups living in different settings;
- More cost effective and impactful stakeholder engagement campaigns where audience and stakeholder needs are understood;
- Application of segmentation to audience and stakeholder groups for the development of more appropriate, targeted engagement strategies, designed to honour audience motivations (refer to section 3);
- Identification of localities where plant health and agronomic knowledge is likely to be very low or very high; and
- Improved ability of biosecurity authorities to predict what sub-populations would be early adopters of biosecurity and plant health training, and therefore training resources may be developed and delivered to suit and appeal to those sub-populations.

To conclude, through mapping of the key spatial and demographic components, the potential strength of a community-based, locally contextualised and supported plant health network across a major city, and linked to regional growing communities, may be realised. The authors propose that the framework used and data sets interrogated are key indicators for understanding the potential for creating, and building on, existing social capital for broader plant health, biosecurity and community outcomes in urban environments.

4.5 Application of this approach for supporting engagement (Case study example - Spotted wing drosophila)

As suggested by Klepeis and Gill (2016) where ideologies overlap there is potential for collaboration. Stakeholder groups that may inherently be disengaged from each other, due to differing values or cultures for instance, may be brought together to address key areas of consensus (e.g. achieving improved vegetable crop quality). From that foundation of shared interest and need interactions may 'spill over' into other areas, such as pest management and identification of invasive species.

Engagement with urban growers on a relatable topic, such as Queensland Fruit Fly (QFF), is one strategy whereby further conversations about plant health could be undertaken. In recent years outbreaks of QFF in metropolitan Melbourne have become more common, leading urban resident to question why outbreaks are occurring and how to manage them. However, as shown by Hu et al. (2018) there is a high willingness among community members (in the neighbouring peri-urban region of the Yarra Valley) to comply the right actions for QFF control and a very high willingness (98% of respondents) to report.

Horticultural industries are well acquainted with the issue of QFF and the challenges that it can pose, both to production and market access, and there is potential for commercial horticulturalists to participate in community education in a mentoring relationship with gardening enthusiasts. As noted by Kruger (2018), "*in most Australian horticultural regions, state governments require local industries to take the lead in securing the voluntary support from local landholders with Qfly host plants on their properties*."

Importantly, the topic of QFF, a pest for which urban and commercial growers can take action on in the here and now, whether it be for detection or control, is a natural discussion point from which other pests may be explored. One candidate is the spotted wing drosophila (*Drosophila suzukii;* SWD), which is not found in Australia, but is classed as a High Priority Plant Pest for several important crops found in the Melbourne food bowl (and commonly in community and urban backyard gardens).

The majority of SWD early detections overseas have occurred in horticultural regions, although this may be a product of proactive trapping and grower vigilance, rather than the fly preferentially establishing in production zones. Several first detections of SWD overseas have occurred near fruit transit hubs. Examples of this include near a grocery store in Sweden, by a selling point for imported fruit in the Netherlands, and in a tourist area in Croatia. The first detection in Hungary was at a highway rest stop. Detections near major seaports have also been common, which may indicate a higher risk of entry and establishment near seaports.

SWD larvae infest ripe and unripe fruit of host crops. Long range transmission is supported by movement of infested produce, and long-range movement of imported fruit is the standout risk for bringing SWD into Australia. When it comes to more modest expansion of the fly range within a region or country, the rate of spread observed overseas suggests that vehicles play a role, rather than flight-based spread.

We can only speculate on likely incursion sites in Australia and New Zealand at this stage. Early detections made in Europe, South America and the United States in recent years were not necessarily at the site of the initial incursion. What we can say is:

- Our berry, grape and stone fruit production zones would be, on the whole, suitable for establishment;
- First detections of SWD commonly occur on the coast;
- Based on how SWD moves long distance (in imported fruit) urban areas are likely incursion sites;
- Imported fruit move through ports and airports, which have been common detection sites overseas;
- Wholesaler and retailer sites are important to consider - unsold imported fruit left in waste piles can present a risk;
- Detection of SWD all year round may be possible in temperate areas of Australia and New Zealand.

