Report Cover Page

ACERA Project
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Title
Post-border surveillance techniques: review, synthesis and deployment - subproject 2d Valuing community engagement in biosecurity surveillance
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Summary
Although there is evidence that passive surveillance services provided by the public can be very valuable (in terms of both reduced program costs and increased probability of success in managing pests) little is known about the return on investment for this type of expenditure. Enabling passive surveillance requires community information campaigns and incentive schemes. This takes funds away from other activities, so it is important to estimate the value of these campaigns relative to other alternatives, such as increasing active (structured) surveillance. This project contributes towards an understanding of the value of passive surveillance provided by members of the community using a case study: the red imported fire ant (RIFA) eradication program in Brisbane. The RIFA program, managed by Biosecurity Queensland Control Centre (BQCC), is well documented. BQCC has an intense public awareness program with multiple activities, including broad and targeted coverage of distinct community groups and zones within the Brisbane area. We have combined data on community engagement events, reports from the public and nest detections recorded by BQCC, with census data to estimate relationships between demographic characteristics of an area and the likelihood that residents from that area will report encounters with RIFA. In this report we present background information and hypotheses regarding the role of community surveillance in the management of biological invasions. This is followed by details of the datasets used and results of a number of analyses. We show the importance of the data clean-up process and identify the limitations that arise when a database designed primarily to track public reports is used for spatio-temporal analyses where accurate dating of events is important. We also estimate the return on investment in community engagement in terms of the savings in structured-search costs it brings. This estimate uses probability maps to calculate the amount of active search that would have been required to detect all the known ant colonies in the period 2006-2010 if passive surveillance would not have been available. Assuming active search costs $400/ha we obtain a value of $52 million return per $1 million invested in community engagement.

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Valuing community engagement in biosecurity surveillance

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Disclaimer

Table of contents

List of Tables

List of Figures

1. Executive Summary

The objective of this project is to contribute towards an understanding of the value of passive surveillance provided by members of the community in the management of invasive species. Passive surveillance consists of reports from the public of encounters with pests and diseases. These reports contribute to the effectiveness of active (or structured) surveillance by allowing better targeting of search efforts. Passive surveillance is activated and maintained through public awareness campaigns and incentive schemes. Although there is evidence that passive surveillance can be very valuable in terms of reduced program costs and increased probability of success in managing pests, little is known about the return on investment for these campaigns.

In this project we view passive surveillance as one component in a portfolio of possible actions that occur in response to a pest or disease incursion. The purpose of the study is to obtain a quantitative relationship between public responsiveness to biosecurity campaigns and observable features of the public (such as income, education, age and occupation). The ultimate goals are to understand the tradeoffs between active and passive surveillance and to contribute to more efficient allocation of biosecurity budgets to meet stated objectives (i.e. achieving a given probability of eradication or containment).

We use the red imported fire ant (RIFA) eradication program in Brisbane as a case study. The program, managed by Biosecurity Queensland Control Centre (BQCC), is well documented. There are nine years of spatial data on searches, treatments and detections of RIFA, and it is known whether detections resulted from active or passive surveillance. In addition, BQCC has an intense public awareness program with multiple activities, including broad and targeted coverage of distinct community groups and zones within the Brisbane area. The main source of data for this study is the Client Contact System (CCS). The CCS goes back to 2002 and contains details of all contacts by the public as well as community events, training activities, media releases etc. We also use point data on passive and active ant-colony detections for the period 2001-2011.

After error-checking and clean-up, the BQCC data were combined with 2006 ABS Census data to test whether demographic features of an area affect the propensity of residents in the area to engage in community surveillance. We found significant differences between census districts that submitted suspect ant samples and those that did not submit any samples in terms of mean values of several demographic variables. But the explanatory power of these relationships is weak and not useful for decision analysis.

Through time-series analyses we quantify the influence of a reward scheme that was in place between April and June 2008. The scheme resulted in a noticeable increase in the number of

public reports and this effect lasted for several months, reducing gradually over time. This increase in client contacts was not accompanied by a reduction in the proportion of positive samples, which is a good sign.

We present several local case studies of small areas of the map that provide insights into the nature of biological invasions and their management in urban and peri-urban areas. The richness of the datasets allows us to explore the influence of historical settlement patterns in the spread and detection of fire ants in Brisbane. The case study also shows the difficulty of assessing the relationship between the already complex pattern of spread, and the socio-demographics aggregated to census district level.

We were able to calculate a distance threshold of around 4.2 km at which recent public engagement events lose their effect on public awareness. Furthermore, the effect of events depreciates over time, so that the estimated radius of influence of all previous events (1 km) is smaller than the influence of more recent events.

We conclude the analysis by estimating the return on investment in community engagement based on the data available complemented by simulation. We obtained an estimate of $52 million return per $1 million invested, measured as the savings in active surveillance caused by the presence of passive surveillance. To come up with this figure we generated a probability map and calculated the amount of active search that would have been required to detect all the known ant colonies in the period 2006-2010 if passive surveillance had not been available. Combining this information with an active search cost of $400/ha results in an annual return of $52 million. Assuming an annual budget of $860,000 or so based on recent figures, results in a return on investment of $60 per dollar invested in community engagement.

The report concludes with a summary of findings and a series of recommendations in Section 8.

2. Introduction

The public can play an important role in invasive species management when they report their encounters with pests and diseases to authorities (MAFBNZ 2008; Beale et al. 2008). This type of general surveillance is also known as community or passive surveillance and is activated and maintained through public awareness campaigns. Public awareness activities might include information sessions at local shows, advertising at bus stops and on billboards, public meetings and media reports. These campaigns are now a common feature of eradication programmes, such as those to eradicate red important fire ants, electric ants, Siam weed and four tropical weeds in Queensland, and European house borer in Western Australia. A number of studies demonstrate the benefits of this engagement with the public, both in terms of detecting new exotic diseases but also in terms of finding new loci or hot spots of incursion outside known infestations where there wouldn't otherwise have been any active surveillance. For example, Brooks and Galway (2008) reported that 26% of new finds of four species of tropical weeds currently under eradication came from public information, Froud et al. (2008) reported that 41% of the reports from the public in New Zealand about suspect organisms associated with recently imported products led to the discovery of new exotics, and the public are responsible for finding 90% of new infestations of the European wasp in Western Australia (Davis and Wilson 1991). Engaging with the community through more formal networks of like-minded individuals have also proven to be fruitful, for example between July 2010 and June 2011 the Queensland Weed Spotters Network were responsible for detecting 12 weed species previously not known to be naturalised in that state (Biosecurity Queensland 2012).

While public awareness campaigns have become an integral part of invasion management programs, little is known about the 'return on investment' in passive surveillance. Recent studies based on spatial models have quantified the value of passive surveillance in terms of costs saved and enhanced probability of eradication (Cacho et al. 2010; Spring et al. 2010; Cacho and Hester 2011; Hester and Cacho 2012), but little is known about the size and types of investment required to achieve the desired level of passive detection. The main problem is that passive surveillance can be controlled only indirectly through community engagement and hence is difficult to measure the link between investment and outcomes.

Our ultimate goals are to understand the tradeoffs between active and passive surveillance and to contribute to efficient allocation of a budget between these two activities to meet stated objectives (i.e. achieving a given probability of eradication or containment). This project addresses an important gap in knowledge required to achieve these goals. The place of this project is shown in the lower portion of Figure 1 within the overall decision problem.

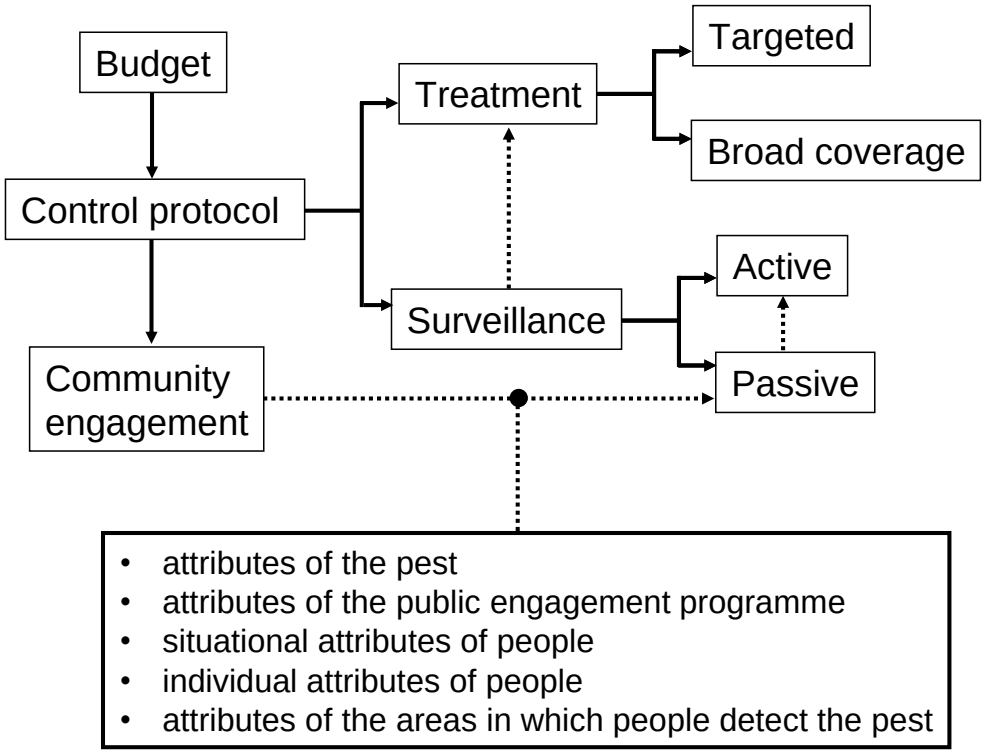


Figure 1. Diagramatic representation of the budget allocation problem.

The decision problem of interest in this study (Figure 1) hinges on the available budget. The budget constrains the options available to design and implement a control protocol. The protocol is defined as the proportion of the budget allocated to each of three general activities: *treatment*, *surveillance* and *community engagement*. In many cases surveillance and treatment happen together, such as the case of a weed control team searching an area for weeds and spraying those that are found. But there are also other treatment methods that allow broad coverage, such as dropping baits from the air. In these cases we do not need to know the exact location of pests, a general idea of their location is all we need to plan bait releases. Surveillance can be expensive, but it is required for targeted treatment; whereas broad-scale treatment is relatively cheap, but not as effective, and provides no information on the exact location of the pest. Surveillance allows us to learn more about the pest and its spread, which broad-scale treatment cannot do. So surveillance is also an investment in learning that can improve future treatment of the invasion. Related to this, the control protocol may also include a research budget to help improve future decisions through investments such as producing habitat suitability maps. We do not consider this problem, but see Baxter and Possingham (2011).

The optimal allocation between surveillance and treatment will depend on their relative effectiveness and cost. The effectiveness of active surveillance can be measured and related to search effort applied per hectare (Cacho et al. 2006; Moore et al. 2011) and the

effectiveness of treatment can be measured by conducting bait release trials. Measuring the effectiveness and cost of passive surveillance, however, is not easy. The problem is that we cannot control passive surveillance directly as we can with active surveillance. We need to convince the public to keep an eye out for the pest, and to report what they find. To activate passive surveillance we use community engagement programs; which, as discussed earlier, are an integral part of any control program. Community engagement involves the maintenance of a hotline to make it easy to report a pest, information and education campaigns, and other activities. These activities raise community awareness temporarily and have limited spatial influence. This means that the frequency and location of community engagement events will influence the effectiveness of passive surveillance (i.e. the passive detection probability). This is not an easy relationship to measure and the project focused on this problem.

The literature on biosecurity community engagement and pro-environmental behaviour[1] suggests that the response of the public to these activities is likely to depend on a range of factors that can be divided into five groups.

- Attributes of the pest, such as its potential to cause physical harm or financial costs for the individual, and the immediacy or otherwise of these impacts.
- Attributes of the public communication programme, such as message content, media channels, and the reputation of the organisation initiating the programme (e.g. see Kruger et al 2010).
- Situational attributes of people, such as their household tenure (rented, freehold owner, strata title owner), size and type of backyards, and the presence or absence of children and pets in the household.
- Individual attributes of people, such as their age, knowledge, self-efficacy, existing habits, level of belief in egoistic, altruistic, materialistic and biospheric values, the size and nature of social networks of which they are part, and the types of organisations to which they belong.
- Attributes of the areas in which people live, such as the amount of public space, type of public space (e.g. playing fields, parkland, bush) and levels of public access permitted.

Invasive species management has similarities with other public policy initiatives, such as natural disaster preparedness and public health programs. In these initiatives there are

[1] See, for example, Kruger et al 2010, Stern 2000, DEFRA 2008

specific behaviours being promoted, such as reporting the occurrence of a pest animal, or weed, or reporting a disease outbreak, or reporting neighbourhood crime to police, or wearing a face mask during a influenza epidemic, or securing loose objects in backyards as a cyclone approaches. These behaviours generally require some effort on the part of the individual, and may or not may not have individual benefits. However, the behaviours all have a substantial public benefit, such as the control of pest or weed outbreaks, the arrest of criminals and prevention of further crime, the reduction in influenza infections, or the reduction of injuries from flying debris in cyclones.

There is a considerable body of evidence to support the view that the propensity of members of the public to undertake these behaviours is influenced by demographic factors such as age, socio-economic status and ethnicity. Studies that have demonstrated the influence of demographic factors have been in areas that include weed management (McCluggage, 2004), influenza communication campaigns (Gray et al., 2012; Bish and Michie, 2010; Eastwood et al., 2009), law enforcement (Huq et al., 2011), and natural hazard preparedness (Paton et al., 2006).

However, it is also possible that demographic factors may have less influence on the public's propensity to undertake the required behaviour, than other variables such as perceptions of risk (Dore, 2000).

Questions of interest regarding passive surveillance include:

- What is the likelihood that members of the community will detect a new or emerging pest or disease?
- How reliable are the reports submitted by particular members of the community?
- To what extent do monetary rewards and public awareness campaigns influence the likelihood that an invasive species will be reported?
- How should resources be allocated between passive surveillance and surveillance undertaken by pest management agencies?
- What is the return on investment in passive surveillance?

In this project we provide quantitative answers to some of these questions and explore the levels of public passive surveillance for a case study. Given the limited time and data available not all these questions could be addressed in the project. The specific aims of the project were:

1. To determine the value of passive surveillance as a component in a control protocol.

2. To estimate a quantitative relationship between public reports and demographic factors of households as reported in Census data.
3. To explore relationships between community engagement events and public reports of suspected pest presence.

We use the red imported fire ant (*Solenopsis invicta*) eradication program in Brisbane as the case study. The program, managed by Biosecurity Queensland Control Centre (BQCC), is well documented. There are nine years of spatial data on searches, treatments and detections of red imported fire ant (RIFA), and it is known whether detections resulted from active or passive surveillance. In addition, BQCC has an intense public awareness program with multiple activities, including broad and targeted coverage of distinct community groups and zones within the Brisbane area. The main source of data for this study is the Client Contact System (CCS). The CCS goes back to 2002 and contains details of all contacts by the public as well as community events, training activities, media releases etc. We also use point data on passive and active ant-colony detections for the period 2001-2011.

A cost function relating dollars invested in community engagement to passive surveillance effectiveness could no be derived with the data available. As an alternative we use the data, combined with simulation, to obtain a rough estimate of the return on investment in community engagement.

This report presents an overview of the methodology used (Chapter 3) followed by description of the datasets available (Chapter 4). Several types of spatial and temporal analysis are then presented to address the objectives of the project (Chapter 5). This is complemented with a series of local case studies that provide useful insights (Chapter 6). The value of community engagement is then calculated based on the datasets complemented by modelling (Chapter 7). The report concludes with a series of recommendations (Chapter 8) which are summarised below.

1. When designing or updating contact databases of public reports care should be taken to prevent the work cycles that affect data entry patterns from introducing errors in dating of actual contact events.
2. Accurate geographical coordinates should be obtained for all contacts when possible.
3. Additional analysis of negative samples is required to make better use of the data to calculate confidence levels of pest absence for particular sites.
4. The interrelationship between spatial and temporal correlations needs to be disentangled to understand the interplay of community engagement events leading to new detections which in turn lead to more events in the area.

5. Future studies on RIFA management should consider the urban ecology of Brisbane (better land use maps, property values, bare soil assessment, etc) to help explain some of the spread and detection patterns found.
6. The habitat suitability map should be updated at regular intervals taking account of patterns of land disturbance.
7. BQCC may wish to consider interviewing people who have reported nests to determine how the colony was found and their motivation for reporting. This would help fine tune the mix of community engagement and active surveillance required in different areas depending on demographic features.

A desirable long term goal for this type of work would be to develop standard protocols for designing and using databases to manage invasive species by allocating passive and active surveillance more effectively in space and time. The environment invaded and the type of invader will affect this allocation. This means that similar case studies with other pests would be useful to gain a more general understanding of how program design features may be affected by the type of pest and the environment invaded.

3. Methodological Overview

The study is based on viewing the public as a heterogeneous population of agents that provide surveillance services when they receive the right combination of information and incentives. The analysis is based on the red imported fire ant (RIFA) invasion in Brisbane using the datasets detailed in the following chapter.

RIFA is one of the world's 100 worst invaders (Lowe et al. 2000), causing substantial adverse impacts to human health and ecosystems (Lofgren et al. 1975) and requiring expensive control programs. The RIFA eradication programme, managed by Biosecurity Queensland Control Centre (BQCC), is well documented (Jennings, 2004).

Data support for the management of BQCC programs comes from three large databases, the Client Contact System (CCS), a detections database and a public communication database. These provide nine years of spatially referenced data on searches, treatments, detections, public responses and communication events for the RIFA eradication program.

An important source of data for this study is the CCS. The CCS goes back to 2002 and contains details of all contacts by the public, including the submission of samples of ants. The database contains the geographical location of the person reporting and of the reported nest (not necessarily the same), it also contains follow-up information so it is possible to distinguish positive from negative samples.

An additional extensive source of secondary data available to the project was the various data products from the Australian Bureau of Statistics Population Census for 2006. This provides a wide range of demographic information at the level of Census Collector District (CCD), a spatial unit containing approximately 200 households.

The availability of the above data sources to the project, and the existing evidence from the literature of effect of the demographic factors on community response to public programs similar to the RIFA eradication program, suggested that it would be possible to quantify the influence of these factors, without recourse to the considerably more expensive approach of community surveys.

It was already known from BQCC's own surveys that the levels of community awareness were extremely high. In addition, the majority of samples submitted by the public were for ants other than fire ants. In other words, right across the study area there were very high levels of awareness, coupled with an abundant supply of ants, most of which were not fire ants. Accordingly, it could reasonably be expected that any demographic influences on community responses would be detected at the CCD level, given that the influence of two

potentially important factors, awareness and the presence of ants was essentially uniform in these areas.

These considerations set the initial choice of methodology for the project. As the project proceeded and as the depth of the complexities in the evolution of the eradication program and community response became apparent, a number of adjustments to the methodology were made when it was discovered that the BQCC data was much more suited to program administration than to the research objectives of the project.

The subsequent chapters of this report document the findings from the analysis first chosen and the ensuing analyses that were carried out as the methodology was adjusted in the light of significant findings.

Chapter 4 describes the three BQCC data sets used in the project, as well as some of the findings from the preliminary investigation of the suitability of the CCS to provide measures of community response.

Chapter 5 presents different types of data analysis, starting with an examination of spatial autocorrelation of colony locations and clustering (section 5.1). This is followed by a detailed description of the data in time series form (section 5.2) and an analysis of the proportion of positive and negative samples (section 5.3). Spatial and non-spatial analyses of the influence of community events on community response are presented next (section 5.4) followed by an examination of a specific community program, the Reward Scheme of 2008 (section 5.5), a comparison of urban and rural detections (section 5.6) and an analysis of the habitat suitability map (section 5.7). Finally, section 5.8 describes the findings from a non-spatial analysis of the relationship between the submission of samples by the public and demographic characteristics, with Census Collector Districts as the unit of analysis. While the expected relationships were not found, the analysis provided a preliminary understanding of the potential complexities in these relationships.

As the range of complexities in the relationships among such things as public response, demography, program events, settlement history, and program operations became apparent, a number of small areas were examined over time to further elucidate and illustrate these relationships. These are described in the local case studies in Chapter 6.

While the project uncovered a wide range of hitherto unsuspected factors that are likely to influence the returns to passive surveillance in different areas, so that it was not possible to quantitatively relate demographic characteristics of areas to these returns, it was nonetheless possible to determine a figure for the returns to passive surveillance for the study region as a whole. This aspect of the project is described in Chapter 7.

In this study, the CCS data provided by BQCC have been organised spatially based on census collector districts and made compatible with the Australian Bureau of Statistics (ABS) Census data for 2006. These data were analysed statistically in a number of stages.

1. Data compilation and aggregation to Census Collector District level (CCD is the ABS basic spatial unit which contains approximately 200 households).
2. Data visualisation and exploratory analysis, where maps of total reports and positive reports were produced, together with maps of demographic attributes from ABS Census data.
3. Spatial trends and autocorrelation were examined. Since contact, event and detection data span a nine-year time period, and Census data are for a point in time, examination of time trends in data were undertaken to identify optimum time periods for analysis.
4. Other statistical techniques were applied to answer specific questions.
5. The effectiveness of passive surveillance was measured in terms of positive predictive value (PPV), the proportion of the total number of reports that are actually positive (Froud et al 2008).
6. The return on investment in community engagement was calculated based on savings in active search to achieve a given level of coverage.

We expect that heterogeneity of the public would cause the investment in passive surveillance to exhibit diminishing returns. This is because inexpensive information campaigns can attract a small proportion of the public (those that are community-minded) but more intense campaigns or additional incentives will be required to capture the attention of a larger portion of the population. As the investment in these activities continues to increase eventually only people that will never respond will remain to be reached. At that point the marginal value of (additional) community engagement is zero. Although this is intuitively obvious, we were unable to provide a quantitative estimate of this saturation point with the data available.

Additional analyses were undertaken on subsets of data in particular areas as small case studies to illustrate specific points for particular types of locations and learn something about how settlement patterns interact with the progress of an urban invasion.

The project was initiated through a visit to BQCC by the research team on 19/11/2010. This provided us with an overview of the data available and provided BQCC with a concrete idea of the project objectives. A data sharing agreement was signed in late April 2011. Additional

details on the data sharing process are presented in a Milestone Progress Report dated 30 June 2011.