Given the likely establishment sites of SWD, as informed by overseas experiences, there is large scope for undertaking discussions with gardens located in close proximity to ports and distribution centres in order to raise detection capacity and early reporting and traceback. Additionally, gardens or clusters of gardens that grow a variety of SWD hosts, demonstrate strong social capital (translating to an increased ability to share information), and are located within close proximity to host production zones (such as east and south east of Melbourne), are candidates for targeted engagement activities.

Figure 4.7. SWD adults (above) and larvae in raspberry (below). Source: Hannah Burrack, Bugwood.org.

5. Community engagement and collaborations

5.1 Community engagement

An outreach component incorporated as part of the project design supported the project team to test an engagement approach for raising awareness of exotic pests. *The Urban Green Series*, a weekly webinar delivered over August 2020, linked the project team and guest presenters with a group of Melbourne gardeners. The online forum allowed the team to field questions about plant health, invertebrate garden ecology, pest management and exotic pests, and deliver information sessions that were designed to build on plant health knowledge acquired in previous weeks. Questions posed to the attendees throughout the series supported the project team in ground-truthing assumptions about information transfer and the profiles of interested demographics. Development of the webinars into YouTube videos gave the project outreach component a level of legacy to support ongoing awareness raising. The authors believe that this legacy aspect is particularly important as information on plant biosecurity directed specifically at urban gardeners remains scarce.

The outreach design was informed by motivators and barriers identified during the social research component and focussed on building confidence and collaboration between individuals on the topic of plant health. Specifically, the outreach method aimed to encourage and empower community members to become more familiar with their urban garden and its ecology in order to raise confidence in detecting unusual species or damage. This is in contrast to a commonly used outreach approach of that aims to raise awareness of exotic pests based on a ‘top pests you should keep an eye out for’ message.

This more novel approach offered a value proposition to participants, in that they could build knowledge around garden ecosystems, gain a holistic appreciation for the complexity of these systems, upskill in methods for detecting pests and pest damage, and in turn become more able to appropriately and consistently identify (and therefore report) unusual findings. The series also placed an emphasis on group discussion and Q&A, which further allowed individuals to appreciate the level of shared interest among other Melbourne gardeners on the topic of plant health.

5.1.1 Audience

The series was promoted to community garden groups over July 2020. Over July and August 2020 over 100 people registered for *The Urban Green Series*. Each session attracted between 20 and 35 attendees, with session 2 attracting the most participants, and with many participants returning each week. Sessions had interactive components, with the opportunity for participants to ask questions of the presenters, of one another, to share their experiences or comment on content. Each week the majority of participants were located in Melbourne. A poll taken during week 1 and week 4 indicated that the majority of participants gardened in a medium to large backyard space and were experienced gardeners (5-10 years experience) (Fig 5.1). The second most common gardening location was a community garden.

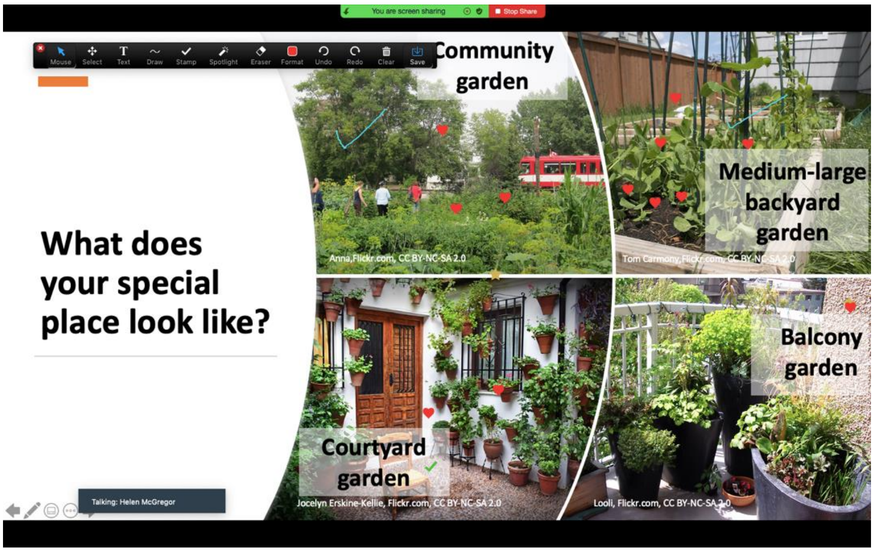


Figure 5.1 Garden types reported to be used by participants in week 1.

5.1.2 Engagement outputs

Weekly session topics were:

- Exotic crop pests – how staying vigilant can help protect our food crops (week 1);
- Beneficial insects in your garden and how to encourage them (week 2);
- Pest monitoring tips & how to report exotics (week 3); and
- Garden green, garden clean – Garden ecosystem management for pest and disease outcomes (week 4).

Week 2 and week 3 featured guest presenters, Dr Lizzie Lowe (Macquarie University) and Dr Elia Pirtle (Cesar Australia) respectively. The series was designed to raise knowledge through several methods. These included the information sessions, complementary set reading, and facilitated chat sessions. During the preceding week before each session registrants were supplied with reading material related to the topic for the week. At the completion of each session the webinar was edited and uploaded to YouTube at youtube.com/cesaraustralia. The uploaded video was distributed to the entire list of registrants each week as the project team had received several requests for the recordings from community members who could not make the session time. *The Urban Green Series* webinars were undertaken in four parts and can be viewed **here**.

5.1.3 Engagement findings & feedback

In week 1 participants were asked 'what is your main source of information on garden pests?'. Answers are included in table 5.1. Interestingly, the most common knowledge source was 'someone local with plant pest knowledge', which reflects findings from the evidence mapping activity whereby studies consistently noted the importance of informal networks in relation to learning about biosecurity.

In week 4 of the webinar series, a facilitation technique (ORID) was utilised to capture the thoughts, feelings and reflections of the participants, many of whom had participated in all 4 sessions (table 5.2). The session was adapted for delivery on-line, but the key principles remained. The technique supports participants through a consolidated, experiential learning process developed by Laura Spencer (Institute of Cultural Affairs USA) and based on the Kolb Experiential Learning Model (Kolb, 1984). ORID stands for 'Objective, Reflective, Interpretive, Decisional' and hence outlines each component of the serial questioning. ORID session findings indicated that some participants felt more motivated to monitor for invertebrate species in their gardens and felt greater confidence to do so. One participant noted that she often uploaded unusual specimen photos to iNaturalist, but after being involved with the webinar series now felt motivated to use the Exotic Plant Pest Hotline number if she found something suspect.

Five participants were polled following the series. All reported that they felt motivated to learn more about their garden ecology after watching the series. In addition, all reported that watching the series had made them more mindful about maintaining garden health, and that being a part of the series had made them more aware of the best way to report a suspect exotic plant pest.

Table 5.1 Main knowledge sources identified by participants during session 1.

Someone local with plant pest knowledge	7	Biodiversity app	6
The museum	0	Information online	5
Community garden / gardening club	1	The library	2
Friend or family member	2	Online interest group (e.g. Facebook group)	4
State department of agriculture	4	Other	0

Table 5.2 Compilation of webinar participant responses to ORID questions in week 4 of the Urban Green series.

Objective **What came to mind most for you as you participated in these sessions?**	What was new?	• *All the "bug stuff"* • *Testing kits available* • *iNaturalist (2)* • *Information about beneficial and pest insect species*
	What stood out most for you?	• *Information possible on perennial veggie gardening* • *Traps for insects* • *To always look for the balance in the garden for it to thrive* • *The cute bugs!* • *The generosity of you offering this information*
Reflective **How did you feel during the sessions?**	What surprised you most in the sessions?	• *How much I already knew* • *I felt assured I was heading in the right direction* • *The interactivity and audience* • *Content was not "dumbed down"*
	What frustrations (if any) did you feel either during or after the sessions?	• *No frustrations* • *Missing out on earlier sessions (2)*
Interpretive **What stands out most for you in terms of what you have learned?**	What are your key insights or take-away points?	• *Importance of documenting observations and reporting* • *Ability to ID pests and insects* • *Soil health and its contribution to plant heath*
	What are you most likely to change or what will you do differently in the future?	• *Buy a magnifier and take more photos for ID of insects* • *Pay more attention to the soil and water* • *More companion plantings* • *Importance of sun and shade*
Decisional **What next steps do you think are most important?**	Who should be involved in the next steps?	• *Partner with Australian City Farms and Community Gardens networks* • *Local councils* • *Anyone with a shovel and a patch of ground*
	What other things do you need most (resources support etc?)	• *Text based and video resources* • *Examples of best practice* • *Urban contextualized research to support practices such as IPM in that context*