The CCS is a complex database that has evolved with the needs of the RIFA control program. The emphasis has been on designing a practical system for entry and retrieval of information on a case by case basis, rather than on the ease of undertaking statistical analysis. Therefore some compromises were necessary. The complexity of the datasets is illustrated throughout this report.

4. Overview of data

The area of interest is within the greater Brisbane region (Figure 2). This study area was chosen to align with the extent of the most current fire ant habitat model. The majority of fire ant colonies have been found in areas that were classified as intensive use (developed) and in natural agricultural areas (grazing and timber harvesting) in 1999 (Figure 3).

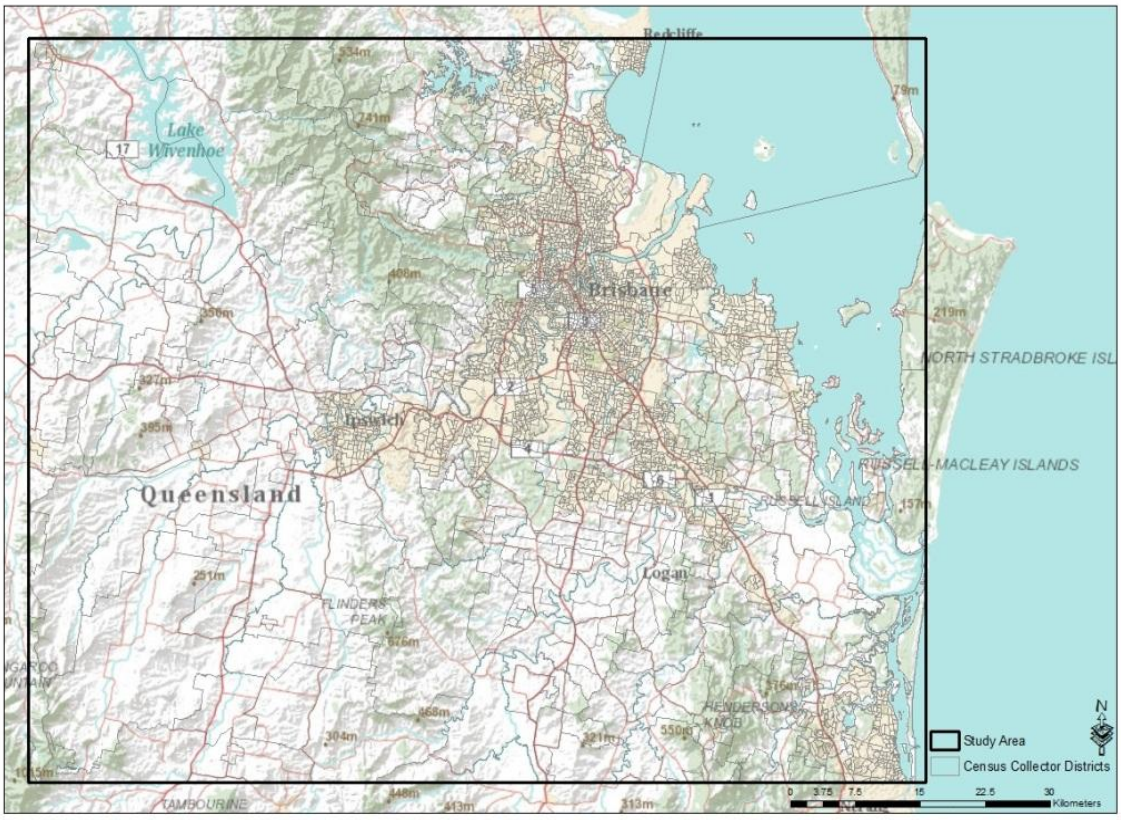


Figure 2. Map of the greater Brisbane region and the study area used in this analysis. Census indicators were modelled at the collector district level, shown in light grey This study area was chosen to align with the extent of the most current fire ant habitat model.

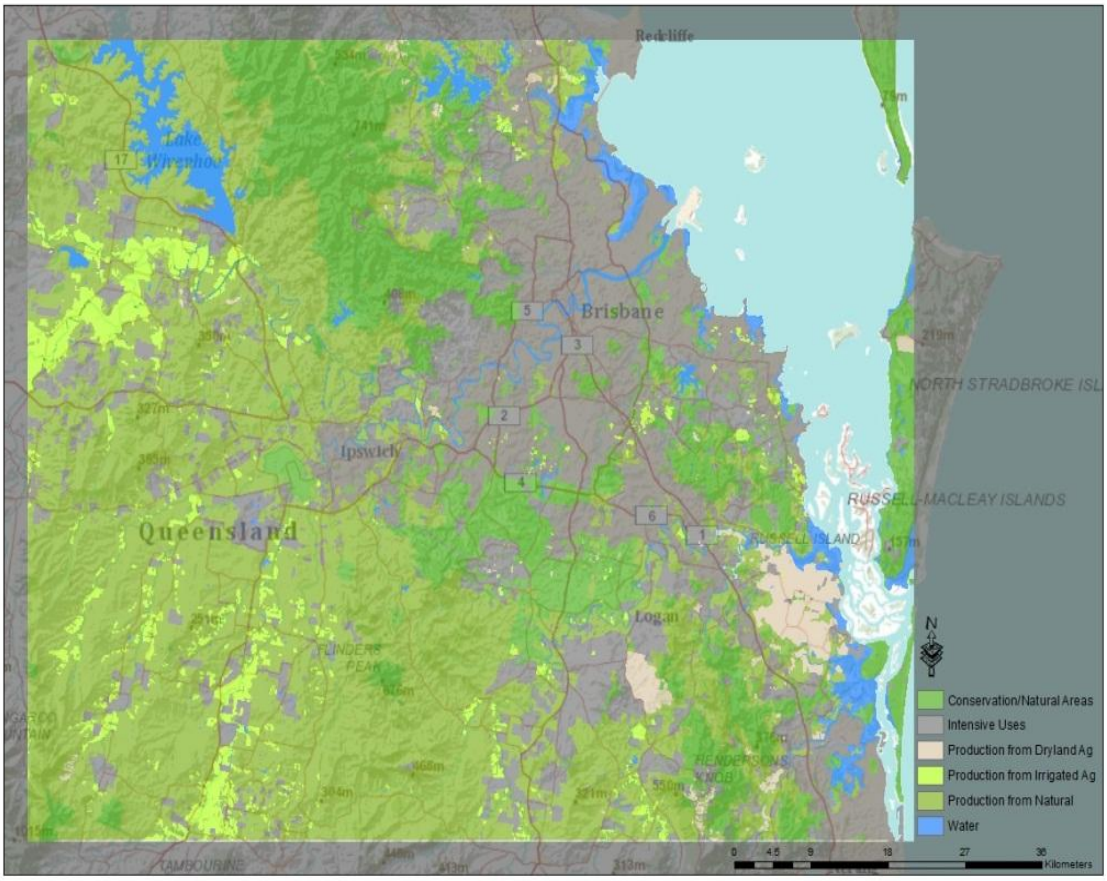


Figure 3. Land use for the study area prior to fire ant invasion (1999). The majority of fire ant colonies have been found in intensive use (developed) areas and in natural agricultural areas (grazing and timber harvesting).

Several datasets were provided by BQCC, each of them is described in some detail in the following sections. Other data provided by BQCC included annual expenditures in community engagement.

4.1 Client Contact System (CCS) Dataset

The CCS dataset includes several types of entries identified by date and location, these include:

- telephone requests for a kit for sampling ants for identification;
- the completion by the client of a survey over the telephone (used by BQCC to prioritise their response);
- telephone requests for the sample to be collected;
- receipt by BQCC of the sample; and

- the identification result, positive or negative for RIFA.

Not all entries had exact geographical coordinates and the inexact ones were excluded from spatial analyses (see Appendix A). Summaries of the full dataset, the reduced dataset and a subset consisting of the years 2006-2010 that were used in some analyses are presented in Table 1. The 2006-2010 subset contains about 59% of the total observations in the reduced dataset. This subset was considered more reliable than the full dataset for reasons explained below.

Table 1. Summary of data contained in the Client Contact System (CCS) and the subset used for further analysis (2006-2010), which represents about 59% of the number of observations in the reduced dataset (92/156)

Contact type		Total	Reduced	Subset 2006-2010	%
1	Data Entry	42,817	31,947	31,947	34.8
2	Kit Request	39,314	28,326	10,438	11.4
3	Kit Sent	22,795	17,753	0	0.0
4	Sample Collection Request	12,286	9,213	9,099	9.9
5	Sample Received	68,559	53,138	24,585	26.8
6	Survey Taken	23,134	15,739	15,739	17.1
	Total	208,905	156,116	91,808	100

Details of the reduced dataset are shown in Table 2. There is a clear break in 2006, when the CCS was created. The period 2001-2005 in the CCS was populated from existing disparate databases. The table shows that type 3 (Kit sent) contacts were discontinued and that surveys (type 6) were initiated. This reflects the change of practice that occurred in the RIFA program in 2006, where survey results determine whether a crew is sent to check the site or a sample kit is sent by mail. Some of the analyses below are based on the full reduced dataset and others are based on the subset of type 5 (Sample Received) in Table 2, as those entries are associated with a positive or negative result.

Table 2. Summary of the reduced CCS dataset with contacts aggregated per year, refer to Table 1 for contact types

	Contact type						
Year	1	2	3	4	5	6	Total
2001	0	5,085	5,085	0	9,254	0	19,424
2002	0	3,115	3,115	0	10,350	0	16,580
2003	0	3,154	3,154	0	4,029	0	10,337
2004	0	2,690	2,690	0	1,784	0	7,164
2005	0	3,844	3,709	114	3,136	0	10,803
2006	5,085	850	0	2,819	12,980	1,982	23,716
2007	7,505	1,996	0	1,447	2,144	2,232	15,324
2008	8,728	3,879	0	1,889	4,019	5,323	23,838
2009	4,853	1,865	0	1,062	2,270	2,711	12,761
2010	5,776	1,848	0	1,882	3,172	3,491	16,169
Total	31,947	28,326	17,753	9,213	53,138	15,739	156,116

Preliminary analysis indicated that the CCS contained sites with multiple contacts (see Appendix A). These include areas such as market gardens and construction sites. The fact that the presence of ants is known in these sites, and that new nests are reported regularly, means that detections in these ‘case-managed sites’ cannot be considered passive. Therefore these contacts must be excluded from the analyses of passive surveillance. As a listing of these sites was not available from BQCC, it was assumed for the purposes of the analysis that case-managed sites in the CCS data were indicated by client ID numbers that had five or more contacts. A summary of these case-managed sites is presented in Table 3.

Table 3. Summary of these case-managed sites (sites with more than 5 entries) which need to be excluded from some analyses where they may confound the effect of passive surveillance

	Contact type						
Year	1	2	3	4	5	6	Total
2001	0	15	15	0	5	0	35
2002	0	13	13	0	4	0	30
2003	0	10	10	0	9	0	29
2004	0	15	15	0	6	0	36
2005	0	21	21	0	12	0	54
2006	37	18	0	66	129	59	309
2007	72	94	0	91	138	108	503
2008	149	126	0	147	259	216	897
2009	66	50	0	80	162	108	466
2010	134	73	0	190	405	217	1,019
Total	458	435	74	574	1,129	708	3,378

The spatial distribution of contacts shows broad coverage in the City of Brisbane and to the north and south (Figure 4). Coverage to the west, in peri-urban and rural areas is relatively

sparse and shows a vulnerable area into which the invasion could escape. This vulnerable area is being targeted through remote sensing in ongoing tests of new detection equipment (C. Jennings pers. comm.). The subset of type 5 contacts exhibited the same general spatial pattern as the whole dataset. This subset was used to analyse positive returns.

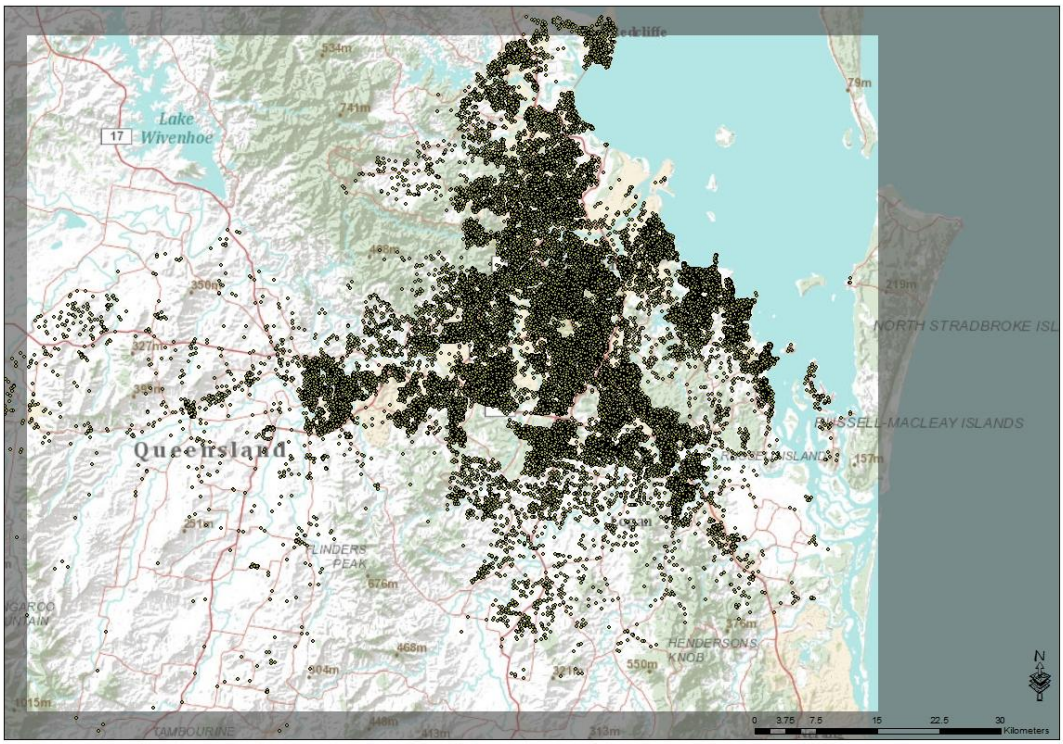


Figure 4. Spatial location of all client contact data from 2001-2011 for the greater Brisbane area.

4.2 Detection dataset

The detection dataset contained 12,081 observations with geographical coordinates and

Table 4. Summary of detection data

Yr	Passive	Follow-up	Structured	Total
2001	110	17	1540	1,667
2002	69	187	492	748
2003	34	150	363	547
2004	6	11	45	62
2005	72	20	101	193
2006	131	58	102	291
2007	36	9	701	746
2008	258	143	140	541
2009	183	171	175	529
2010	471	566	5376	6,413
Total	1,370	1,332	9,035	11,737
Percent	11.7	11.3	77.0	100.0

detection dates and distinguishing between passive, structured and follow-up detections. In the text below, ‘active’ detections refers to the combined number of structured and follow-up detections found by pest-management authorities. Note that not every single nest is included in this dataset, when infestations are very dense only a few nests may be pinned with GPS. BQCC believes it is more appropriate to use properties infested rather than nests as a measure, but the property maps were not available within the time required in this project. In the analyses below we use both the original point data and raster data expressed as number of nests per km^2. The detection data per year are shown in Table 4. The total number of observations in this table is 11,737 and not the full 12,081 because 2011 detections were excluded as the series was not complete.

Passive detections accounted for 11.7% of the total known colonies with considerable variation between years. Annually, the proportion of fire ant colony detections reported by the public ranged from 5% to 48%.The spatial distribution of colony detections is presented in Figure 5.

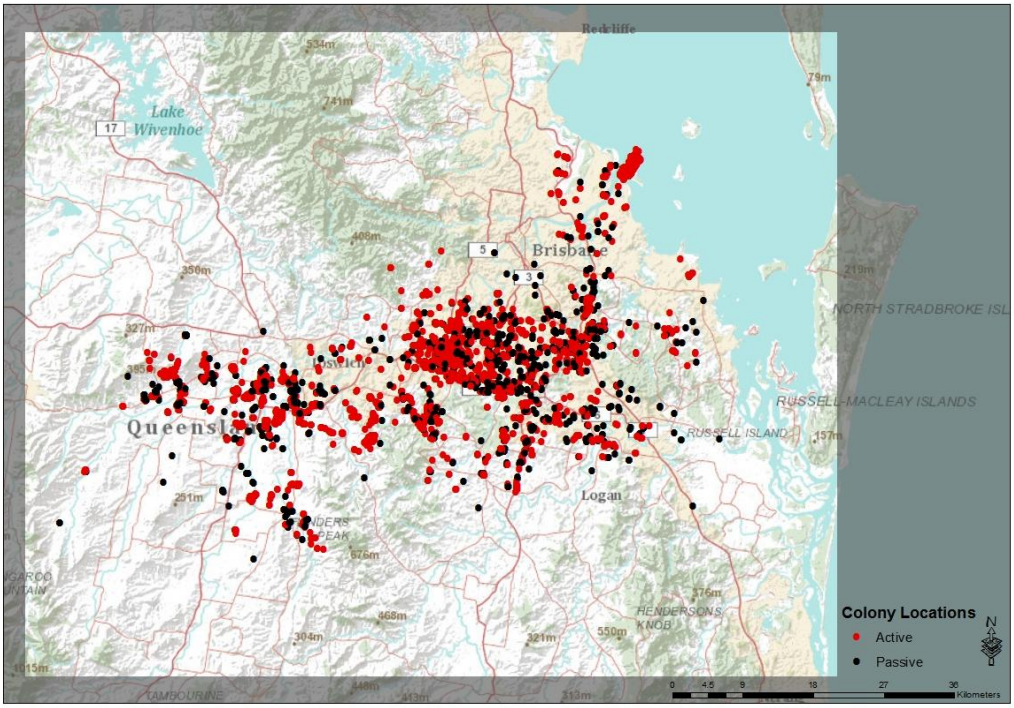


Figure 5. Known fire ant colony locations within the study area. Passive colonies account for 11.7% of the total known colonies. Active detections include structured and follow-up surveillance. Annually, the proportion of fire ant colonies detected by the public ranged from 5% to 48%.

4.3 Event dataset

The event dataset contained 1,818 records after deleting events that had no accurate location data. The following types of events were contained in the dataset, identified by date and location:

1. Training
2. Talks
3. Education
4. Static Display
5. Interactive Display
6. Display Sent
7. Shopping Centre Display
8. Public Meetings
9. FACWG Meeting
10. Community Meetings[2]

The break down per event is presented in Table 5. The majority of events were of type 1 (Training) and 2 (Talks) followed closely by type 5 events (Interactive Display). The total number of events has varied through time, with lower numbers on average in recent years as saturation has occurred and the community engagement budget has decreased.

Table 5. Summary of event data. The different types of events are listed in the text.

	Event type										
Yr	1	2	3	4	5	6	7	8	9	10	Total
2001	82	33	6	2	26	5	14	0	0	0	168
2002	103	204	36	11	68	0	13	16	5	0	456
2003	56	116	48	3	91	0	14	4	3	0	335
2004	47	38	27	0	36	0	0	1	0	0	149
2005	53	32	15	12	50	2	2	1	6	0	173
2006	38	18	15	5	59	0	1	9	2	0	147
2007	32	9	4	1	34	0	0	0	0	0	80
2008	32	6	5	0	32	0	5	0	1	0	81
2009	43	21	10	0	38	2	10	1	0	2	127
2010	32	26	4	3	36	0	1	0	0	0	102
Total	518	503	170	37	470	9	60	32	17	2	1,818

[2] Public meetings are open to the public in general whereas community meetings involve specific community groups.

Figure 6 shows the combined data on contacts, events and passive detections. The spatial coverage of events seems to be related to the spatial coverage of passive detections. But the relationship is complex as events may lead to passive detections, but passive detections in an area may also lead to events being held in that area to increase awareness of the presence of an infestation in the neighbourhood.