5.2 Collaborations

The project team have significant existing connections to commercial grower communities, peri-urban communities and the developing urban agricultural community in Melbourne. As the project progressed a number of key activities being conducted by other groups emerged as opportunities for collaboration and potentially sharing of intel, and in one case, of data. These opportunities to build on existing relationships in the broader context of plant health, urban greening and in safeguarding food supply, was also leveraged by the broader societal context due to COVID-19 and a heightened awareness and interest in food security and supply. The collaborations and communications that were generated offer a unique opportunity to further build relationships between those who have a food security or urban focus and professionals working in broader scale food production.

A key, reciprocal collaboration was with the Food Print Melbourne team who have shared mapping data to support analyses of spatial relationships and potential relative risk for commercial and community growers in outer urban and peri-urban areas, clearly identifying key areas for commercial production and facilitating data analysis and the proposal of appropriate engagement strategies for the broader communities in these areas. The data and its application in this project are further described in section 4.

Collaborations have also been fostered with a number of key organizations through the project work to date, many of whom are also regarded as key influencers in the field of urban agriculture, and further activity will continue beyond the life of the project. These included community urban greening leadership initiatives, such as CERES, Food Garden, and the Cardinia Food Circle Movement. These groups are important knowledge brokers in relation to crop food growing best practices in Melbourne, and discussions with these groups throughout the project served to explore the concept of empowering community groups to champion plant health activities through ‘grey’ communication channels.

Due to the reciprocal nature of the relationships formed, the novel nature of the work being completed in this project and the existing networks and professional relationships of the researchers, there remains considerable opportunity to continue these collaborations for mutual benefit in the future. These outcomes were unforeseen at the inception of this work and offer a unique opportunity for otherwise somewhat disparate but similarly focused organizations to work to augment and empower one another. The development and understanding of the significance of these ‘professional’ networks, also facilitates the exploration of a trusted informal network of advocates and advisers, supporting grass roots food growers and community gardeners in urban communities. The data compiled on community gardens and environmental groups has also been highly sought after by several research and outreach groups. The project has supplied data to the following projects:

> Project: Foodprint Melbourne, Dr Rachel Carey, University of Melbourne – Purpose: Measure and predict the value of the Melbourne food bowl.
>
> Project: Use of Pb isotopes to trace the source of plant pest biosecurity incursions, Dr Karen Armstrong at Lincoln University (part of an Australian Rural Research & Development for Profit project) – Purpose: Data may aid in identifying community groups that can collect samples of plant tissue in transects across Melbourne to determine Pb isotope distribution. Ultimately this sampling process will support an innovative new method of tracing the origins of exotic pest outbreaks in urban environments. This is currently a B3 project with NZ MPI collaboration and NZ GIA (Fruit Fly Council) plus AUS Rural R&D for Profit (GRDC Boosting Diagnostics project) aligned funding. The technical collaborators are at Queensland University of Technology and the University of Otago.

In addition, the project has identified linked industry and community initiatives that will benefit from release of this report. One opportunity relates to Queensland fruit fly (QFF) awareness and management. For example, the Yarra Valley Regional (QFF) Coordinator undertakes activities to raise awareness about the detection and management of this pest in the peri-urban zone east of Melbourne. Similarly, the Victorian Farmers Federation, Mornington Peninsula branch, are planning QFF awareness activities in the peri-urban south east of Greater Melbourne. Both of these areas are notable for the current production and future production potential of QFF host crops, such as berries, grape, cherry, summerfruit and pome fruit. During the project the Yarra Valley Regional QFF Coordinator and the VFF (Mornington Peninsula) expressed an interest in using project results to improve their tactics for engaging with peri-urban non-farming audiences and improving detection and management throughout Greater Melbourne.