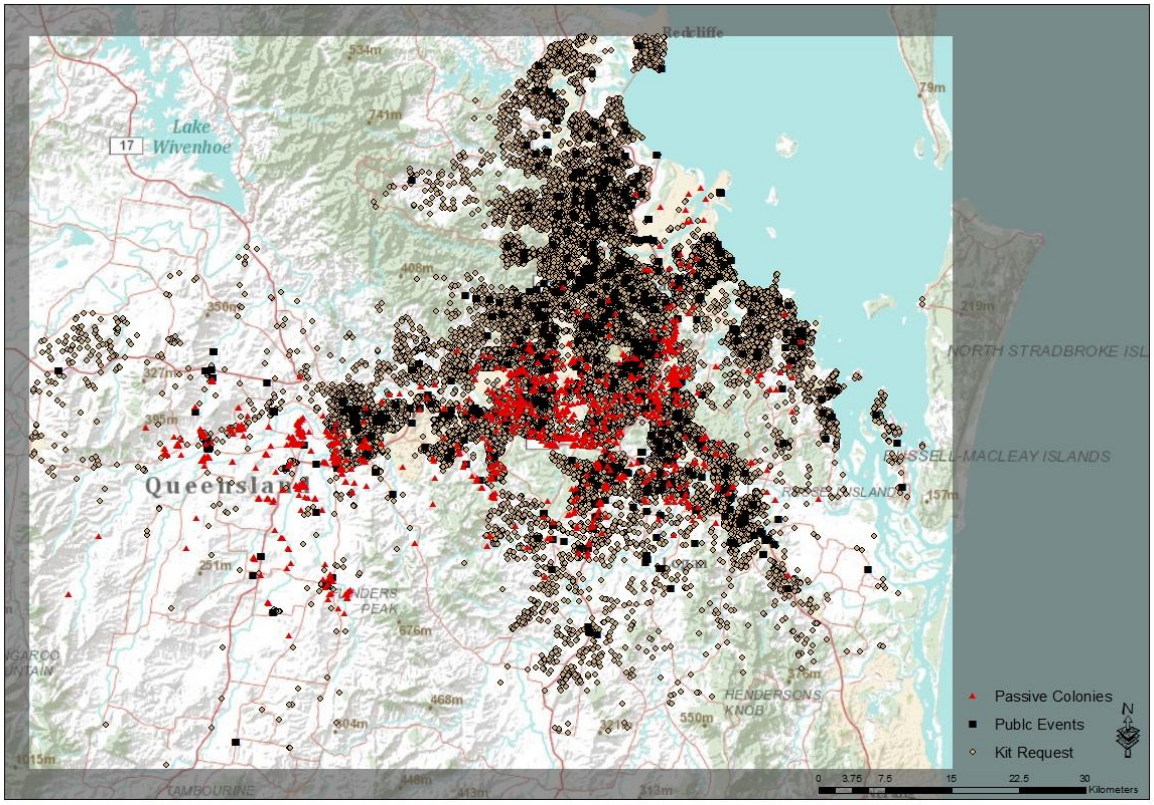


Figure 6. Map showing distribution of kit requests, public events and passive colony detections

4.4 Census data

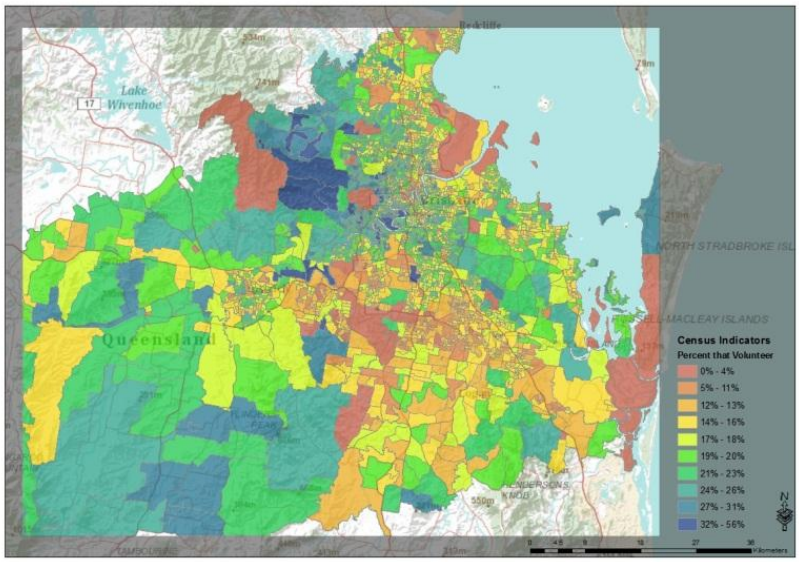
The census data consisted of 2,940 records, each representing a census collector district (CCD). Each CCD contains approximately 200 households (Figure 7).

The demographic variables described in Table 6 were included in the analysis, all expressed as percentage of households in the district reporting a particular feature, except for population density which is in number of people per km^2.

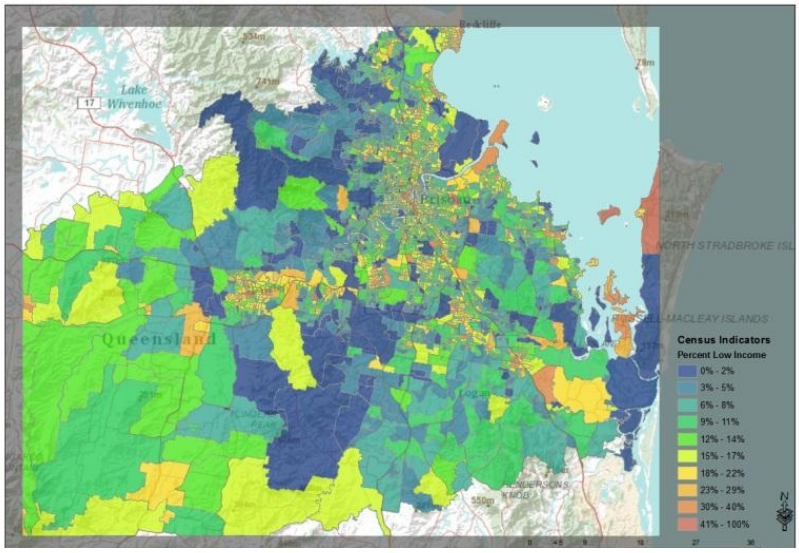
These demographic variables have been used in a number of studies for social profiles and as indicators of the levels of human and social capital in the context of community adaptive capacity (see, for example, Fenton, 1998; Reeve et al., 2010, Vinson, 1999; Stenekes et al.,

2010). While the constraints of the question content of the ABS Population Census prevent the compilation of a set of indicators that might be more directly related to community propensity to take note of public awareness campaigns, recognise fire ants and submit samples, it is reasonable to expect that general levels of human and social capital might have some relationship with this propensity. For example, people who are socially marginalised with low levels of education may be less likely to be reached by community awareness programs and have neither the interest nor resources to participate in the

(A)



(B)



(C)

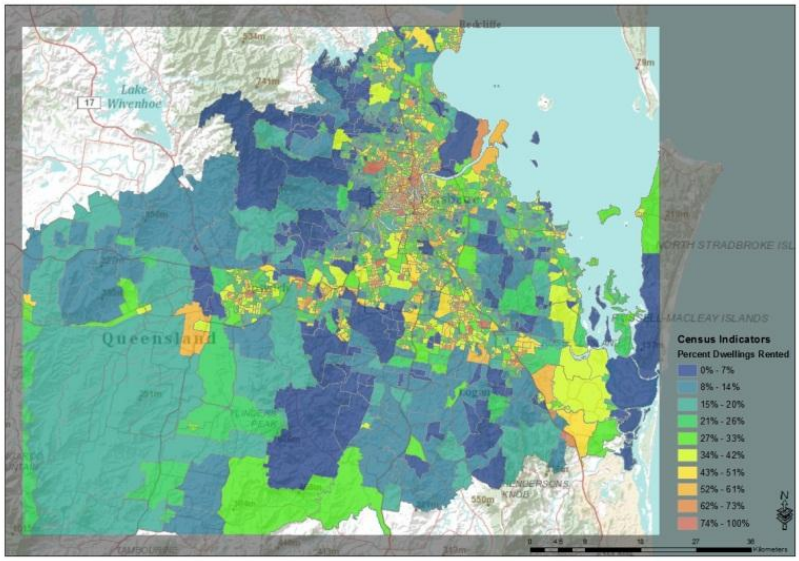


Figure 7. Examples of some of the census indicators used in this analysis (A) percentage of people, per collector district, that reported volunteering. (B) percentage of homes that are classified as low income families. (C) percentage of dwellings, by collector district, that are rented

community effort to locate and identify fire ant colonies.

Table 6. Description of ABS data items use to construct the demographic variables used in the analysis.

Indicator	ABS data used
Population density	Total number of persons / CCD area
% 65 and over	Total persons aged 65 and over / total persons
% one parent	Total single parent families/total families
% language spoken at home not English	Total other language spoken at home / total persons
% Over 15 no qualifications	% Of persons 15+ with no qualifications: certificate, diploma, undergraduate degree, postgraduate degree
% Graduates	Total bachelor degree + total graduate diploma/certificate + total postgraduate degree / total persons 15+
% Household weekly income less than $349	% Of houses with income between $0 and $349 per week – 2006 readjustment of Water 2010 indicator 'Low income households'
%Dwellings rented	Rented properties / total dwelling structures
% new residents (<= 1 year residing in SLA)	Persons living overseas or in different CCD one year ago / total persons > 1 year old
Total unemployment (%)	Total unemployed / total labour force
% Women in non-routine occupations	Female managers + female professionals + female technicians + female community & personal / total female employed persons
% Voluntary work	Total volunteers / total persons 15+

4.5 Habitat suitability

A habitat suitability map in raster format was provided by BQCC that ranked sites between 1 (low suitability) and 10 (high suitability) for RIFA establishment (Figure 8). This map was used in some of the analyses as an explanatory variable.

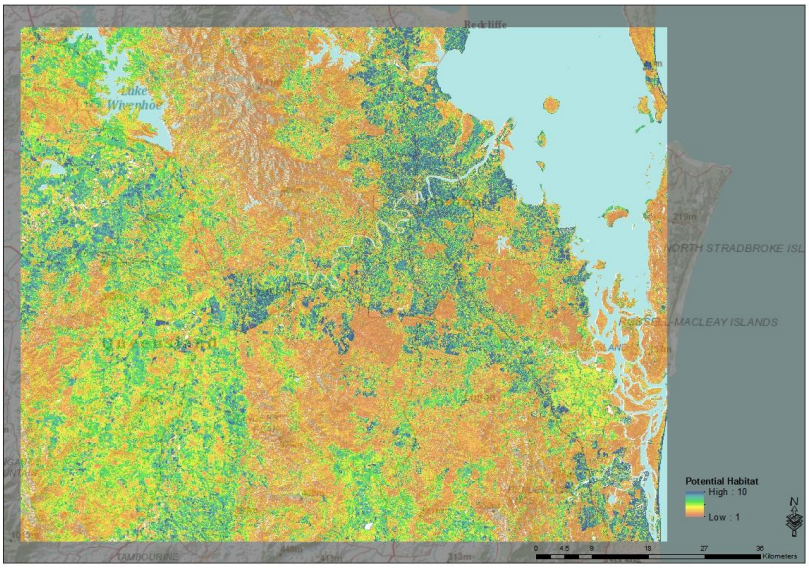


Figure 8. Potential fire ant habitat model used in this analysis (BQCC)

The habitat suitability map (George, 2004 unpublished) was based on a “combination of a transformed normalised vegetation index (TNDVI) and a tasselled capped vegetation water index (TCWI) as measured from data acquired from the Landsat 7 ETM+ platform. 4”. According to the author, testing of the model indicated that it was 6.5 times more likely to find colonies of *S. invicta* than random samples. Although the success rate per unit area decreased as the area targeted increased, success rates were higher than expected from randomised sampling. The model identified 98.9% of all known colonies when fitted to the positive sample data set. The habitat suitability map is currently being updated by BQCC to account for significant land use changes that have occurred in Brisbane in the last decade. However the new map was not available at the time of the study.

5. Data analysis

The process of data clean-up and exploratory analysis involved the following steps:

1. Data compilation and aggregation to Census Collector District level.
2. Data visualisation and exploratory analysis.
3. Spatial trends and autocorrelation analysis.
4. Statistical techniques for further stages of analysis.
5. Measuring the effectiveness of passive surveillance.
6. Measuring the return on investment in passive surveillance.

More details on data compilation and exploratory analysis are presented in Appendix A.

The spatial patterns of sample kits returned, community engagement events and passive detections through time show an interesting evolution (Figure 9). Initially the program was dominated by community events, and passive detections were concentrated in the central area of the map (2002). Over time sample kit returns became dominant over events and passive detections spread towards the south and west. This shows clearly that public awareness has increased in both density and spatial coverage.

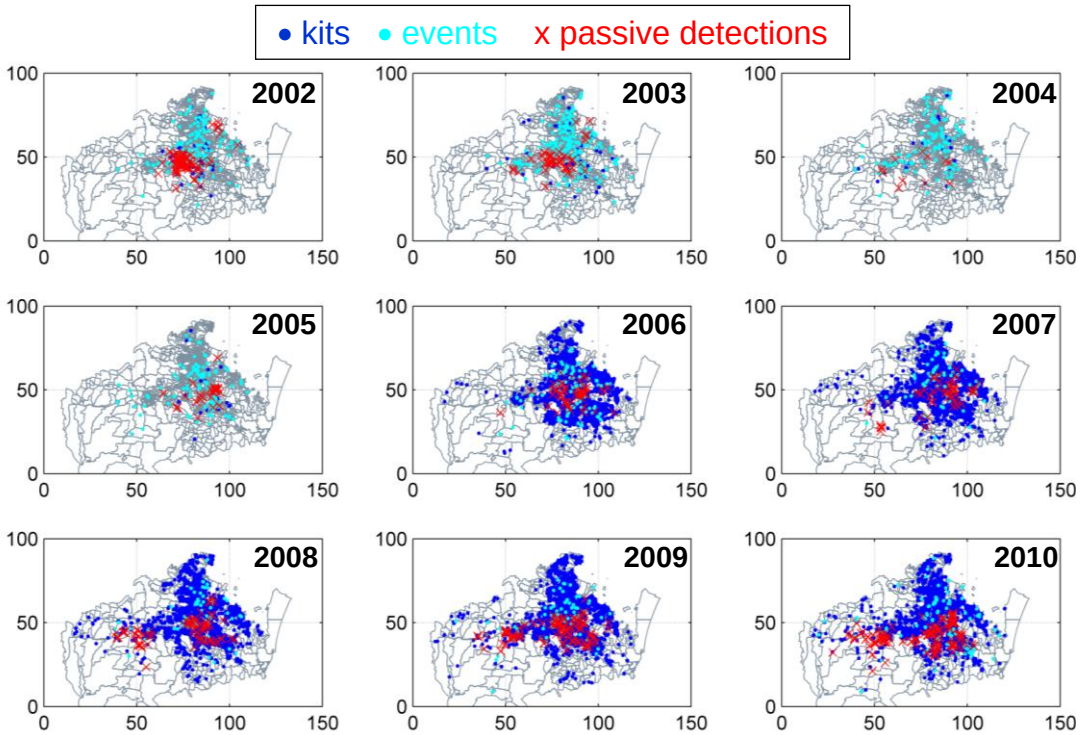


Figure 9. Annual spatial distributions of sample kits returned to BQCC, community engagement events and passive detections overlaid on the Census Collector District boundaries. Axis labels represent distances (km).

5.1 Spatial autocorrelation

Spatial autocorrelation in the colony locations was very apparent. Moran's I was calculated for all of the colony locations, as well as just the active and passive detections, and found significant ($p < 0.05$) clustering. When assessed using Ripley's K for multiple distance bands, spatial clustering was found at all distances for all colony data. When separated, active detections were most clustered within 150 m, while passive detections were most clustered at 750 m (Figure 10). Approximately 28% of passive detections fell outside of the 150 m radius of an existing colony. This emphasises the value of passive detections in providing a larger (spatial) sample of colony locations.

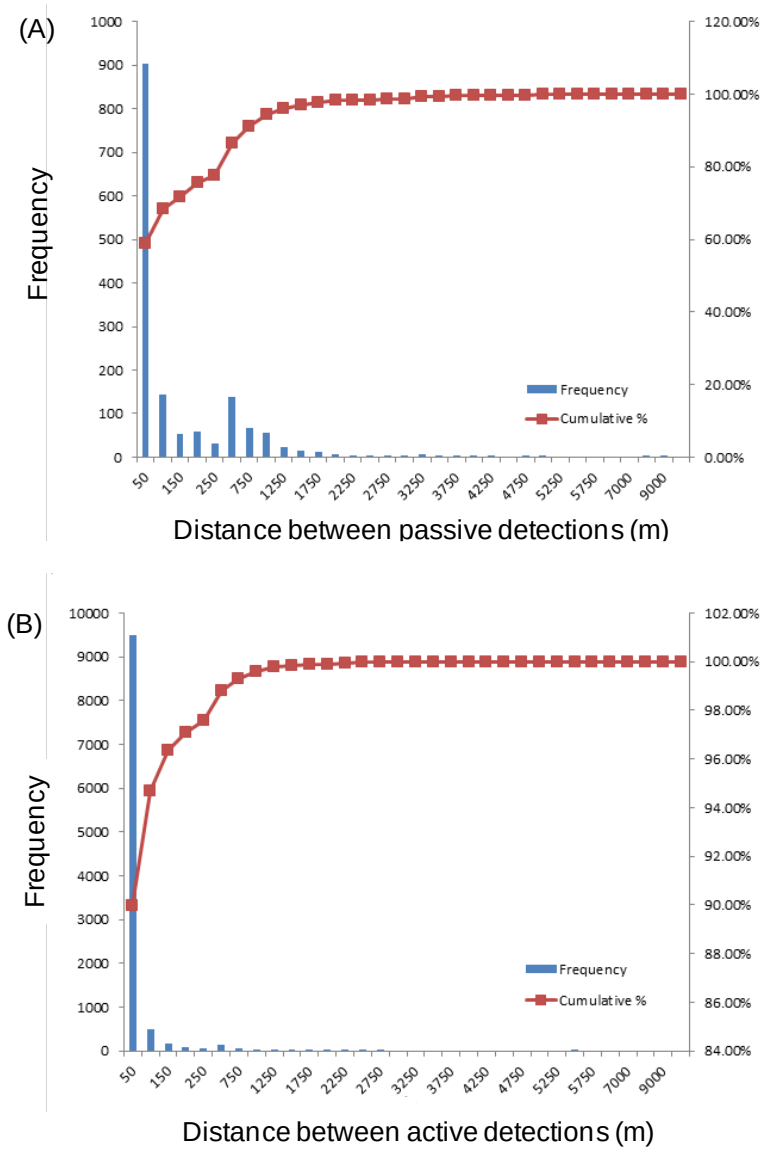


Figure 10. (A) Distance between passive detections for all years; 75% of passive detections are within 250 m, 90% are within 750 m, and 95% are within 1 km of other passive detections. (B) Distance between active detections for all years; 90% of active detections are within 50 m, and 95% are within 100 m of other active detections.

5.2 Time series analysis

Preparatory work for time series analysis revealed artefacts in the data which may reflect the staff catching up on office work in June of each year. Possibly this occurs because the reporting cycle is based on financial years. The requirement to get all the numbers in the CCS up to date for each year's report in June means there are spikes in the number of contacts recorded during that month. Further initial exploration revealed the following:

1. weekly cycles because nothing happens on weekends;
2. an annual short dip due to the Christmas break;
3. a large increase in sample receipts just prior to the introduction of the new CCS around June 2006, followed by an increase in data entry in July, probably associated with the new system;
4. a large increase in data entry, but nothing else in June 2007;
5. a short duration increase in kit requests, sample receipts and surveys taken around the middle of 2008, with an increase in data entry lagging by a month; and
6. and long duration (summer long) but smaller increases in all the CCS data items in all the summer periods, but particularly the summers of 2008/09 and 2009/10.

These trends suggest that the ‘Data Entry’ records (contact type 1 in Table 1) can be eliminated from further analyses.

Other patterns in the CCS and colony detection data include:

1. Negative sample receipts tend to increase over the summer months and fall away in winter. This might reflect the combination of greater levels of activity outside the home by the public, and greater activity by ant species, making them more visible to the public. The exception is early winter in 2008 then there was an unseasonal increase in negative sample receipts, probably due to the reward scheme.
2. Positive sample receipts are not as cyclic as the negative ones. In 2007, they were six months out of phase, with the rate of positive receipts being highest in winter. There is a similar out of phase relationship between positive and negative sample receipts in 2009, but not as strong as in 2007. In 2010, positive receipts lag negative receipts by less than six months, although it is not a strong relationship. The year 2008 is different from other years, in that there is a strong early winter increase in both positive and negative sample receipts, which again probably reflects the impact of the reward scheme.
3. As might be expected, there is a strong correlation between positive sample receipts and public nest detections, including during the period of the reward scheme in 2008. There

has been an improvement in public nest detections and positive samples relative to negative samples in 2010 and 2011. The reward period stands out for the number of public detections in a short time period, but 2010 to the end of the data in May 2011 shows a steady and moderate rate of public detections.

5.3 Analysis of positive and negative samples

The positive predictive value (PPV), measured as the percentage of samples returned by the public that are positive (Table 7), has increased over time, suggesting that the community engagement program has become more effective. The PPV for 2010 was close to 13% for the full dataset, but when the case-managed sites were excluded from analysis, this decreased to about 6%. As explained in section 4.1, case-managed sites are those, such as market gardens, where the presence of ants is well-known, so that the regular reports from the public cannot be considered passive detections. Table 7 shows the much higher level of positive samples for the managed sites, with an average of 31.4% and reaching 57.5% in 2010, than for the passive detections by members of the public, with an average of 1.1% and reaching 6.1% in 2010 (Figure 11).

Table 7. Summary of positive samples for the full dataset (All) case-managed sites (MS) and all other public detections (Other).

	Positives samples (%)		
Year	All	MS	Other
2001	1.08	0.00	1.08
2002	0.34	0.00	0.34
2003	0.12	11.11	0.10
2004	0.11	16.67	0.06
2005	0.48	41.67	0.32
2006	0.39	2.33	0.37
2007	3.59	16.67	2.69
2008	2.91	10.42	2.39
2009	5.81	38.27	3.32
2010	12.67	57.53	6.11
Mean:	1.76	31.44	1.12

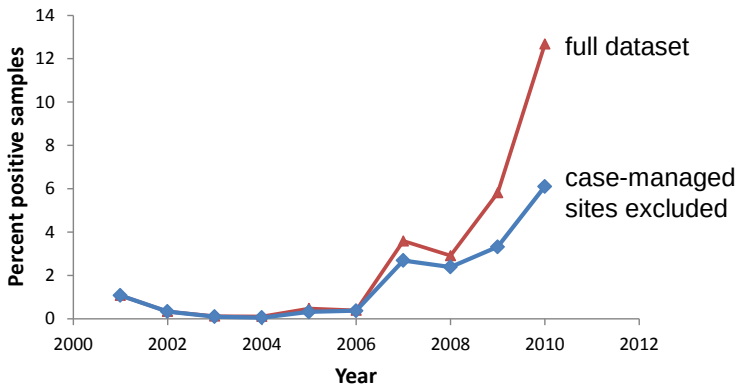


Figure 11. Proportion of samples returned by the public that were positive for the full dataset (brown-triangles) and excluding case-managed sites (blue-diamonds).

Figure 12 shows the spatial distribution of positive and negative samples and Figure 13 illustrates the value of negative results in client contacts. These data provide useful information on the probability that ants are absent from certain areas.

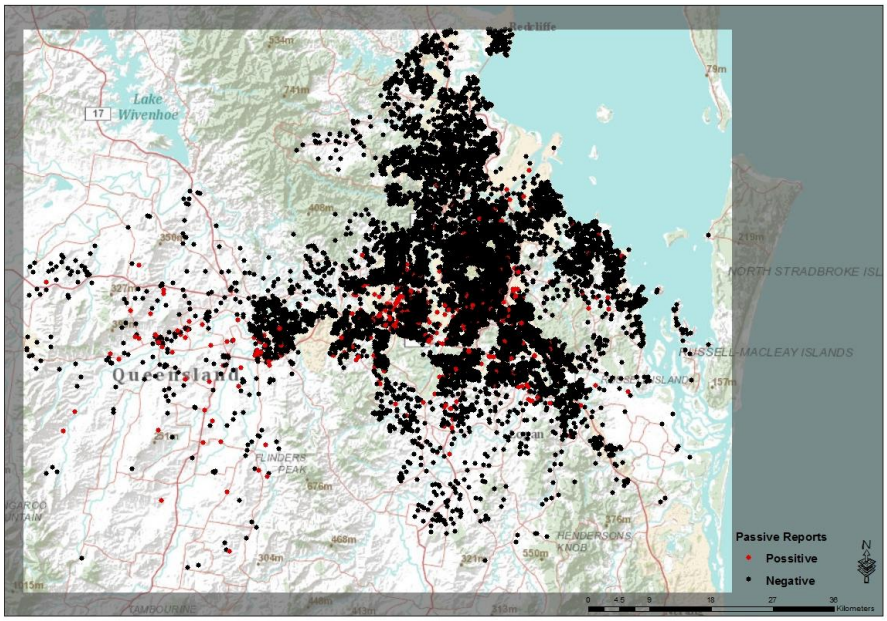


Figure 12. Client contacts that resulted in a positive sample (red) and those that were negative (black)

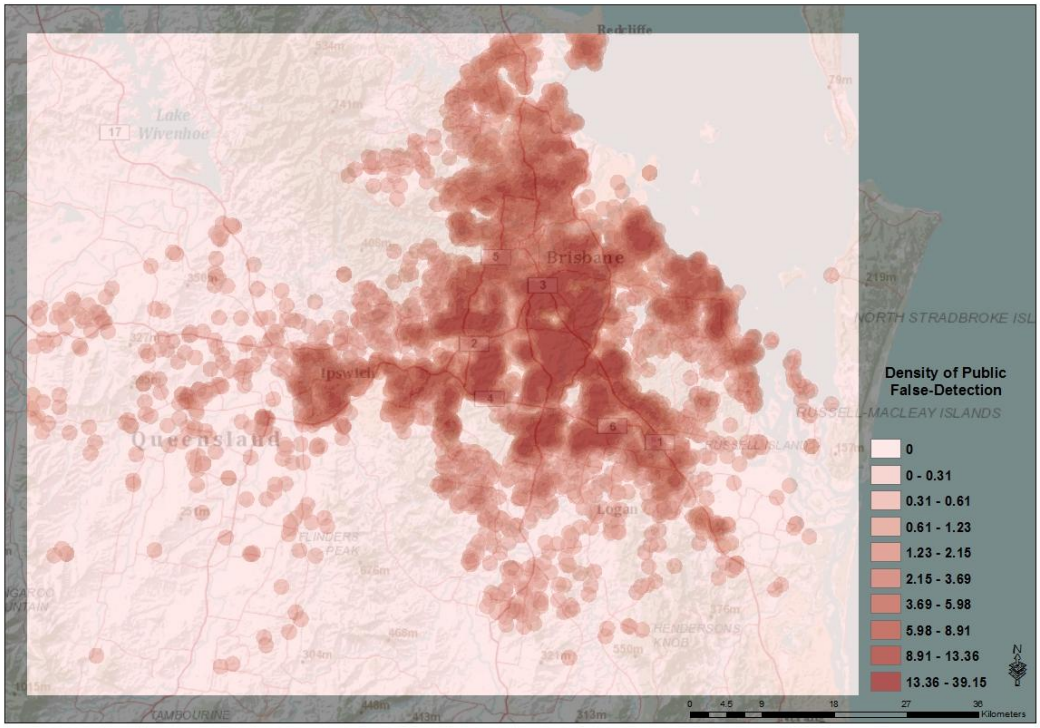


Figure 13. Density (1km search radius) of negative samples from the client contact system. These data are indicative of areas where there is high likelihood of absence.

5.4 Effect of events on public response

If community engagement events are effective, we would expect proximity from previous events to increase the likelihood that the public will detect a fire ant colony. The spatial influence of events is difficult to ascertain, as events vary in size, duration and population catchment and therefore would vary in their spatial influence. However, we can obtain an average measure by calculating frequency distributions of distances between events and subsequent passive detections (Figure 14). Using 2008 passive detection data, and based on 2007 events only, there appears to be a distance threshold at ~4.2 km at which the average event loses its effect on public awareness (Figure 14A). A similar relationship is found when all previous events (2001-2008) are used, but this time at just over 1 km. This confirms our expectation that the effect of events depreciates over time, so that the estimated radius of influence of all previous events (1 km) is smaller than the influence of more recent events (4.2 km).

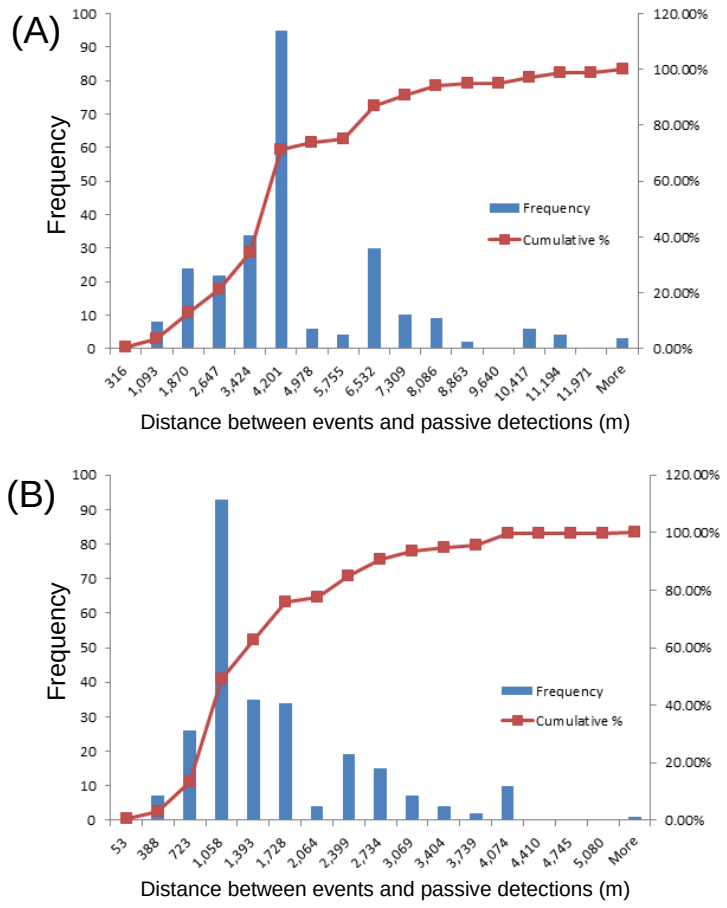


Figure 14. (A) histogram of distances from each passive detection in 2008 to the nearest event in 2007; there appears to be a distance threshold at ~4.2 km at which the average event loses its effect on public awareness. (B) histogram of distance from each passive detection in 2008 and the nearest event for all years prior to 2008; again there is a clear threshold, but this time at just over 1 km.

The simple analysis illustrated in Figure 14 does not consider the complex serial correlation between community events that lead to detections by the public that then lead to more events being held in the area. However, our interpretation of the data is valid because the causality is one directional in time. By relating each passive detection for only one year (2008) to events held in previous years only, we abstract away from the question of whether an event was caused by a previous detection in the area. Disentangling the spatio-temporal correlation between events and passive detections will require more thorough analysis than was possible in this project.

5.5 The reward scheme of 2008

The reward scheme that took place between April and June 2008 is an event that differs significantly from those analysed above. The offer of $500 for reports of new nests received widespread media attention and attracted segments of the population that may not have responded to standard community engagement events. The reward scheme seems to have caused an increase in the number of weekly contacts relative to the number of events that took place during the period May 2008 to November 2009 (Figure 15). This suggests that the effect of the reward scheme lasted for several months after its conclusion. There was a gradual decrease in this effect as indicated by the solid line approaching the broken line close to the top in Figure 15.

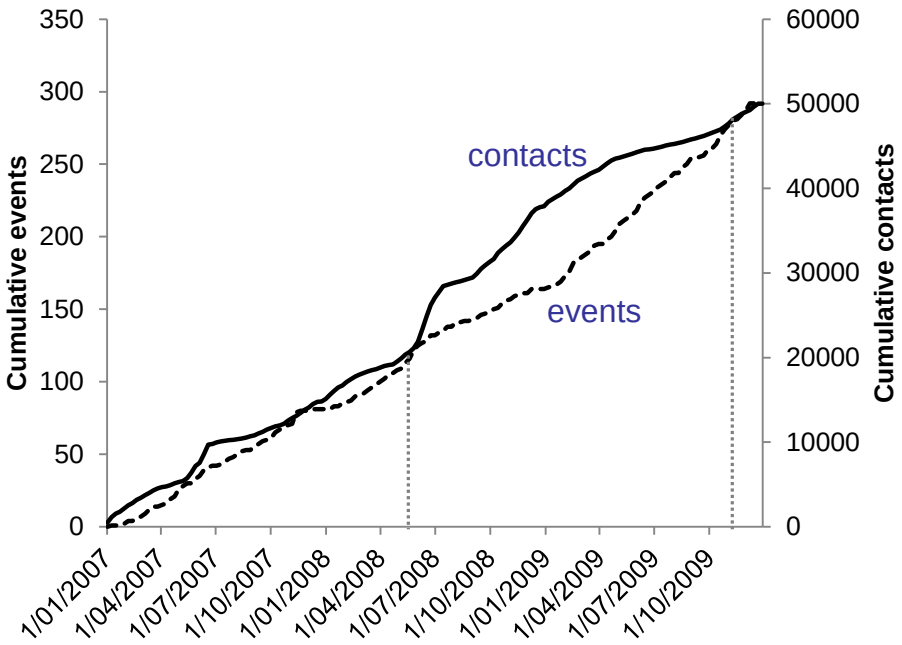


Figure 15. The reward scheme that took place April-June 2008 seems to have caused an increase in contacts by producing increased awareness and an incentive to search for and report ant colonises

Another way of looking at these results is shown in Figure 16, where the slope of the relationship between events and contacts increased for several months after the end of the reward scheme.

Apart from the spike in client contacts related to the reward scheme in 2008, there was another one around May and June 2007. The reason for this has not been ascertained but it should be possible to go through the history of the program with the BQCC team to identify possible reasons.

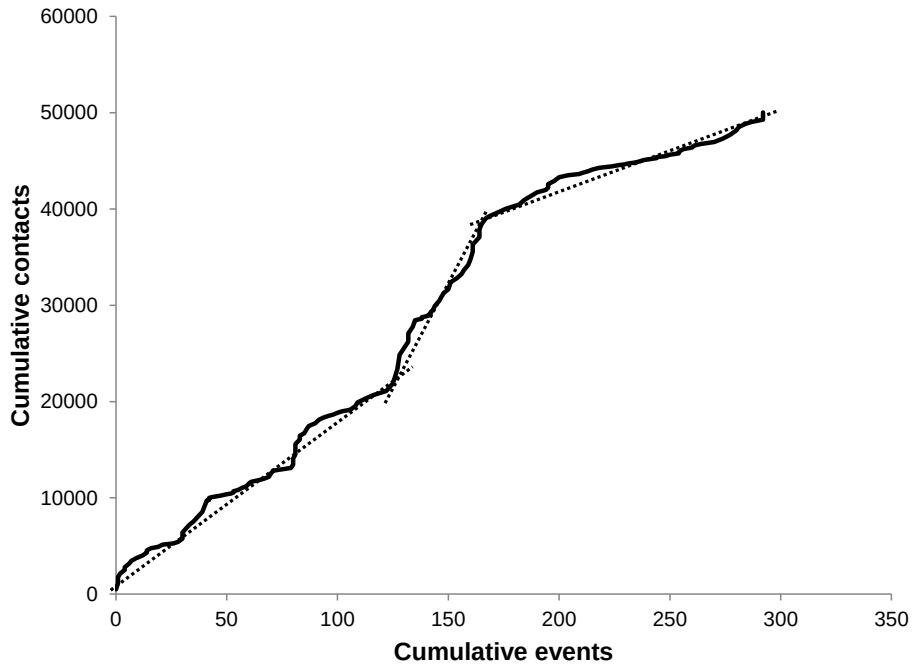


Figure 16. An alternative view of the period where the reward scheme was in force shown as an increase in the slope of the relationship between events and contacts by the public.

The cumulative curves in Figure 15 come back together after October 2009, and the third segment in Figure 16 is flatter than the first segment. These two patterns could indicate that there was compensation after the reward scheme was finished, so that there was no net effect after all in total number of nests detected. However, even if the reward scheme only encouraged people who were going to respond to do it sooner, early detection can be quite valuable as shown by Spring et al. (2010). Detecting nests earlier reduces the number of new nests produced, and it is possible that the reduction in detections was caused by fewer nests available to be detected. Once again we have confounding factors that need to be disentangled.

5.6 Urban vs Rural Detection Probability

Contrary to our hypothesis, it appears that passive detection probability is equal in urban vs rural areas. Urban was defined as those collector districts with greater than 200 people per km² (including any districts surrounded by urban districts). Similarly, the proportion of passive detections vs active detections in urban and rural areas is nearly equal across all years (not shown). Although there were far more passive detections as a whole in urban areas (1,196 vs 184), proportionately to population there was little difference in passive detections between rural areas (28%) and urban areas (26%). This is particularly interesting given that over 92% of events are held in urban areas.

5.7 Effect of habitat suitability

Our analysis suggested that the current habitat model does not improve the predictive value for describing the detection of fire ant colonies. When habitat was compared between positive and negative sample returns, there was no significant difference (Figure 17A). Similarly, when habitat was compared between the passively and actively detected colonies, there was no significant statistical difference (Figure 17B). Furthermore, after examining the variation in habitat between positive and negative samples, and active vs passive detections, there seems to be little correlation between colony location and habitat in general. Average habitat (across all colony datasets) is 7, with most of the colonies falling between 5 and 9

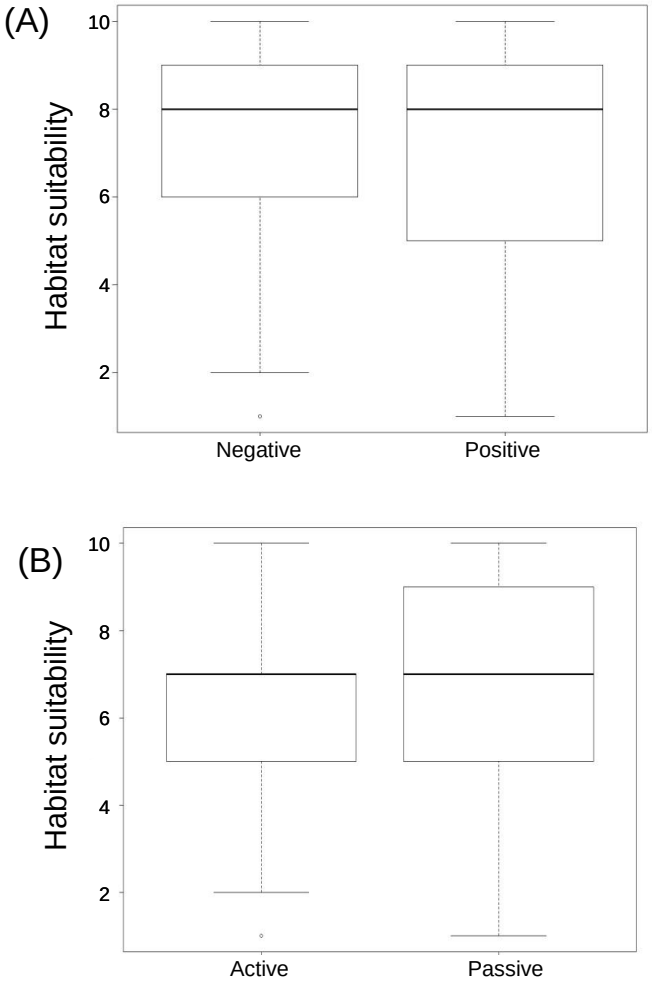


Figure 17. (A) Habitat suitability of negative and positive samples submitted by the public; there is no significant difference in potential habitat between negative and positive samples. (B) Habitat suitability of passive and active detections of RIFA colonies; there is no statistical difference in the potential habitat between passive and active detection colonies, suggesting passive colonies have the same probability of occurrence than active (when colonies are present). The variance in passive colony habitat is slightly higher, showing that passive detections can occur in what is considered low habitat value, leading to detections that would otherwise be missed by structured surveys.

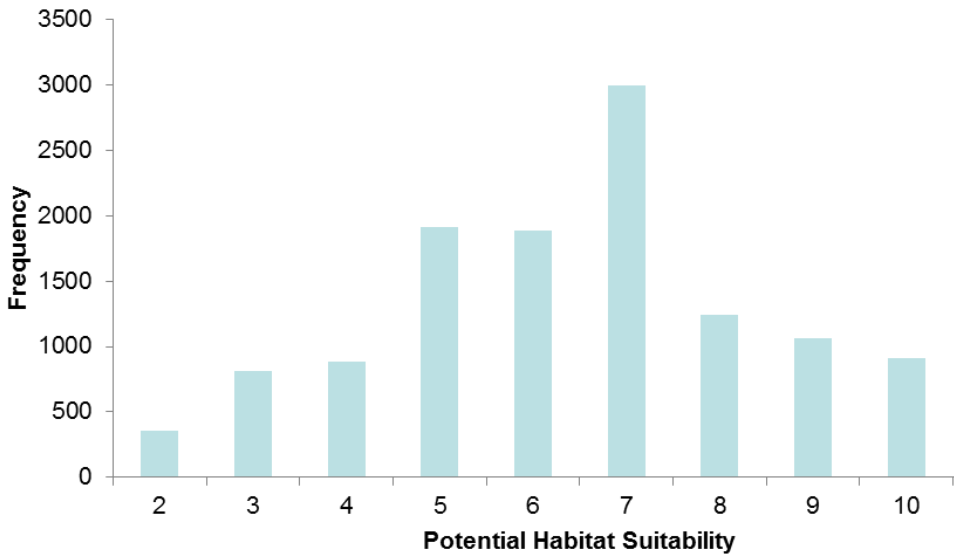


Figure 18. Habitat suitability across all colonies.

(Figure 18). Passive detections cover a broader range in habitat suitability, as most of the actively detected colonies fell between a suitability of 5 and 7 (not shown).

5.8 Effect of demographic variables on passive detections

Initial exploratory analysis using the Census-derived indicators of human and social capital described in section 4.4, above, was undertaken to test whether there were any relationships between these indicators and the propensity of people to submit ant samples. It is important to note that in this analysis the data used, viz. the number of samples submitted by the people in a CCD and demographic variables at CCD level, is not based on a sample of CCDs from the study area. Rather, it is based on all CCDs in the study area, apart from several CCDs with very small numbers of people, for which the ABS does not provide Census data for privacy reasons. As such, the analysis is essentially dealing with the whole population of CCDs and not a sample of CCDs drawn from this population. For initial exploratory analysis in this situation, inferential statistics are not required, as the object of the analysis is not to test a hypothesis about the population using a sample from that population, but rather to describe any relationships of interest in the population itself.

Table 8 is a comparison of the means of the demographic variables for CCDs submitting samples of ants and CCDs that did not. The table shows that the differences between

means are generally small, with the exception of population density and percent of households in rented dwellings.

Table 8. Demographic comparisons of Census Collector Districts (CCDs) sending one or more samples and those sending no samples of suspect ants.

Census indicator	Mean for CCDs not sending any samples	Mean for CCDs sending one or more samples
Population density	3084.4	1930.3
Percent females in non-routine occupations	41.73	34.998
Percent in new residence in last 12 months	20.682	15.453
Percent graduates	23.071	17.072
Percent language other than English spoken at home	10.503	10.894
Percent participating in voluntary work	17.846	17.568
Percent adults with no qualifications	55.921	59.164
Percent persons over 65 years	12.709	11.368
Percent single parent families	15.463	16.685
Percent of households in rented dwelling	41.359	30.033
Percent of low income households	13.755	11.612
Percent adults unemployed	4.5825	4.5641

Even when the comparison was limited to the upper and lower deciles of CCDs in the distribution of number of samples returned per square kilometre of CCD, where it might be expected the greatest difference would occur, the differences between means remained small.

Only very weak linear relationships (adjusted $R^2 < 0.2$) were found between the total number of samples returned and the demographic characteristics of collector districts. This suggests that, at a broad aggregate scale and over a long time period, demographic characteristics do not predict community response in terms of returning samples of suspect ants. It might reasonably be expected that the apparent absence of moderate or strong relationships could be due to spatial and temporal autocorrelation effects. However, for some years there has been near universal awareness of fire ants among people across the study area, and there is also an abundance of ant species which people could submit as suspected fire ants (as demonstrated by the lack of relationship between fire ant habitat suitability and sample returns described in section 5.7). This would suggest that spatio-temporal variation in the awareness of the public and in the presence of ants for the public to submit is unlikely to obscure differences in the public propensity to submit samples. This gives some confidence that the general lack of relationships between the demographic variables available to the study and the public propensity to submit samples, at least at the broad aggregate scale across the study area and period, is not an artefact of the analysis. However, this is not to say that such relationships may not exist within limited areas and periods of time. Further, it

is also not to say that such relationships may not exist with other demographic variables which are unavailable from Census data.

The difference in mean population density between CCDs that sent samples and those that didn't was unexpected. This result indicates that more densely populated areas are less likely to send samples, whereas we expected high population density to lead to a higher likelihood of contact with ants and therefore to more reports, other things being equal. But considering that higher density areas include apartment buildings that would not provide suitable RIFA habitat may provide an explanation for this result.

The lack of a difference for participation in voluntary work and language other than English is also contrary to expectations, given that altruistic behaviour indicated by participating in voluntary work could be expected to extend to submitting ant samples, and that proficiency in English might be expected to affect the comprehension of community awareness campaigns about fireants.

While it was found that there is no relationship between fire ant habitat suitability and sample returns (section 5.7), we explored the relationship between habitat suitability and demographic variables to provide further background to the study.

There were some significant but weak correlations between two demographic variables and average habitat suitability of collector districts (Figure 19). These two variables: population density and proportion rented dwellings, had the strongest relationship with habitat suitability, all others were weaker or non-existent.

In Figure 19A, the relationship between habitat suitability and rented dwellings might be an artefact of the history of urbanisation. Older parts of Brisbane and Ipswich are low lying areas closer to the rivers (exceptions are Spring Hill, Paddington, Red Hill etc), and older areas have more rental accommodation. In Figure 19B the relationship with population density may also be an artefact of the history of urbanisation. Older parts of Brisbane and Ipswich along the rivers have the higher population densities of inner urban areas.