6. Conclusion

Project outputs have included:

- A comprehensive meta-analysis of social research conducted in Australia relating to urban and peri-urban resident knowledge and attitudes towards biosecurity;
- Analysis of the first biosecurity focused social research survey to compare differences in attitudes between urban and rural residents;
- The most thorough dataset yet compiled on the location and classification of potential reach or networked impact of community gardens across an Australian capital city;
- A documented methodology for applying geospatial mapping approaches to assess plant biosecurity risk and opportunity;
- A needs and projections analysis to support planning of plant health activities in Melbourne, the Melbourne food bowl, and for other large Port of Entry cities across Australia more broadly; and
- Initial engagement with the urban growing community and influencer organisations as well as the production or information videos that may be used for further awareness.

Project outcomes have included:

- An understanding of the research gaps and opportunities for research conducted in Australia relating to urban and peri-urban resident knowledge and attitudes towards biosecurity;
- Demonstration of how a value-based knowledge framework may be applied to community engagement activities based on insights into attitudes and beliefs for urban and rural residents; and
- The enhanced ability to formulate strategic urban engagement strategies to the benefit of hobbyist and commercial food producing communities through demonstration of an integrated social research and geospatial analysis-based planning approach.

Validation and application of the analysis conducted, and the methodology developed in this project will further inform medium and longer-term outcomes. Projected long-term outcomes include:

- More integrated, resilient grower communities and community garden networks;
- Engaged councils that are supportive of grower and community needs in agriculture;
- A more dextrous approach to engagement activities for plant heath and biosecurity outcomes in urban and peri-urban environments;
- A reduction in actual and perceived plant biosecurity risk for grower communities – especially those in urban and peri-urban areas;
- An increase in food plant health and productivity in urban and peri-urban community gardens; and
- A more connected, informed and resourced community gardens network.

At a high level, this work aimed to develop a process of identifying stakeholder engagement needs, opportunities and risks for urban and peri urban communities and environments, that may be used to guide future work in the area of plant biosecurity in Australia. The resulting social research and geospatial mapping-based framework is available for immediate use to apply to selected case studies for validation of the methodology proposed. Further activities would seek to test and refine the defined methodology in the pilot region (Melbourne), and support beta testing and replication in other jurisdictions.

Whilst the data sets compiled for the mapping activities are representative of the key attributes and actors involved in this network mapping, they are by no means exhaustive nor specific to any one context; based on sector, geography, societal or economic influencers. The methodology applied and data collected to date in this project, offers an in-principle demonstration of an approach that can be refined, contextualized and further applied. A further series of case studies is proposed to refine and better understand the application of this approach and identify the resources required to actualize the use of this framework at a local, regional and sectoral basis (section 7.1).

Information generated in the proposed case studies will provide guidance for agricultural industries and biosecurity agencies on current and future risks in their region, including high risk pathways, locations and monitoring gaps for priority pests for different plant agricultural sectors. Local council and community organisations will have access to detailed and insightful demographic data with clear direction and recommendations for development of impactful engagement strategies. Findings will also aid implementation and delivery of future legislation and engagement activities to ensure optimal community reach and effective uptake of urban-based biosecurity initiatives.

The significance of the potential for engagement through social media was highlighted through this work. Further work to determine a communication strategy will be applied in future work and highlighted in the case studies. This includes the recommendation that local councils, key influencers and organizations could examine their communication outputs, such that current community communication networks are supported and utilized, thus improving community group social capital. As discussed in sections 4.5 and 5, there exists a future opportunity to design targeted urban stakeholder engagement plans, for example for limiting Queensland Fruit Fly spread throughout Melbourne, which if undertaken would offer an opportunity to ground truth and validate both the mapping methodology and assumptions and integrate social research findings. Such a campaign would also provide a platform from which biosecurity engagement relating to other pest topics (such as exotic analogues) may be explored.