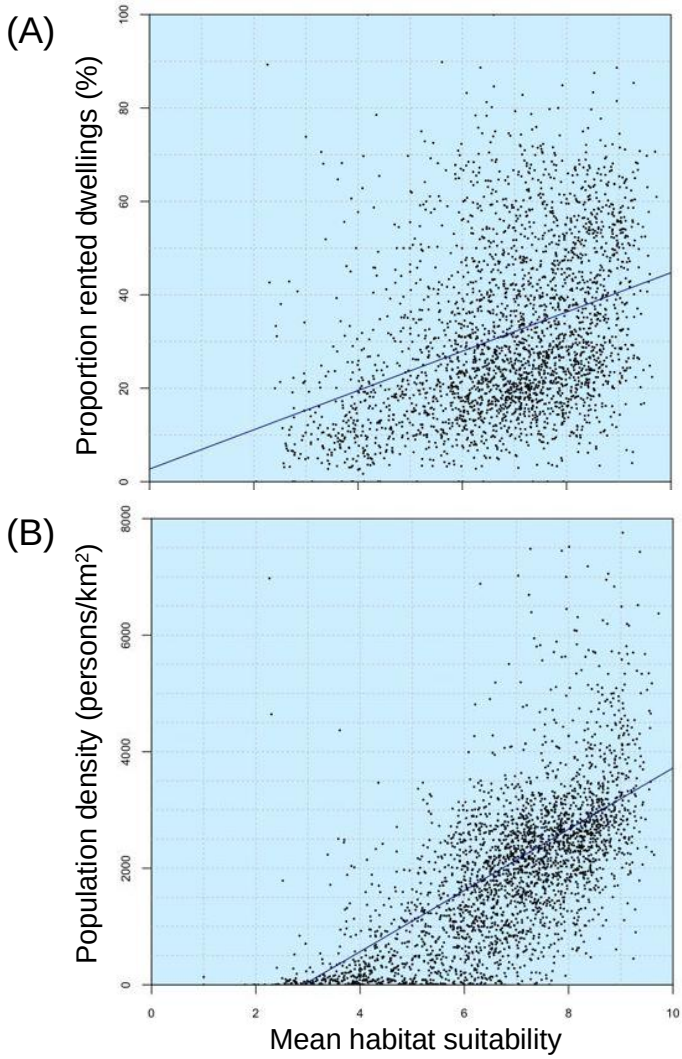


Figure 19. (A) The relationship between proportion of rented dwellings and average habitat suitability of census districts Y=2.7+4.2X, R2=0.13, p<2e-16. (B) relationship between population density and average habitat suitability of census districts Y= –1533 + 5.

One way to control for temporal autocorrelation on an annual time scale is to look at a single year subset. We looked at the relationship between passive colonies in 2008 to the various demographic indicators and found several strong relationships; however, when spatial autocorrelation was accounted for those relationships disappeared. Indirect ordinations were assessed to explore any possible relationship between the demographic indicators and the presence of passive detections, but proved unsuccessful in disentangling the temporal autocorrelation between colony locations. Classification and regression tree analysis was also performed, but given the complexity of temporal and spatial autocorrelation, no strong relationships emerged.

The analysis revealed some of the challenges in establishing relationships between passive surveillance activity by the public and the demographics of the population. Firstly, the data available from the BQCC databases do not lend themselves immediately to this type of statistical analysis. Secondly, there are many opportunities for confounding factors to weaken any relationships. Obviously, suburban demographics is of little consequence to RIFA when it spreads by natural means or by accidental human means. However, given the presence of colonies in an area, demographics could be expected to have an influence on the probability of detection of the colonies within a given time period. This suggests the need for a more targeted analysis focusing on time periods and regions within Brisbane when significant numbers of detections have occurred. These case study analyses are presented in Chapter 6.

716

6. Local cases studies

The autocorrelation issues present in the datasets used in this study are illustrated in Figure 20, where areas with high incidence of positives samples overlap areas with high incidence of negative samples. To cut through the complexity created by the large scale of the dataset, we present some local case studies that help understand the dynamics of interactions between pests and people.

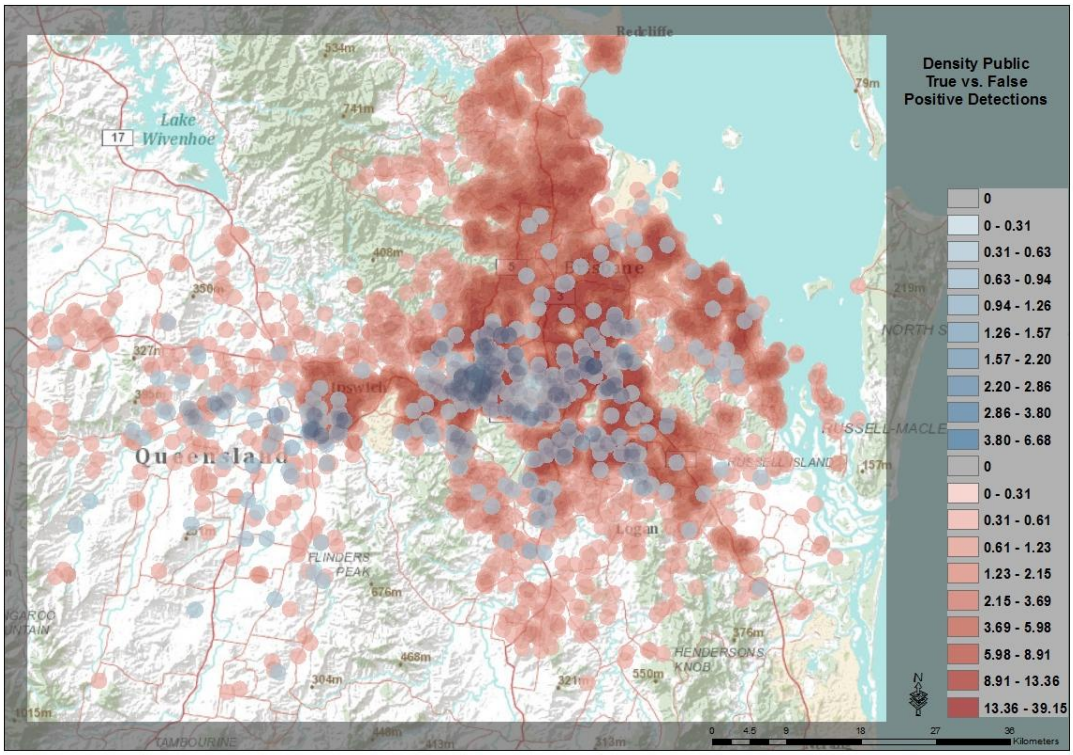


Figure 20. Positive and negative sample density (1km search radius). The overlap in high positive and high negative samples highlights the autocorrelation issues abundant in this dataset.

The Northern suburbs, where no nests have been found, have exhibited a constant stream of negative samples from the public from 2001 to 2011 (Figure 21). This provides some assurance that the RIFA invasion has not spread to that area. This may also provide some evidence of containment of the RIFA invasion on the northern front.

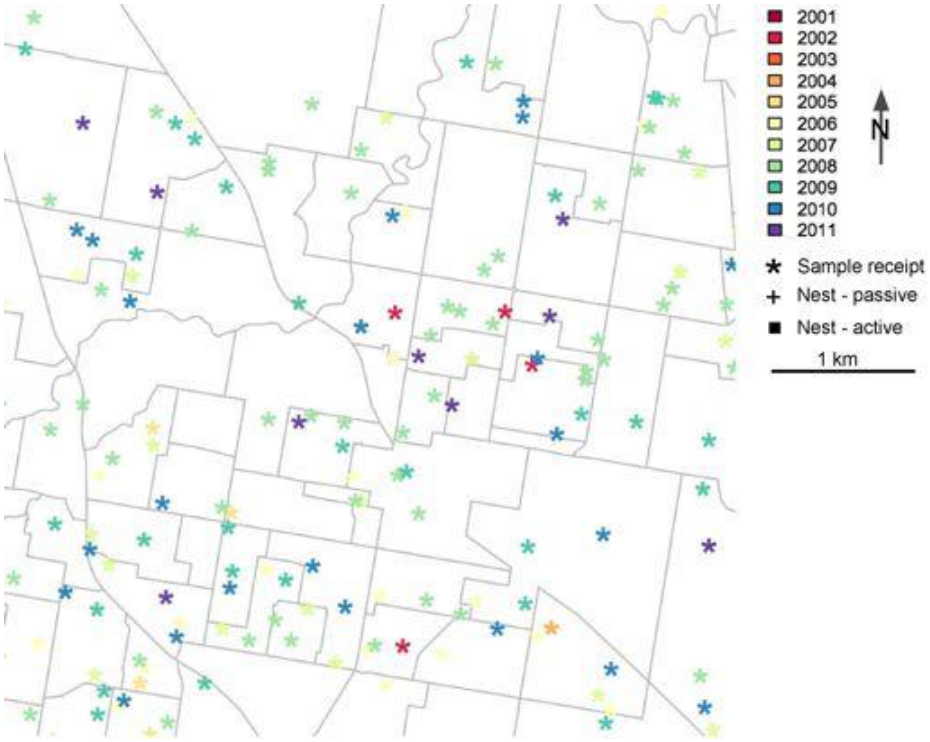


Figure 21. Example 1. Northern suburbs where no nests have been found, but there has been a constant stream of negative samples from the public from 2001 to 2011.

An interesting case is found in the Wacol, Richlands, Ellen Grove area immediately east of the junction of the Ipswich and Logan Motorways (Figure 22). Active nest detections in the

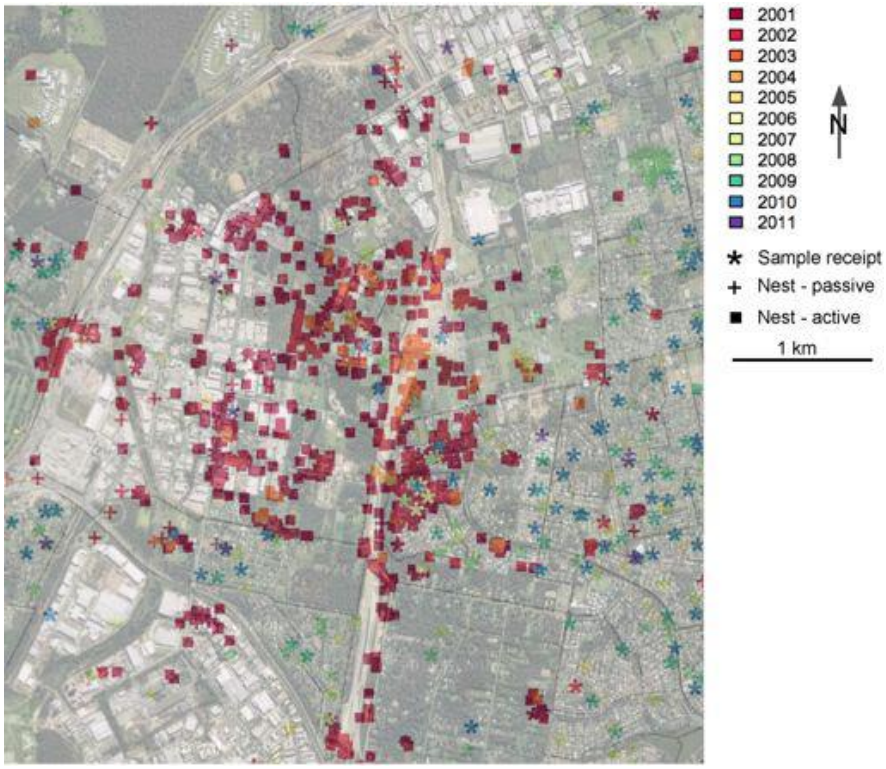


Figure 22. Example 2. Wacol, Richlands, Ellen Grove area immediately east of the junction of the Ipswich and Logan Motorways.

period 2002 to 2004 are mainly in the industrial area west of the Centenary Motorway (north – south centre of figure), and along the Centenary Motorway (under construction about this time). Some active nest detections occurred in the suburban area to the east of Centenary Motorway during the same period, however samples continued to be received from the public through to 2011. The cluster of active detections in the far left centre of the figure straddle a Census Collector District boundary (Ipswich Motorway).

The infestation around the Gateway Motorway between Mt Gravatt-Capalaba Rd and Cleveland Rd. (Figure 23) shows active and passive detections straddling CCD boundaries. This pattern, which also occurred in other sites, provides another explanation for the lack of demographic effects in the statistical analyses from Chapter 5. These last two examples illustrate that CCD boundaries often follow topological features such as roads, drainage lines, creeks and parks that may act as ant corridors.

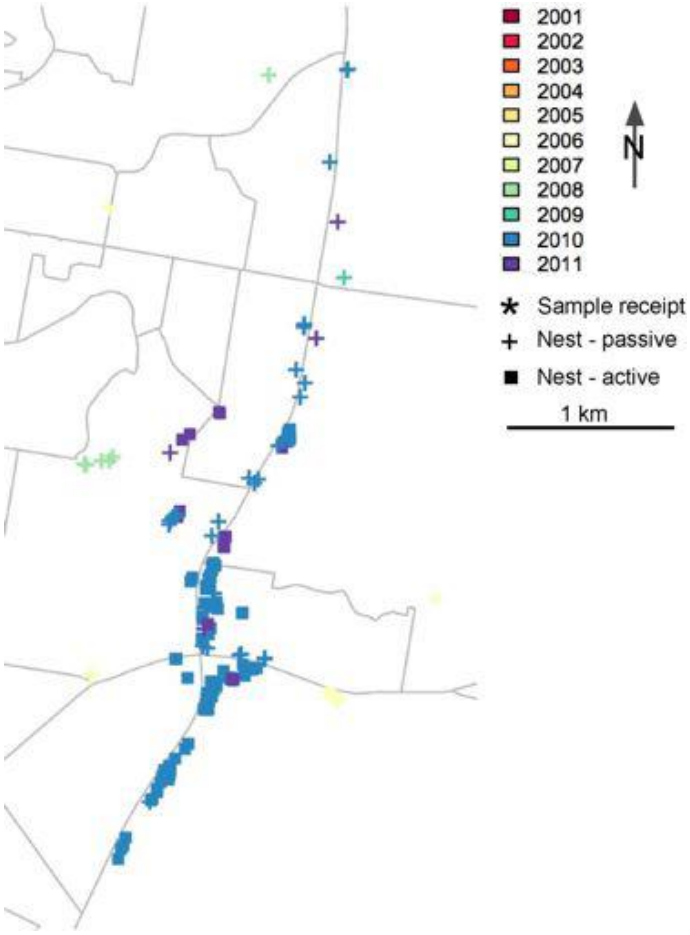


Figure 23. Example 3. Gateway Motorway between Mt Gravatt-Capalaba Rd and Cleveland road. Active and passive detections straddle CD boundaries. Sample receipts not shown.

An example of the dynamics of case-managed sites showing how passive detections led to extensive active detections, is presented in Figure 24. In this market garden, publically detected colonies were identified in early 2009 and this was followed by several active detections later in 2009. Similarly, colonies were publically identified in 2010, with several active colonies being found later in 2011.

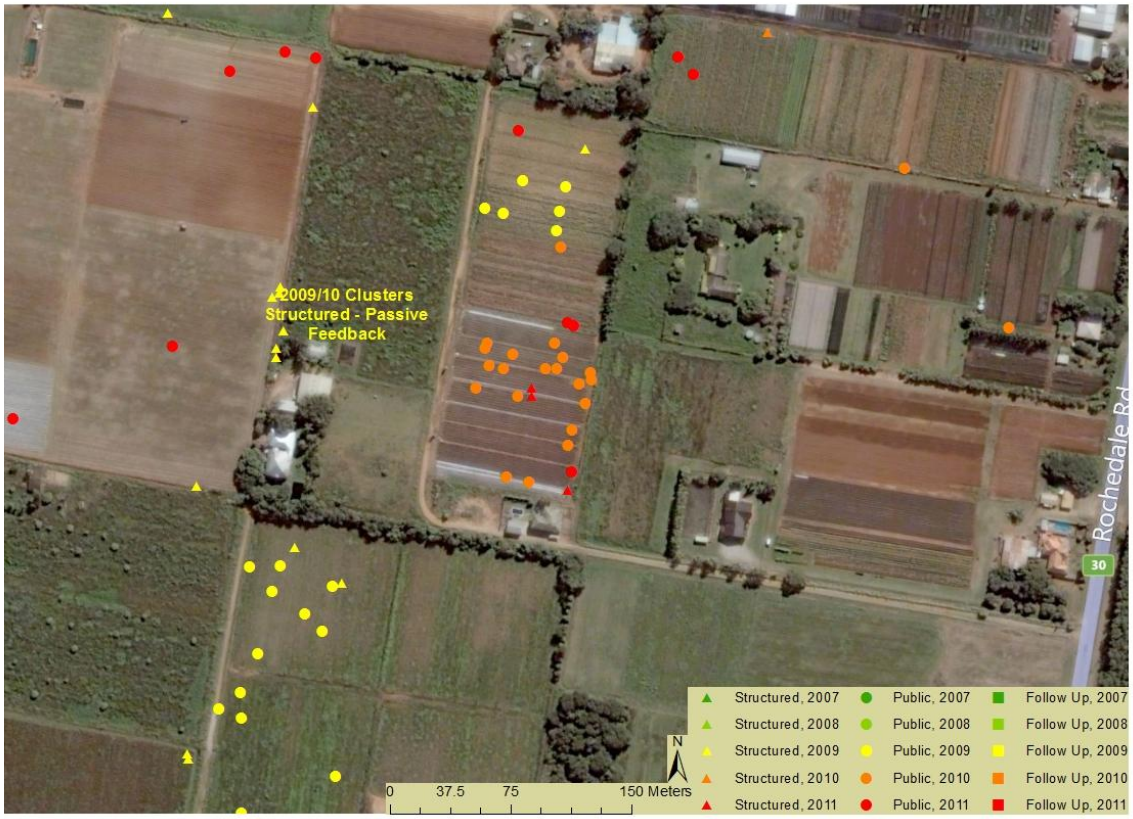


Figure 24. One example of how passive detections led to extensive active detections. Publicly detected colonies (circles) were identified in early 2009, followed up by several structured surveys (squares) later in 2009. Similarly, colonies were publicly identified in 2010, with several active colonies being found later in 2011

Another example of how passive detections led to active detections is presented in Figure 25. A cluster of passively detected colonies occurred in 2008 and this was followed by active detections in 2008 and 2009. Another separate cluster occurred with passively detected colonies in 2010, followed up in 2011 by active detections.

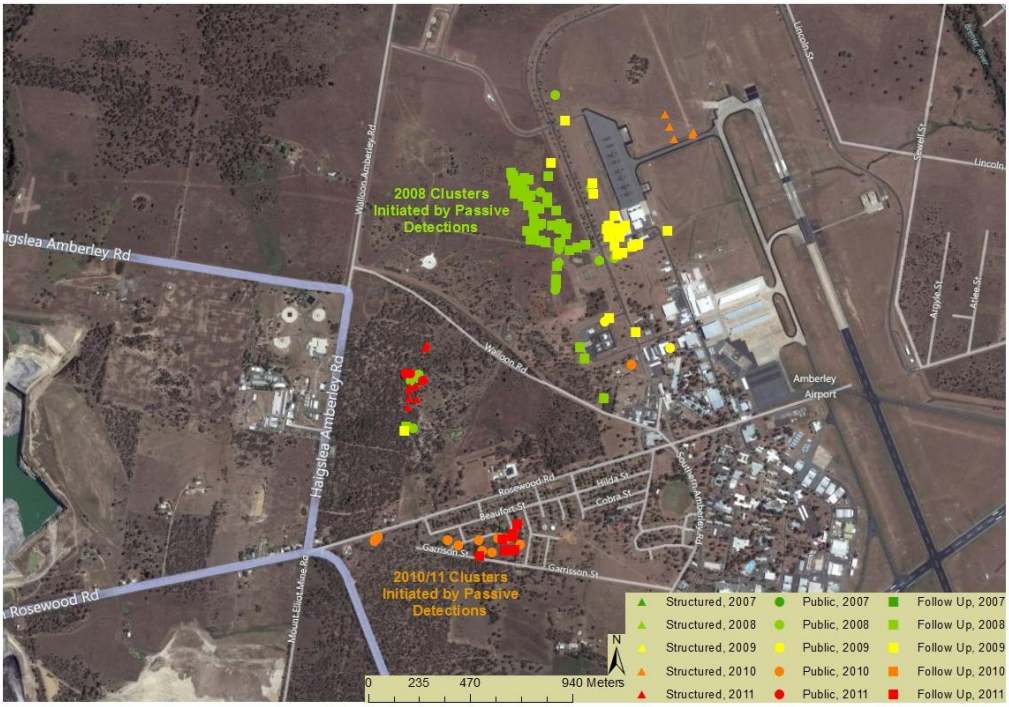


Figure 25. Another example of how passive detections led to actively identified colonies. A cluster of passively detected colonies occurred in 2008 and were immediately followed up by active surveys in 2008 and 2009. Another separate cluster occurred with passively detected colonies in 2010 which were followed up in 2011 by active surveys.

A final example illustrates the possible feedback between passive and active colony detection (Figure 26). Actively and passively detected colonies were intermixed through 2009 and 2010. Active detections along the shoreline may have prompted local residents to look for colonies, leading to multiple passively detected colonies. Likewise, the structured surveys in the newly developed residential area in 2009/10 may have motivated the passively detected colonies in 2010/11.