This work integrated a number of discipline areas, including social research and geospatial analysis, in a novel application framework to support development of targeted, local-level community-based engagement strategies in urban environments. Future testing and refinement of this framework will support improved urban plant health and safeguarding of peri-urban production industries.

7. Recommendations

The following recommendations are drawn from needs and projections identified during this exploratory project and are prioritised and classified into the following categories:

Validation and pilot activities

The main priority for future activities is ground truthing, validation and piloting of geospatial mapping aspects of the study. This will inform the development of a logic model for biosecurity and plant health extension program development, such that it is relevant to all sectors in the horticultural industry at a national level.

Knowledge transfer and resource development

This project also highlighted the lack of suitable resources and knowledge infrastructure, and support for urban and peri urban growers, despite the rapid increase in activity and engagement from and within these communities. This need has been identified in previous works but has not been addressed (Schembri & McGregor 2019).

Capacity building activities

Key capacity development recommendations support building social capital and collaborations between urban and commercial/regional growers and offer a way to build local and regional networks, involving key community groups, commercial growers and local and regional council. As noted previously in this report, greater social capital within communities has been shown to increase community resilience and improve rates of recovery in the face of disruptions, such as natural disasters.

7.1 Validation of methodologies and piloting (priority recommendations)

1. Undertake a qualitative assessment to evaluate the level of risk for the introduction and spread of priority exotic and emergency plant pests, in association with known urban and peri-urban pathways for potential entry, spread and detection.

2. Strategically select and conduct industry relevant case studies to further investigate how cultural, geographical and physical variables, policy overlay and availability of resources affect urban and peri-urban production (grower and community) behaviours and engagement. Within these case studies, use geographical, land use and demographic data to conduct stakeholder mapping for urban and peri-urban areas in each case

3. Using the methods outlined in this report conduct industry stakeholder analyses to determine the likelihood of contact and collaboration between stakeholders, and assessment of communication pathways for improved biosecurity engagement and extension in major Australian cities. Use of a geospatial analysis of community demographics will support this activity.

4. Develop recommendations and processes to integrate these communication strategies at local council, industry and organisational level.

7.2 Knowledge transfer and resource development

1. Conduct a review of current plant health related education and training opportunities for urban and peri-urban growers, including for addressing the contemporary context, relevance and access. Use data and information collected in this project to inform the needs, gaps and existing strengths in these communities.

2. Develop an urban agriculture focused biosecurity guide informed by stakeholder analysis and appropriate for community gardens, small scale growers and grower communities in urban and peri-urban areas and support urban agriculture research to support contextualised IPM and biosecurity management advice. This may involve the development of urban demonstration sites.

3. Identify mechanisms for distribution of resources and outreach, and the priority areas for distribution, using geo-spatial mapping methods as detailed in this report.

4. Support the development of biosecurity portfolios at local council level to provide resources and build communication networks between council and local growing communities. Prioritise council areas that are demonstrated to be in a high-risk location for production industries based on case studies conducted (7.1) and councils that have been shown to be supportive of further greening initiatives through current plans and policies (4.3.8).

5. To support improvement of professional knowledge among community engagement personnel, biosecurity institutions should refer to the review of Master's unit ENV521 – *Community engagement for biosecurity and natural resources management* by Kruger and Stenekes (2019), which has assessed current course material against the latest knowledge and best-practice in behaviour change theory and approaches on involving communities. This review highlights approaches that can be used to build social capital within communities.

7.3 Capacity building

1. Investigate the role of key 'Influencers' (sections 4.2 and 4.3.5) as a network node or catalyst and to act as a mentor and trusted advocate for interaction between governments and industry and small-scale producers or community garden groups. Develop an urban and peri-urban peer-led biosecurity champion program to mentor and build capacity for knowledge transfer between urban growing communities and rural and peri-urban commercial grower communities. Commercial grower and community involvement in champion-led programs will support cultural change and biosecurity engagement from the bottom-up.