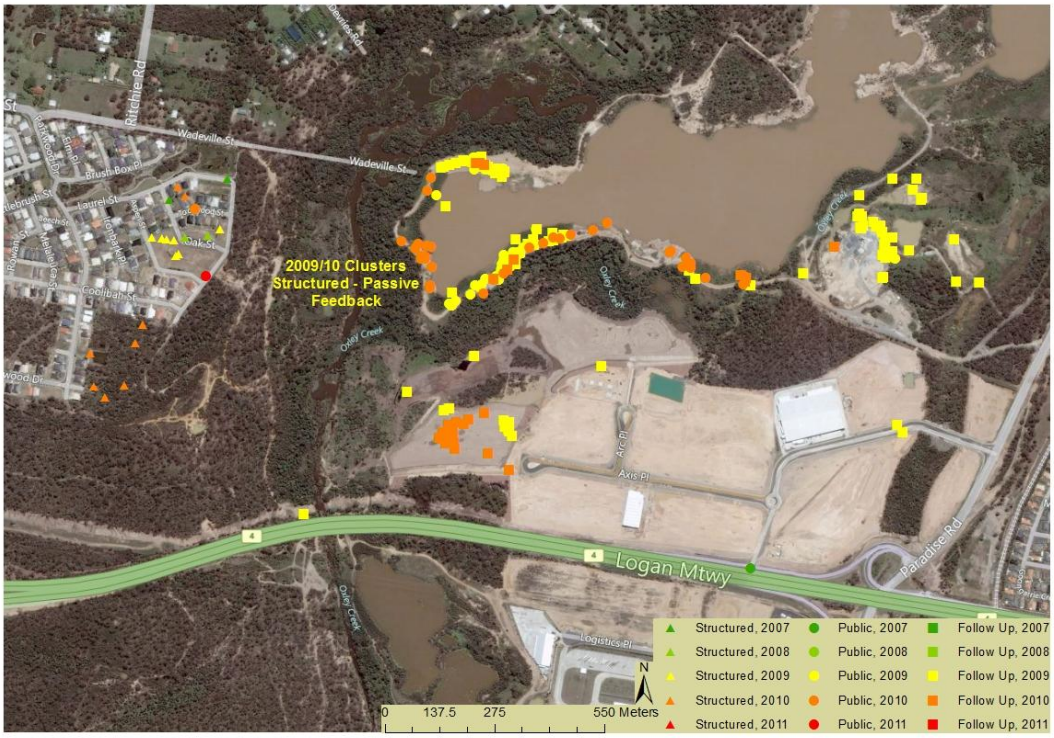


Figure 26. Example of the possible feedback between passive and active colony detection. Active and passively detected colonies were intermixed through 2009 and 2010. Structured detections along the shoreline may have prompted local residents to look for colonies, leading to multiple passively detected colonies. Likewise, the structured surveys in the newly developed residential area in 2009/10 may have motivated the passively detected colonies in 2010/11.

A general observation drawn from the examples above is that nests are often found in industrial areas, due to the soil disturbance associated with construction and outdoor storage. These areas are included in the Census, because there are often a small number of people resident in the area, or the CCD boundary will take in a small area of adjacent residential land to give the target CCD population. So an industrial area CCD may have a small resident population and a large transient population who work there during the day. Consequently the demographic characteristics of the people available to notice and report nests may be quite different from the characteristics of the resident population recorded in the Census. This may partly explain the lack of explanatory power of the models involving census data. This suggests future analyses should include a land use layer for the study region and conduct the search for demographic relationships in residential areas and industrial areas separately.

Another observation from these case studies is the difficulty of assessing the relationship between the already complex pattern of spread, and the socio-demographics which is aggregated to CCD level. The example in Figure 26 (the lake, industrial area, and residential

area) is a good example of where the socio-demographics from the Census will have no bearing on the attributes of people that might happen to see ants in the industrial area. The example in Figure 24 (market garden) illustrates a further complication: if the owner of the farm is reporting colonies, this hardly counts as passive detection, since this area and presumably the owner has a long history of interaction with BQCC. This justifies dropping out case-managed sites from the passive detection analysis.

7. The value of community engagement

As explained in the introduction, our objective in measuring the value of community engagement is driven by an attempt to contribute to efficient allocation of surveillance resources. Economic principles prescribe that resource allocation should be based on marginal quantities (rates of change) rather than absolute quantities. The optimal operating point is where the marginal benefit of an action equals its marginal cost. In many practical situations it is not possible to calculate the cost and benefit functions required to derive marginal values through differentiation. This is one reason benefit-cost analysis (BCA) is popular. In BCA we compare total benefits to total costs (in present-value terms) for different scenarios, and select the alternative with the highest benefit-cost ratio. However, an alternative selected from an arbitrary set of scenarios may not be optimal. Notwithstanding this deficiency, BCA is still widely accepted and remains useful to rank alternatives.

In our case, to estimate the marginal cost of passive surveillance we would need to derive a function relating expenditure in community engagement to passive detection probability. The derivative of this function could then be used to calculate the marginal cost of detecting one additional nest. On the benefit side, we would need a function to calculate the additional benefit (avoided damage in $) obtained by detecting one additional nest. The point at which the two marginal functions intersect would be the optimal level of detection and this point can be related back to expenditure in community engagement. The actual optimisation problem is more complex than this because of its dynamic nature -- nests available to be detected today depend on previous actions that have been taken. But this simplified description illustrates the process involved and the information required.

There are at least three reasons why this process could not be applied with the data available: (1) not enough variation occurred in community engagement expenditures between years to cover the range of interest in a regression function between community engagement and passive detections; (2) there are complex spatio-temporal correlations that will require more detailed data analysis than was possible in a short-term project; and (3) a dollar value of avoided damages per nest detected was not available.

Based on annual expenditure data, the community engagement budget fluctuates but it has tended to decrease between 2002-03 and 2008-09 (Figure 27A). This was accompanied by equivalent fluctuations in the number of events held per financial year. The effectiveness of passive surveillance seems to have increased over time judging by the number of passive detections per $1,000 (Figure 27B). This is consistent with the increase in positive samples identified earlier in Figure 11.

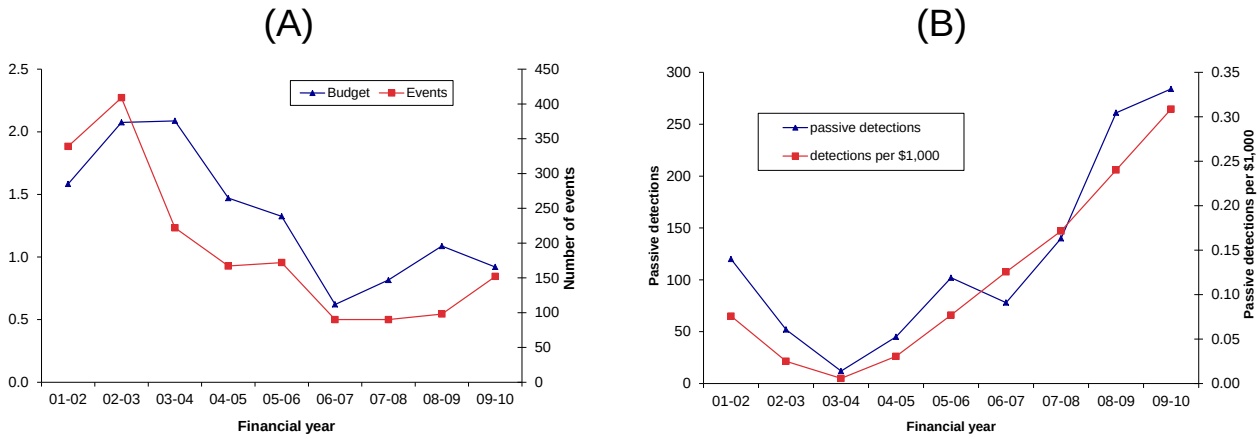


Figure 27. (A) The annual community engagement budget compared to the number of events per financial year. (B) The number of passive detections and passive detections per $1,000 per financial year.

However, the increase in passive detections could also be caused by an increase in the number of infestations, which would lead to increasing probability of contact with RIFA and therefore to more passive detections. Notwithstanding this possibility, these results suggest that return on investment could be calculated based on the degree to which passive detections replace or enhance the effectiveness of active search undertaken by pest-management agencies. The savings associated with this replacement of active for passive surveillance are a measure of return on investment.

To calculate this return on investment we used the data from 2006-2010 combined with simulation of the managed RIFA invasion. Simulations where undertaken based on the model described by Schmidt et al. (2010) and adapted by Spring et al. (2010) to simulate alternative search strategies. The mathematical description of the model and assumptions are presented by Schmidt et al. (2010) and not duplicated here. Briefly, the model generates probability maps for pest presence at annual intervals based on known ant colony locations from the previous time period. Derivation of a probability map is based on proximity to existing nests, habitat suitability and human population (equation 3 in Schmidt et al.). The model considers local growth and spatial spread on a grid of pixels representing one ha each. The model was calibrated based on data for the period 2001-2008.

The following steps were followed to calculate the return on investment in community engagement:

1. For each year (*t*) known colony locations were used, together with the habitat suitability map, to generate a probability map of pest presence based on the RIFA

spread model of Spring et al (2010). All known colonies at *t* were included in the calculations, whether actively or passively detected.

2. The amount of active search effort available (a proxy for the budget) was set to a desired value, expressed in terms of area (ha) that can be actively searched in one year using the standard search procedure.
3. A search map was created, based on the probability map from point (1), by selecting sites in descending order of probability until all search effort available had been used.
4. The detections for year t+1 were overlaid on the search map to determine how many of the known nests at t+1 would have been missed if passive surveillance would not have been available.
5. The process was repeated for increasing values of search effort and for *t*=2006 to 2009.
6. Curves were derived showing the number of known colonies that would have been missed as a function of active search effort in the absence of passive surveillance.

Figure 28 shows step (1), the probability maps calculated based on detections for 2006-2009.

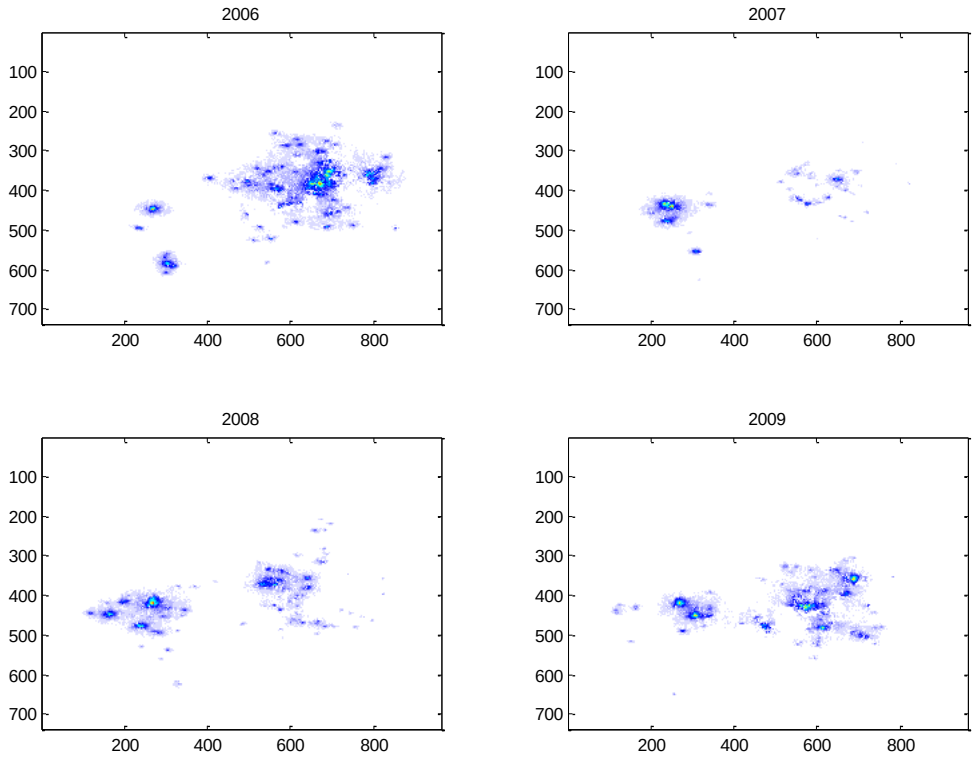


Figure 28. Probability maps of RIFA presence based detections for 2006 to 2009. Red represents high probability sites and blue low probability sites. Axis labels represent distances at increments of 100 m (each pixel represents 1 ha).

Figures 29 and 30 show step (4) for two values of active surveillance available. Figure 29 shows the case where the budget allows only 10,000 ha to be actively searched per year. In this case between 72 and 94 percent of nests would have been missed for the period 2007-2010 if passive surveillance had not been available. Even with enough budget to search 80,000 ha actively per year (Figure 30), up to 10 percent of colonies would have been missed if passive surveillance were not available. This assumes that the probability maps calculated based on the known infestations in the previous year (see Figure 28) are used to allocate search effort. Notwithstanding the uncertainty in model parameters and assumptions, and the need to update the habitat suitability map, this is a reasonable measure given the data available.

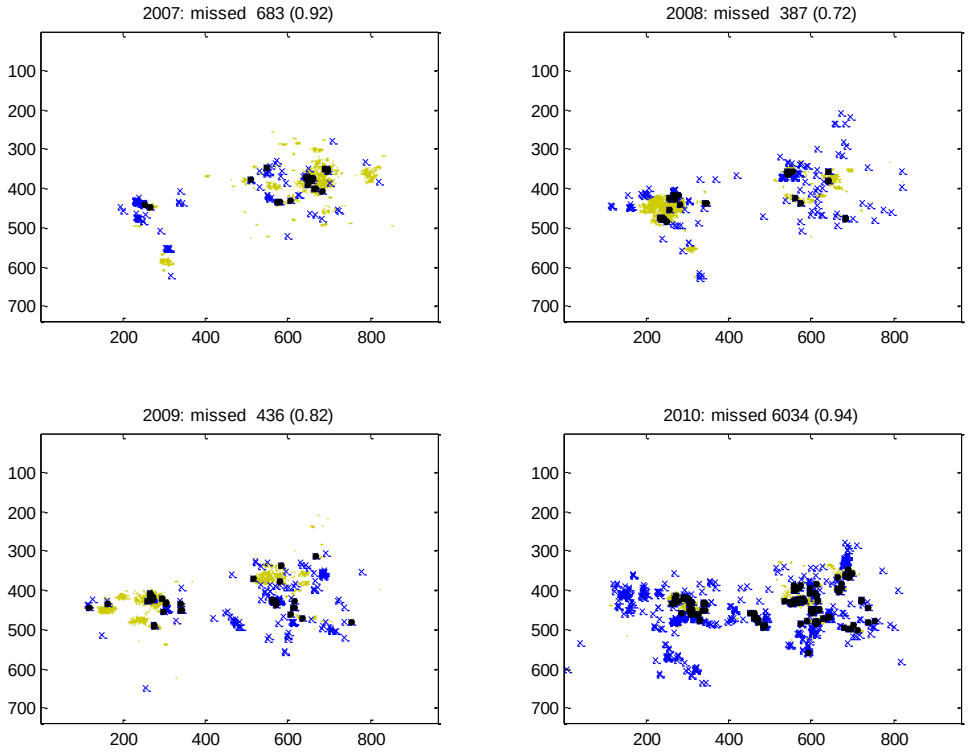


Figure 29. Known RIFA colonies that would have been missed without passive surveillance based on probability search with active search resources available to cover 10,000 ha. Dots represent nests that would have been found with no passive surveillance and using probability search, x's represent nests that would have been missed. Axis labels represent distances at increments of 100 m (each pixel represents 1 ha).

867

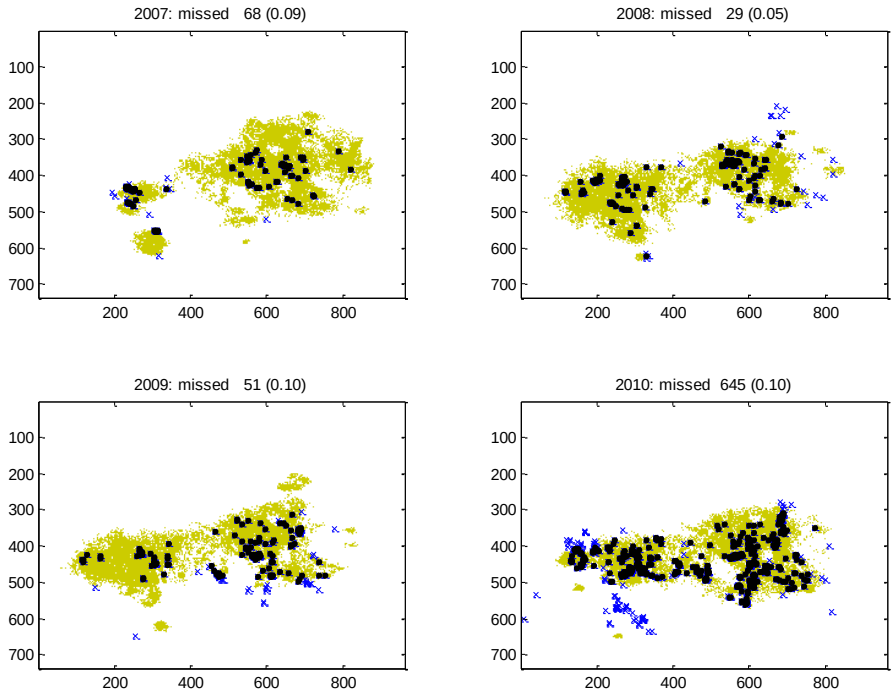


Figure 30. Known RIFA colonies that would have been missed without passive surveillance based on probability search with active search resources available to cover 80,000 ha. Axis labels represent distances at increments of 100 m (each pixel represents 1 ha).

Applying the analysis explained above for a range of search budgets, allowed us to find a relationship between search area and the proportion of nests that would have been missed in any given year in the absence of passive surveillance (Figure 31). Using these results the return to passive surveillance is measured as the amount of funds saved in active surveillance. Search budgets available in recent years would allow between 10,000 and 20,000 ha to be searched at a cost of \$400 ha^{-1}. The figure indicates that this sort of budget would result in over 50% of nests being missed if relying on active surveillance only. Search effort would have to be increased to between 150,000 and 200,000 ha to achieve a performance equivalent to that achieved currently with passive surveillance. This is roughly an increase of 130,000 ha searched at \$400 ha^{-1} = \$52 million.

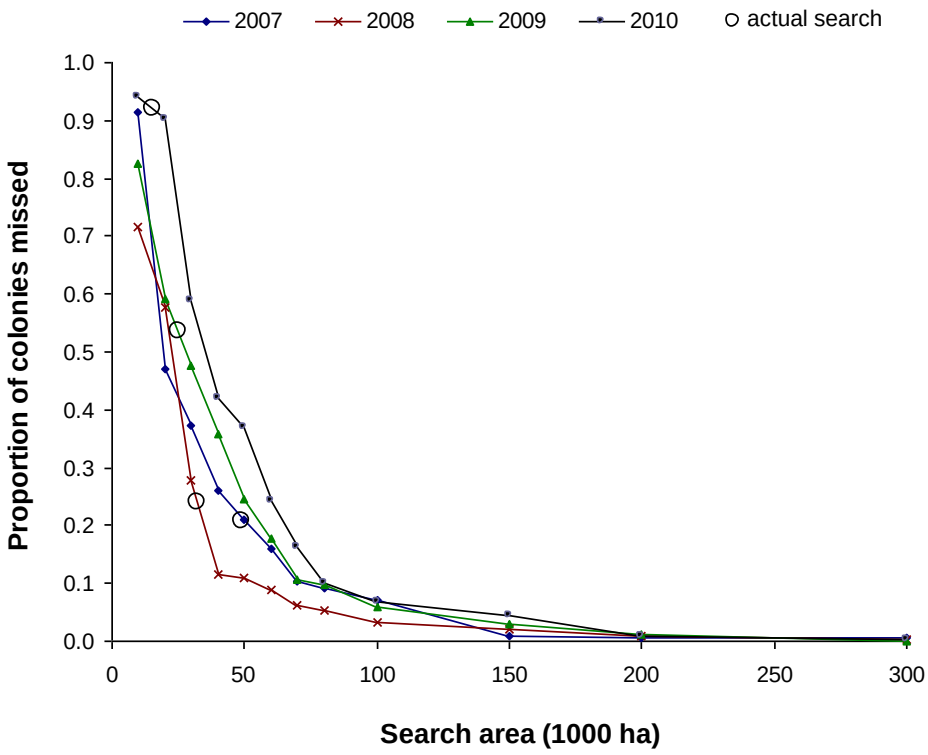


Figure 31. The proportion of colonies that would have been missed in the absence of passive surveillance with increasing amounts of active search resources (in terms of area that can be searched in a year) for the years 2007 to 2010. The actual amount searched each year is indicated by an open circle. This indicates that the RIFA program has decreased active surveillance over time as reliance on passive surveillance has increased.

In summary, our analysis indicates that the annual value of community engagement in the RIFA program is at least $52 million. Given the average annual expenditure on passive surveillance activities since 2007-08 of $861,000, this represents a return on investment of $60 per dollar invested in community engagement.

It is important to keep in mind that these are only approximate estimates based on simulations with a model that has been calibrated to RIFA data but which is still subject to both measurement and knowledge uncertainties.

A recent development that may affect the return on investment in community engagement is the introduction of remote sensing for RIFA nests. The cost of detecting ant colonies with remote sensing is expected to be substantially lower than with ground search (C. Jennings. pers. comm.) and this would reduce the savings achieved by introducing passive surveillance. However, remote sensing is likely to complement rather than substitute passive surveillance by allowing better coverage of areas with low population density. Conceptually, remote sensing could be integrated in the analysis by adding it as a new box under surveillance in Figure 1.

895

8. Conclusions and recommendations

In this report we have presented a wide variety of analyses in space and time and we have gained useful insights into the complex interactions between human populations and pest spread in the context of a managed invasion. The three aims of the project were achieved to some extent but additional questions remain to be answered.

Our first aim was to determine the value of passive surveillance as a component in a control protocol. This was achieved through a spatio-temporal model of the invasion and detection process combined with RIFA data for the period 2007-2010. An average return of $52 million was estimated, measured in terms of active surveillance savings. Given the average annual expenditure of $861,000 in community engagement over the same period, this represents a return of $60 per dollar invested in community engagement. This is a rough estimate of the value of passive surveillance and depends on the assumption of a cost of $400 per hectare searched using active surveillance. If this cost decreases, for example through the introduction of remote sensing, the value of passive surveillance may be lower than this. However, the final outcome is unclear because the sensitivity of remote sensing is likely to be lower than that of search crews on the ground. This fact would need to be considered when repeating the model runs to assess the value of passive surveillance in the presence of remote sensing.