2. Establish a professional development scheme for urban and peri-urban community gardeners and commercial growers to maintain and increase their knowledge and skill-base, especially for Emergency Plant Pest recognition, monitoring and reporting outcomes. In particular, identify key knowledge broker groups and individuals within the urban and peri-urban communities and support these knowledge brokers in sharing of information

3. Initiate national longitudinal (multi-year) social research mapping of NRM and biosecurity knowledge and awareness in key Australian cities and adjacent food bowls. Target cities undergoing high rates of growth and geographic expansion in order to aid prioritisation of engagement and capacity building initiatives.

4. Further refine and test the concept of building confidence and knowledge about home and community garden ecology in order to support improved plant health and biosecurity resilience. Focus on endemic pests, beneficials, whole garden ecology, and building monitoring and of taxonomic and symptom recognition skills among potential reporters and plant health stewards.

The recommendations in this report reflect the collective outcomes from this work and works conducted in the last two years involving commercial growers and community gardeners.

Appendices

Appendix 1. Extended list of evidence mapped studies

Authors	Publication	Title	Report type	Date
Arevalo-Vigne, M. L. I.	The University of Western Australia	Community engagement in biosecurity: Evaluating the role of knowledge and incentives in the area wide management of Mediterranean fruit fly in Western Australia.	Doctor of Philosophy thesis	2017
Aslin, H. J., Mazur, N.,	Bureau of Rural Sciences	Biosecurity awareness and peri-urban landholders: A case study approach.	Government report	2005
Choy, D. L., & Harding, J.	Land & Water Australia	Exploring Agents of Change to Peri-urban Weed Management.	Government report	2010
Collins, D	Published by the CRC for Australian Weed Management	Investigation into community awareness and attitudes about weeds as a significant problem in Australia	Government report	2008
Curnock, M., Farbotko, C., Collins, K., Robinson, C. J., & Maclean, K.	*Geographical Research*	Engaging with risk (or not): shared responsibility for biosecurity surveillance and the role of community gardens.	Peer-reviewed academic research study	2017
Hayes, L., Woodgate, R., Rast, L., Toribio, J.-A., & Hernández-Jover, M.	*Preventive Veterinary Medicine*	Understanding animal health communication networks among smallholder livestock producers in Australia using stakeholder analysis.	Peer-reviewed academic research study	2018
Fenton, M	Published by the Central West Catchment Management Authority	Central West awareness and attitudes to natural resource management (NRM) benchmarking survey	Government report	2007
Gilmour, J., Beilin, R., & Sysak, T.	*Journal of Risk Research*	Using stakeholder mapping and analysis with a mental models approach for biosecurity risk communication with peri-urban communities	Peer-reviewed academic research study	2011
Steele, S. G., & Mor, S. M.	*Australian Veterinary Journal*	Client knowledge, attitudes and practices regarding zoonoses: a metropolitan experience.	Peer-reviewed academic research study	2015
Schembri, N., Hernandez-Jover, M., Toribio, J.-A., & Holyoake, P. K.	*Australian Veterinary Journal*	Demographic and production practices of pig producers trading at saleyards in eastern Australia	Peer-reviewed academic research study	2013
Hine, D. W., McLeod, L. J., & Please, P. M.	*Human Dimensions of Wildlife*	Understanding why peri-urban residents do not report wild dog impacts: an audience segmentation approach.	Peer-reviewed academic research study	2020
Hayes, L., Britton, S., Weerasinghe, G., Woodgate, R. G., & Hernandez-Jover, M.	*Preventive Veterinary Medicine*	Insights into the knowledge, practices and training needs of veterinarians working with smallholder livestock producers in Australia	Peer-reviewed academic research study	2018
Hollier, C., Reid, M., Curran, E. et al.	Published by the Rural Industries Research and Development Corporation (Australia)	Small landholders: an assessment of potential biosecurity and land management risks	Industry report	2008
Hu, X., Feng, Y., Santhanam-Martin, M & Nettle, R.	The University of Melbourne and the Box Hill Institute	Assessment of industry and community awareness, understanding and control practices relating to Queensland fruit fly in the Yarra Valley: Implications for engagement strategies.	Research study, not peer reviewed	2018
Hernández-Jover, M., Hayes, L., Woodgate, R., Rast, L., & Toribio, J	*Frontiers in Veterinary Science*	Animal Health Management Practices Among Smallholder Livestock Producers in Australia and Their Contribution to the Surveillance System	Peer-reviewed academic research study	2019