Our second aim was to estimate a quantitative relationship between public reports and demographic features of households as reported in Census data. In this case we were not able to demonstrate that knowledge of the demographic characteristics of an area would enable prediction of the levels of passive detection. However, we suspect this inability may be due more to the complexity of temporal and spatial autocorrelation and bi-directional causal effects, than to a lack of relationships.

Our third aim was to explore relationships between community engagement events and public reports of suspected pest presence. As expected, we found that community events have an influence on the number of reports received from the public. Although many of these reports are false alarms, the information they provide is valuable in assessing whether the invasion is being contained. A more thorough analysis than was possible in this project will be required to estimate a causal relationship between events and passive detection probability. Our preliminary analysis confirms our expectation of the limited spatial and temporal influence of events (see Figure 14 and associated text).

Our findings also suggest there is a need to re-examine the value of habitat suitability mapping to guide active search in urban areas where there are high levels of "eyeballs to the acre". Habitat suitability mapping may still be valuable in low population density areas, or

areas with no population. There is also the possibility that the habitat map may need to be updated annually given the importance of disturbed soil caused by construction areas.

The richness and complexity of the datasets mean that a lot more statistical work will be required to make full use of data available in decision analysis. This work will have spinoffs beyond the RIFA invasion by providing information that can help improve the efficiency of invasion management in general.

Our findings demonstrate the amount of additional work required to use operational data systems for evaluative and research purposes. Given BQCC is likely to face future pressures on its funding, it would be worth them assessing the data systems to see where small changes could be made to improve the suitability of the systems for evaluation and research purposes, which would in turn improve their capacity to demonstrate the cost effectiveness of the program.

Given that no relationship was found between habitat suitability and colony detections, or between demographics and colony detection by the public, an option for future work would be to interview people who reported nests to determine how the colony was found. Initially this could be through a qualitative study with a random sample to find factors that affect people contacting BQCC, and check whether the results are related to demographics. If the answer is positive, then a larger sample could be used for quantitative analysis. This would give us a set of public detection methods. The frequency of each method could be interpreted as a probability of detection by that method. The relationships between detection methods and demographic variables could also be tested.

Recommendations:

1. The findings in this report should be considered when designing or updating contact databases of public reports, ensuring that the work cycles that affect data entry patterns do not introduce errors in dating of actual contact events.
2. Accurate geographical coordinates should also be obtained for all contacts when possible.
3. Negative samples indicate public awareness of the problem and willingness to cooperate with BQCC. Additional analysis is required to make better use of these data to calculate confidence levels of ant absence for particular sites.
4. Further analytical work should be undertaken to look at the interrelationship between spatial and temporal correlations in order to disentangle the possible effects of community engagement events leading to possible detection which in turn lead to more events in the area.

5. Future studies on RIFA management should consider the urban ecology of Brisbane (better land use maps, property values, bare soil assessment, etc) to help explain some of the spread and detection patterns found.
6. The habitat suitability map should be updated at regular intervals taking account of patterns of land disturbance.
7. Consider interviewing people who reported nests to determine how the colony was found and their motivation for reporting. This would help fine tune the mix of community engagement and active surveillance required in different areas depending on demographic features.

A desirable long term goal for this type of work would be to develop standard protocols for designing and using databases to manage invasive species by allocating passive and active surveillance more effectively in space and time. The environment invaded and the type of invader will affect this allocation. This means that similar case studies with other pests would be useful to gain a more general understanding of how program design features may be affected by the type of pest and the environment invaded.

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10. Appendix A. Data clean-up and preliminary analysis

This appendix contains a document prepared in the early stages of the project to communicate with BQCC and clarify the issues to be addressed and additional data needs.

10.1 Data compilation and aggregation

The dataset from BQCC contains the following fields: client ID number, latitude, longitude, spatial accuracy, type of surveillance activity/event (see dot points below), date, sample ID number, positive or negative for RIFA, ABS CCD[3] code, ABS SLA[4] maincode. The ABS CCD code enables the data to be merged with Australian Bureau of Statistics Census data for 2006.

This dataset posed a number of definitional challenges for the analysis. While the concept of passive surveillance by the public is a straightforward one, care had to be taken in how the concept was represented quantitatively using the CCS database. Firstly, there are a number of different types of events recorded in the database that represent different levels of passive surveillance activity by the public. These include:

- telephone requests for a kit for sampling ants for identification;
- the completion by the client of a survey over the telephone (used by BQCC to prioritise their response);
- telephone requests for the sample to be collected;
- receipt by BQCC of the sample; and
- the identification result, positive or negative for RIFA.

Some members of the public, having requested a kit, do not return it. Others bring samples they have collected themselves directly to BQCC at Oxley. Some members of the public request and/or return samples a number of times.

Consequently, analysis can be carried out with members of the public (each person contacting BQCC has an individual client ID number) as the unit of analysis, or with individual surveillance activities as the unit of analysis.

There are also differences in the spatial accuracy in the location of clients, with some being known to an exact location, and others attributed to either the centroid of a street, or a suburb, of a postcode. The numbers of records for each type of spatial accuracy is shown in Table A1.

[3] Australian Bureau of Statistics Census Collector Districts.
[4] Australian Bureau of Statistics Statistical Local Area.

Table A 1. Distribution of spatial accuracy in second dataset

Spatial accuracy	Number of records	Proportion of records (%)
Exact address	119,512	73.4
Centroid of postcode area	28,993	17.8
Centroid of suburb	9,968	6.1
Centroid of a building	359	0.2

The client data associated with an exact address were used in the spatial analysis. The remaining client data was utilised in non-spatial analyses. The distribution of clients with multiple records is shown in Table A2.

Table A 2. Distribution of clients with multiple records.

Number of records pertaining to a client	Number of clients	Proportion of clients (%)
1	35,265	42.8
2	29,186	35.4
3	5,310	6.4
4	11,002	13.4
5	1,151	1.4
6	278	0.3
7	137	0.2
8	37	0.0
9	12	0.0
10	6	0.0
11	5	0.0
12	2	0.0
13	2	0.0
14	2	0.0
15	1	0.0
17	1	0.0
18	1	0.0
20	2	0.0
21	2	0.0
22	1	0.0
23	1	0.0
26	2	0.0
35	1	0.0
42	1	0.0
44	1	0.0

A number of the clients with large numbers of records is associated with BQCC's site management regime, and consequently do not fall within the ambit of passive surveillance. BQCC will be supplying the IDs for these clients so that they can be removed from the analysis. Once these clients are removed, we will examine ways of incorporating the other clients with multiple records into the analysis.

The 35,256 clients with single records and an exact location are the subset within the dataset that are most amenable to statistical analysis. We have tested whether they are not significantly different from other clients in the dataset with respect to the other attributes recorded in the data base, or that they are in atypical areas compared to RIFA colony locations.

We have found that the main difference between the address-located clients and other clients relates to the date recorded for their surveillance activity event. This is a consequence of the improvement over time achieved by BQCC in the proportion of client

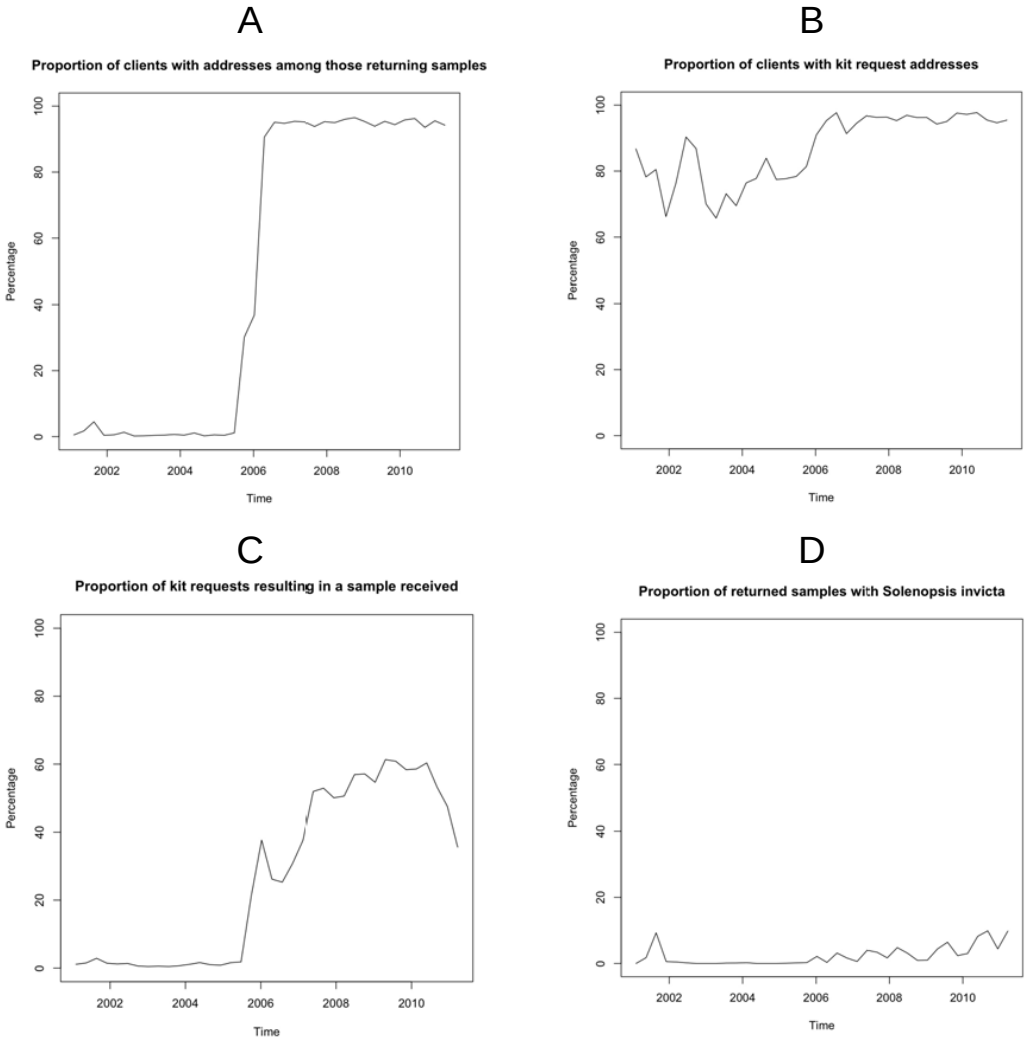

Figure A 1. **Time trends in the proportion of clients located by addresses and the sample return and positive identification rate. Proportions estimated over 100 day periods**.

records with an address. We are currently considering whether to confine the analysis to records after June 2006, which was the date of an upgrade of BQCCs client contact system. This is obvious in Figure A1, where the proportion of clients with addresses increased dramatically in 2006.

Figure A2, shows there are no obvious spatial differences in the location of address-located clients and other clients, and this is borne out by a highly significant cross-type Ripley's K function for the spatial dependence between the two types of client.

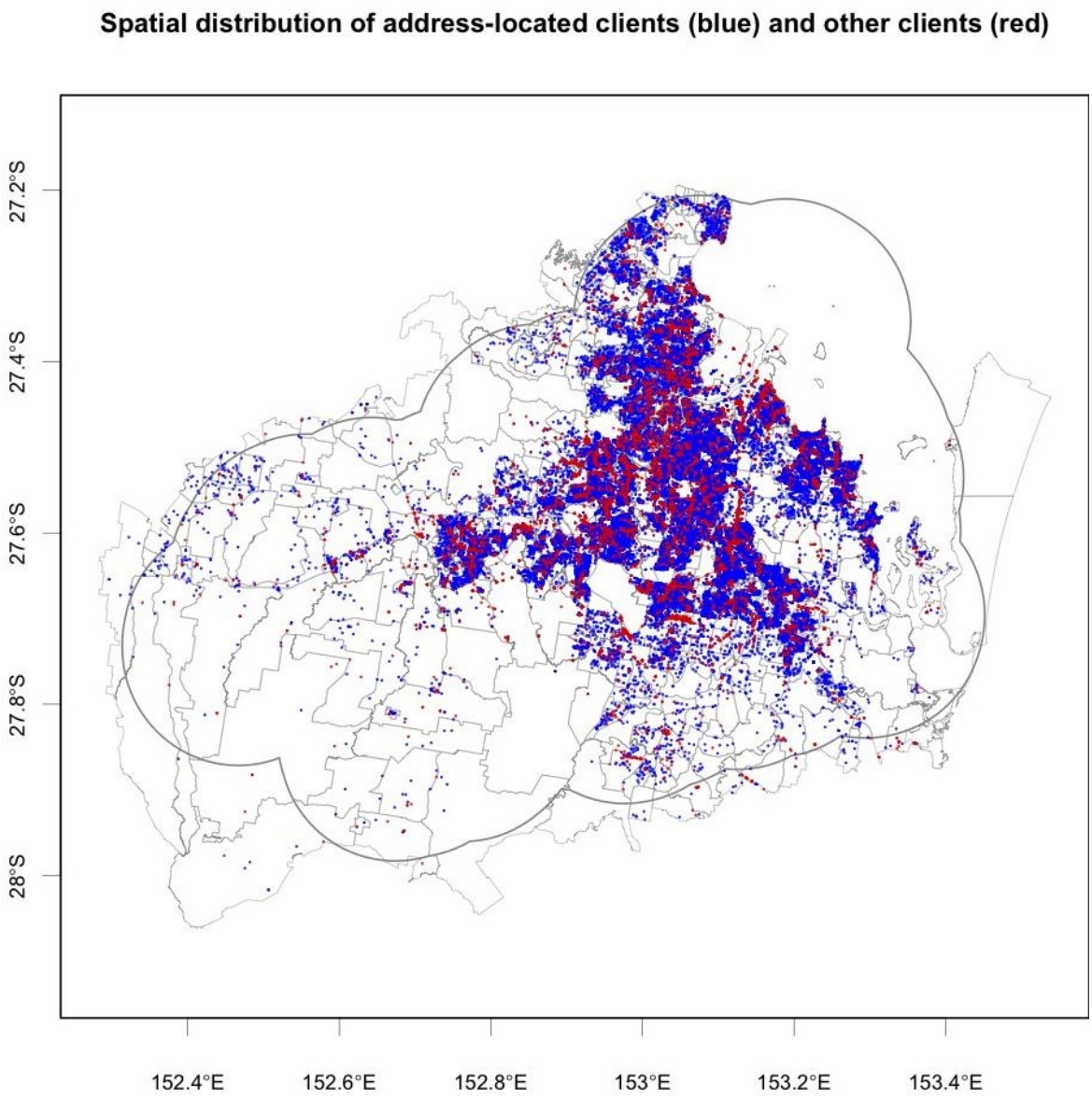

Figure A 2. Comparison of the spatial distribution of address-located clients and other clients. The black bounding arc represents the area of interest

Figure A3 shows an acceptable concordance between the spatial distribution of address-located clients and RIFA colonies. There appear to be only two areas where there are colony locations without large numbers of clients nearby. These are the Port of Brisbane, where there are few residential areas, and the area south-west of Ipswich, where population densities are lower.

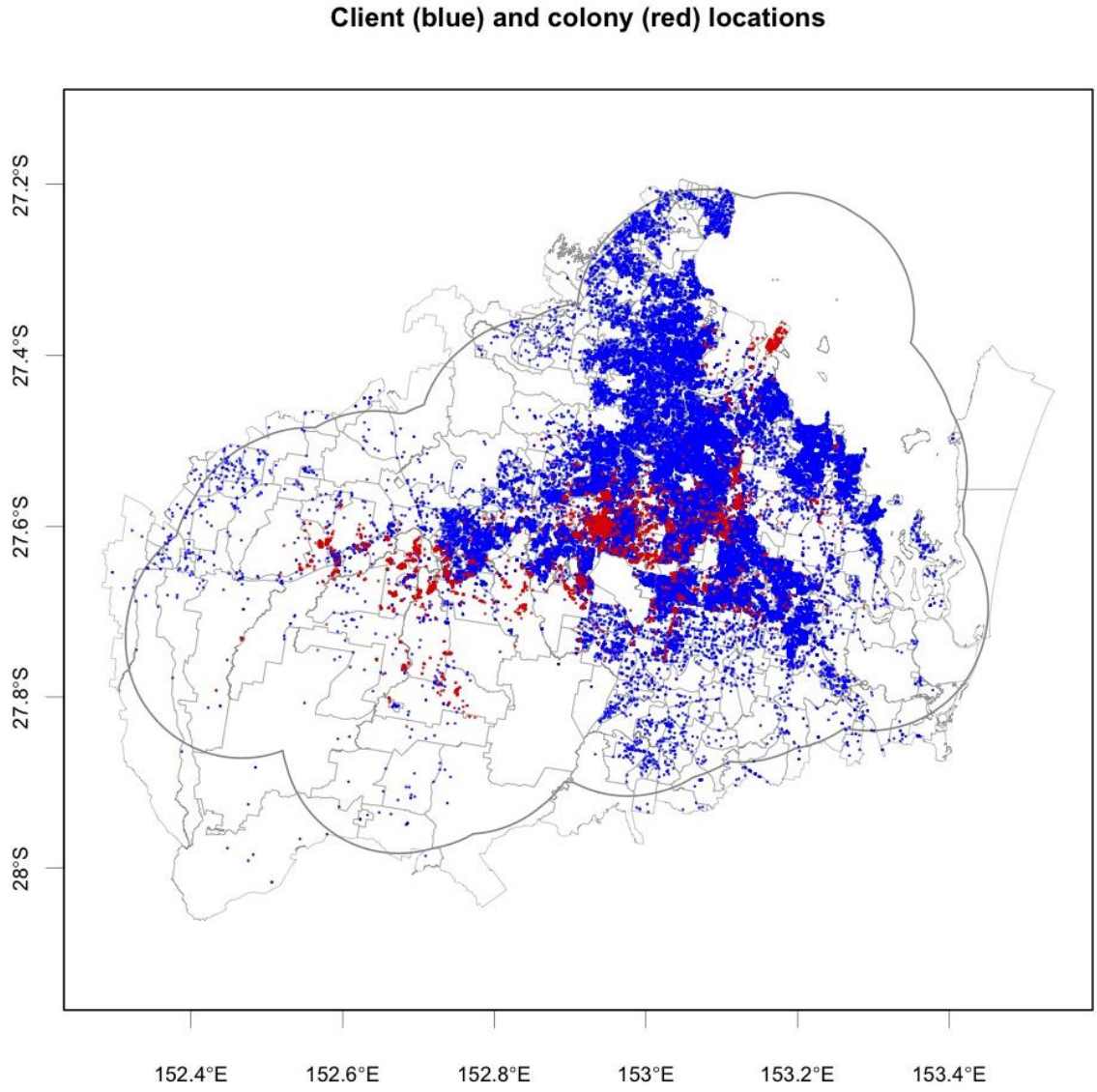

Figure A 3. Comparison of the spatial distribution of address-located clients and *S invicta* colonies. The black bounding arc represents the area of interest.

10.2 Data visualisation and exploratory analysis.

Preliminary exploratory analysis and visualisation of the relevant 2006 ABS Census data at CCD level focused on the proportion of people participating in voluntary work and a range of other Census indicators that might be expected to be related to the proportion doing voluntary work. These Census indicators were considered to have the highest likelihood of being related to passive surveillance activity by the public.

The analysis showed that there were relatively well defined patterns in the spatial distribution of the values of the Census indicators. For example, the distribution of proportion of people participating in voluntary work, shown in Figure A4, shows higher levels of participation in the

more affluent inner western suburbs and in the semi-rural south western periphery, with lower levels of participation in the southern suburbs and along the south east growth axis towards the Gold Coast.

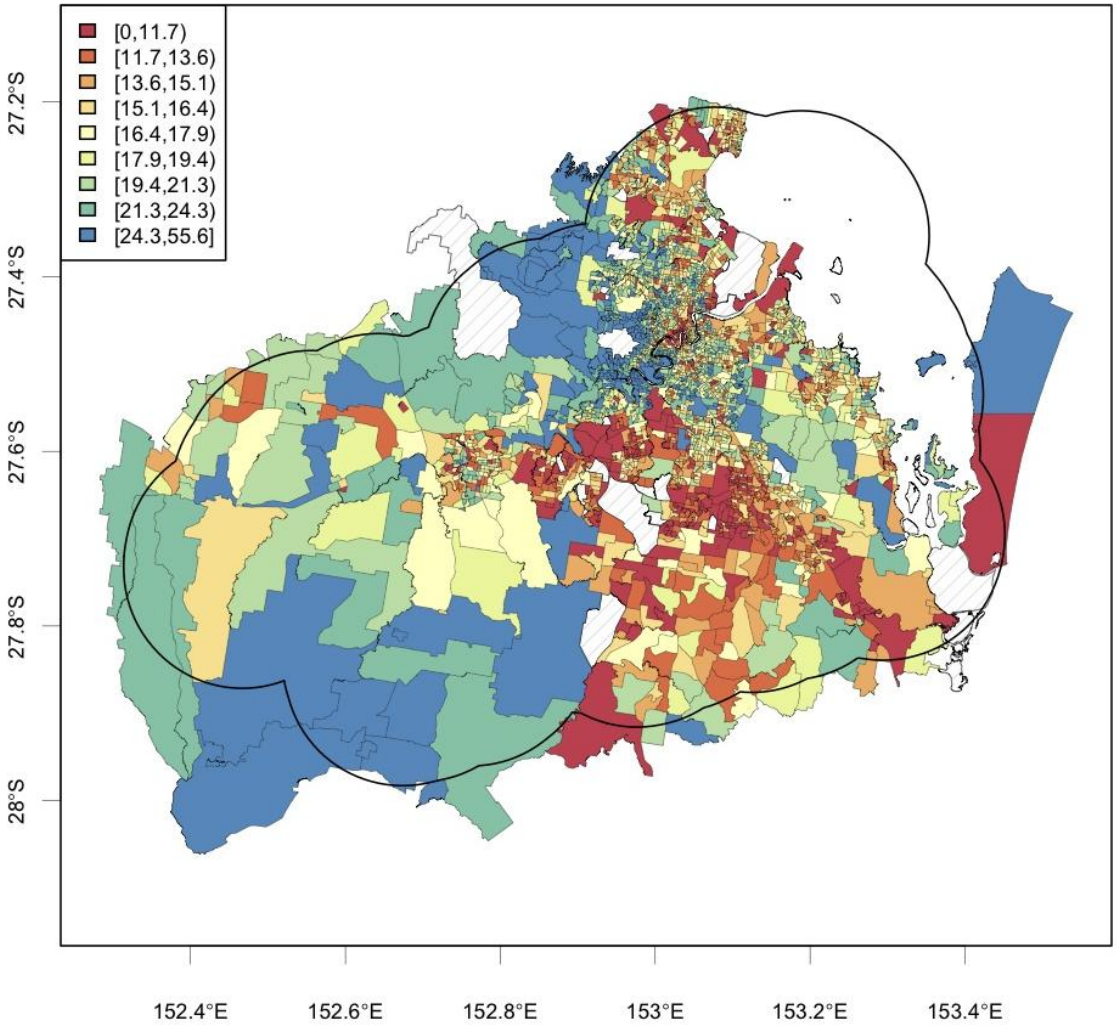

Figure A 4. Spatial distribution of level of participation in voluntary work. The black bounding arc represents the area of interest.