Hernández-Jover, M., Schembri, N., Toribio, J. Holyoake, P. K., Hernandez-Jover, M., Schembri, N., … Holyoake, P. K.	*Animal*	Biosecurity risks associated with current identification practices of producers trading live pigs at livestock sales.	Peer-reviewed academic research study	2008
Hernandez-Jover, M., Gilmour, J., Schembri, N., Sysak, T., Holyoake, P. K., Beilin, R., … Toribio, J.	*Preventive Veterinary Medicine*	Use of stakeholder analysis to inform risk communication and extension strategies for improved biosecurity amongst small-scale pig producers.	Peer-reviewed academic research study	2012
Klepeis P., Gill N.	Taylor L., Hurley P. (eds) A Comparative Political Ecology of Exurbia.	The Paradox of Engagement: Land Stewardship and Invasive Weeds in Amenity Landscapes.	Book chapter	2016
Maller, C., Kancans, R., & Carr, A.	Bureau of Rural Sciences	Biosecurity and Small Landholders in peri-urban Australia.	Government report	2007
Please, P. M., Hine, D. W., Skoien, P., Phillips, K. L., & Jamieson, I.	*Human Dimensions of Wildlife*	Prioritizing community behaviors to improve wild dog management in peri-urban areas.	Peer-reviewed academic research study	2017
Schembri N, Hart K, Petersen R, Whittington R.	*Australian Veterinary Journal*	Assessment of the management practices facilitating the establishment and spread of exotic diseases of pigs in the Sydney region	Peer-reviewed academic research study	2006
Schembri, N., Hernandez-Jover, M., Toribio, J. & Holyoake, P. K.	*Preventive Veterinary Medicine*	On-farm characteristics and biosecurity protocols for small-scale swine producers in eastern Australia.	Peer-reviewed academic research study	2015

Appendix 2. Data sources for Geospatial analysis

https://www.melbourne.vic.gov.au/SiteCollectionDocuments/community-food-guide.pdf

http://directory.communitygarden.org.au/

https://localfoodconnect.org.au/

https://sharewaste.com/share-waste

https://3000acres.org/

https://directory.whittlesea.vic.gov.au/community-and-special-interest-groups/gardening-groups.aspx

http://www.portphillip.vic.gov.au/gardens.htm

https://www.gleneira.vic.gov.au/services/sustainable-living/gardening-and-nature/community-gardening

https://www.monash.vic.gov.au/Services/Environment/Living-Sustainably-in-Monash/Garden/Community-Gardens

https://www.sgaonline.org.au/

https://www.localharvest.org.au/

https://www.boroondara.vic.gov.au/waste-environment/sustainability/community-gardens-and-food-sharing

https://www.whitehorse.vic.gov.au/community-directory?keyword=community+garden&cat_id=124&suburb_select_other_list=All

https://www.frankston.vic.gov.au/Our_Community/Community_Development/Community_Gardens

https://greaterdandenong.com/document/27247/community-gardens

https://www.maroondah.vic.gov.au/Community-support-services/Community-involvement/Community-Gardens

https://mvcc.vic.gov.au/feature/community-garden/

https://www.maribyrnong.vic.gov.au/Community/Community-programs-and-grants/Community-gardens

https://www.wyndham.vic.gov.au/services/environment-sustainability/get-involved/community-gardening-wyndham

https://www.hume.vic.gov.au/Leisure_Sport_amp_Recreation/Parks_and_Reserves/Community_Gardens

https://www.kingston.vic.gov.au/Community/Sustainability-and-Workshops/Community-Gardens

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