Overall, the results suggest there is significant spatial autocorrelation in the dependent variable in three sub-areas within the Area of Interest. These are:

- the peri-urban and rural areas south-west of Ipswich, where there is a concentration of CCDs with high levels of voluntary participation,

- the inner western suburbs of Brisbane, where there is also a concentration of CCDs with high levels of voluntary participation, and
- the growth axis from Logan City to the Gold Coast, where there is a concentration of CCDs with low levels of voluntary participation.

The presence of significant spatial autocorrelation suggests the need for spatial regression. For the purposes of the trial, the following independent variables available from the 2006 Census were selected – percentages of persons or households in each CCD with the following characteristics:

- unemployed persons,
- low income households,
- households in a rented dwelling,
- single parent families,
- persons over 65 years of age,
- graduates,
- households with language spoken other than English,
- females (adults) in non-routine occupations, and
- persons resident in CCD for less than one year.

The results in Figure A5 suggest some relationships between voluntary work and independent variables but no serious multi-collinearity between independent variables. Ordinary least squares regression indicates all independent variables are significant at least at the 0.05 level, with the exception of total unemployment, which is not significant. Adjusted R-squared is 0.505 and significantly greater than zero.

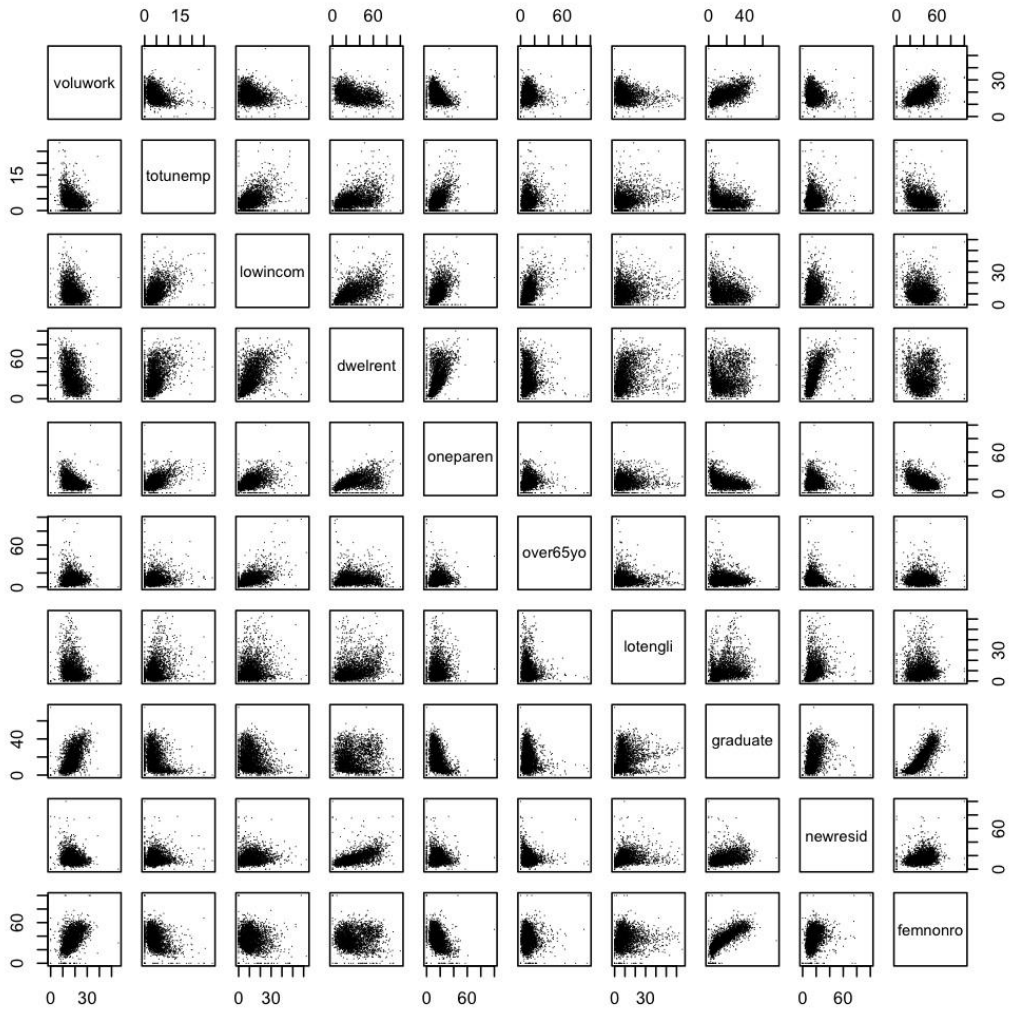

Figure A 5. Lattice scatter plots for selected census variables

10.3 Spatial trends and autocorrelation analysis.

The preliminary exploratory analysis of the Census data showed that there was relatively strong spatial autocorrelation in the Census indicators examined. For example, Figure A6, below, shows the Moran scatterplot for proportion of people participating in voluntary work. This has a highly significant Moran I statistic of p = 2.2e-16. So the graph shows the relationship between the value for each CCD and the mean value of its neighbourhood. The concentration of points along the diagonal suggests there is spatial autocorrelation, i.e. if the percentage voluntary work is high in a CCD, it tends to be high in the neighbourhood of that CCD. Similarly, if it is low in a CCD, it tends to be low in the neighbourhood.

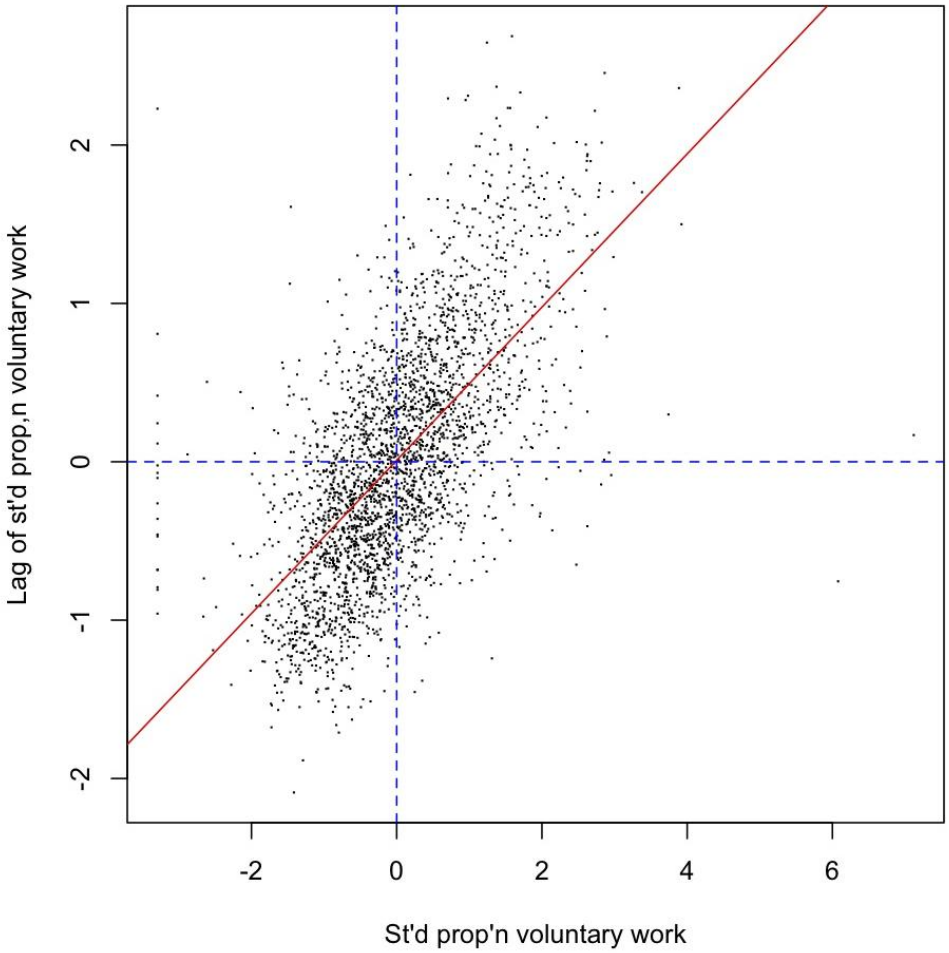

Figure A 6. Moran scatterplot of proportion participating in voluntary work. The x axis is the standardised percentage doing voluntary work for each CCD. The y axis is the mean of the same indicator across the CCDs that are contiguous (share a boundary), to each CCD.

The hot spot analysis for the same Census indicator is shown in Figure A7. This shows regions of significant spatial autocorrelation across CCDs with high participation rates in the south-western periphery and the inner western suburbs (red hot spots), and significant spatial autocorrelation across CCDs with low participation rates along the south-east growth axis (blue cold spots).

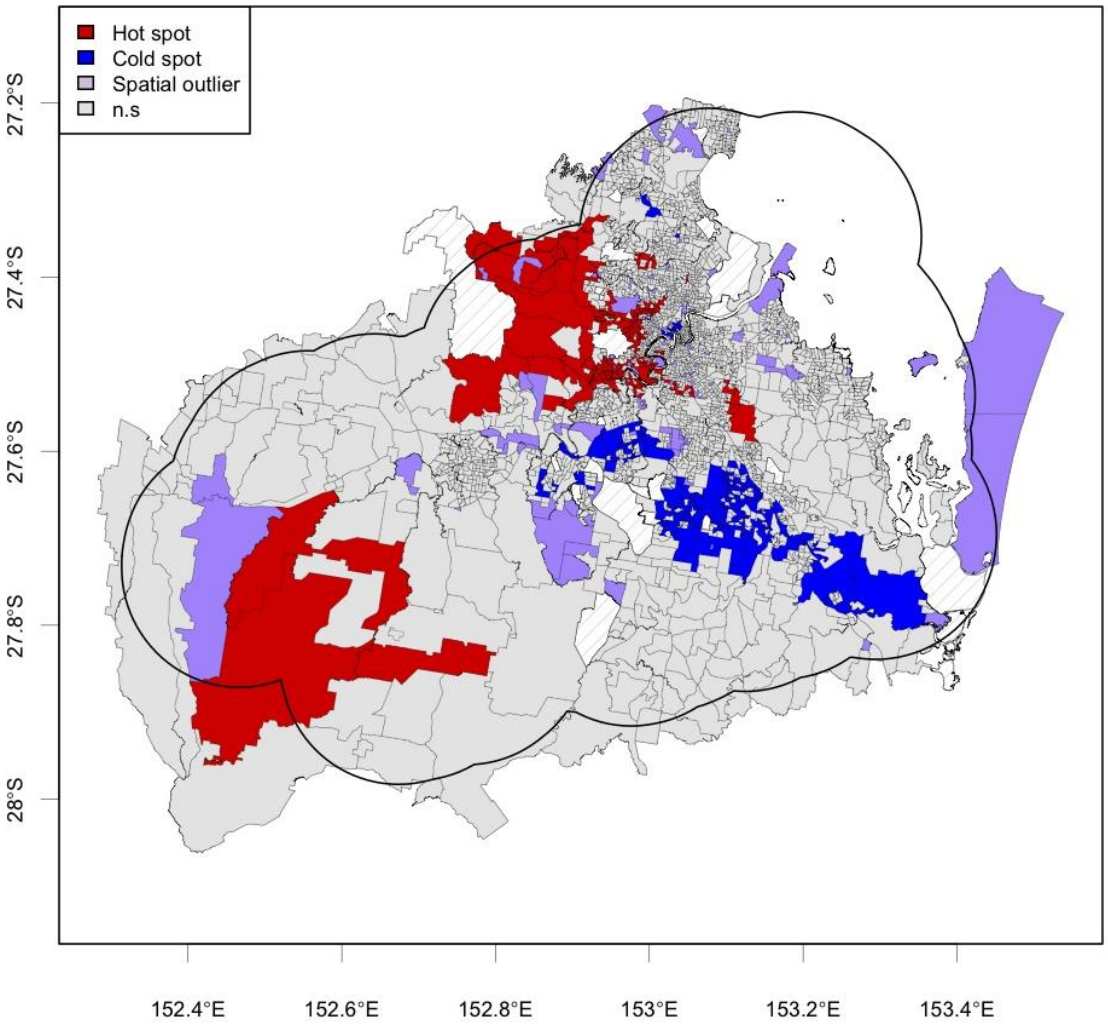

Figure A 7. Hot spot analysis for proportion participating in voluntary work. The black bounding arc represents the area of interest.

Preliminary regression analysis was undertaken, examining the relationship between the number of sample receipts in a particular time period, and the number of sample receipts in the previous time period, together with a range of Census indicators. This work showed that, while the Census indicators have acceptable distributions, the distribution of the number of sample receipts in a time period is particularly ill-shaped compared to the normal distribution that ordinary least squares regression requires. Figure A8, below, shows the spatial distribution of the number of sample receipts in 2006. It can be seen that there are a small number of CCDs with one or more samples, and a large number with zero receipts, resulting in a highly skewed distribution. Furthermore, the areas with high numbers of sample receipts are clustered, suggesting strong spatial autocorrelation. However, expressing the sample receipt numbers as the logs of proportions of CCD populations was found sufficient to transform these variables to a distribution suitable for regression analysis.

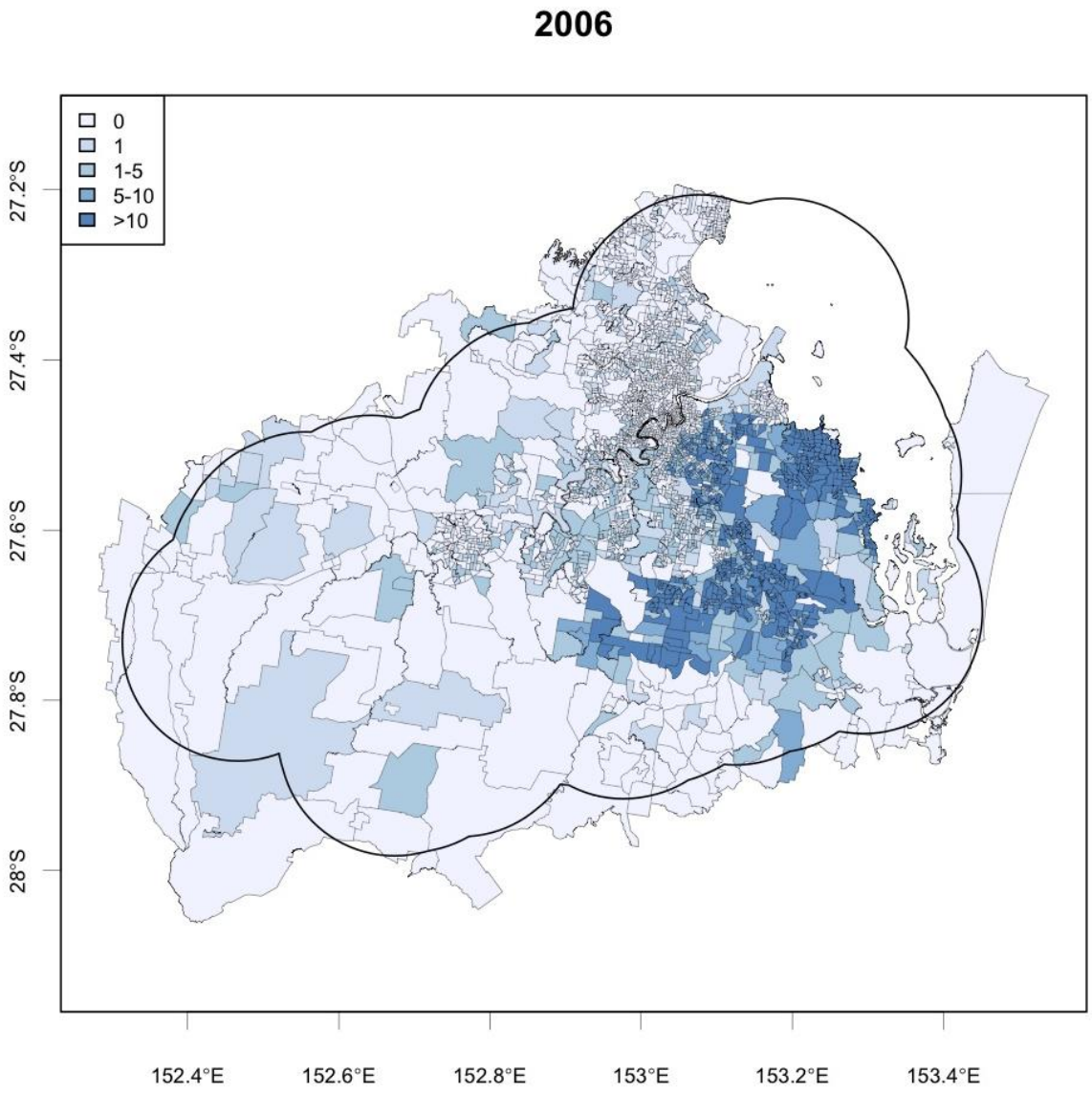

Figure A 8. Spatial distribution of sample receipts in 2006. The black bounding arc represents the area of interest.

Preliminary regression results showed that the level of passive surveillance activity, as reflected in the number of sample receipts per head of population, tends to be higher for CCDs with higher population densities, lower levels of education, higher proportions of people with non-English speaking backgrounds and lower proportions of rented dwellings. However, the R-squared values were low, at best around 0.2, suggesting only weak predictive power for these Census indicators. Since some of the directions of these relationships are opposite to what might be expected, further investigation is required.

11. Appendix B: Community Engagement Activities at BQCC

Prepared by Marion Lawie, Community Engagement Officer at BQCC, 29/11/2010

National Red Imported Fire Ant Eradication Program: Community engagement activities

Working in long term partnership with stakeholders (community, industry, colleagues) to ensure program awareness and participation because this is critical to achieving eradication

We **want** everyone to:

- look for and report suspect ants
- let us onto their properties so we can do treatment and surveillance
- comply with movement controls
- champion the program within their spheres of influence

Everyone is:

- Industry bodies
- Individual businesses
- Community groups
- Residents, tenants and landholders
- General public, specifically Indigenous and CALD groups where appropriate
- Local councils
- Schools and colleges
- Volunteers
- Elected representatives
- Other state and federal departments and agencies
- Other units within our own department

To get what we want, everyone has to be **motivated** to act.

That means they need to be

- aware
- informed
- educated
- able

In short, they need to be **engaged**.

Some **tools** we use:

- presentations/slide shows
- displays, posters, signs, stickers, flyers, brochures, magnets, identification cards
- giveaways – water bottles, caps, Frisbees, magnifying cards, balloons, mini footballs
- sample kits
- maps
- web pages
- live ants
- materials for teachers and children (educational and just fun ones)

Some **methods** we use:

- Events and displays (recorded in CCS)
    - we look for appropriate events in a target area and invite ourselves along,
    - we accept invitations (prioritising target areas)
    - we set up our own if there's nothing else (and invite others where appropriate)
- Static displays (CCS)

    - Display board with comparisons of RIFA and natives.
    - Sample kit stands
    - Tear off slips in hardware outlets and Bunnings stores
    - Posters and brochures placed in vet surgeries and dog parks. Medical centres, pubs, post offices, retail outlets etc etc
- Education and training (recorded in CCS)
    - we offer to deliver talks/lessons/materials to schools in target areas
    - we accept invitations from schools (prioritising target areas)
    - Provide words to be included in newsletters and materials including brochures, id cards to be sent home to parents and contract activities for in class
    - we conduct regular industry training sessions both at Oxley (for mixed businesses) and onsite (for individual businesses at their place of business)
        - trainees usually attend because our inspectors tell them to; businesses such as Energex require contractors to attend training whether individuals required accreditation for their role or not
    - we conduct regular approved persons training sessions for council employees, officers of state and federal departments and staff of “utility” agencies and bodies at Oxley and onsite at their place of business
        - trainees usually attend because their agency requires them to work within fire ant restricted areas (RA)
        - trainees are responsible for carrying out initial site inspections and issuing site inspection reports before disturbance of the ground or movement of high risk materials around or from the site within an RA
- Networks
    - We encourage our contacts to pass information along to their contacts (e.g. environmental groups, wildlife carers)
    - Provide copy for newsletters
    - We attend to information flowing back to us through networks (e.g. Pest Management Technicians)
- Partnerships (recorded in CCS)
    - We have developed a partnership with individual real estate agencies across and around the fire ant restricted area of SEQ where agencies provide fire ant and movement control information to new tenants and buyers and submit completed Property Information Forms (PIF) to BQCC
    - Cross department relationship of sharing and distributing information eg CSIRO Rural education program, RIFA info in Mobile Office Unit and RIFA info on Communities stand at events.
- Community talks (recorded in CCS)
    - we offer to deliver talks to groups in target areas
    - we accept invitations from groups (prioritising target areas)
    - we recognise the extra value of talking to some groups who may be more likely to encounter ants, e.g. gardening clubs or environmental groups
    - we also recognise the value of talking to groups such as Rotary or Neighbourhood Watch as they include people with a wide range of interests and networks who may not otherwise tune in to a message about pest ants
    - Provide copy to be included in newsletters also brochures and id cards for distribution to members and visitors
- Media (recorded in CCS, copies of all clips are available, some reports on value of news media – equivalent to paid advertising)
    - We pursue a constructive media strategy, pushing information out to gain free media coverage reaching a wide demographic
    - We want people to know we’re still here and still important
    - We want people to know what’s going on, especially if there are any developments in the program (e.g. major detections or just start of treatment season)
- Paid advertising (we should have proofs and cost estimates of all ads but will be a bit of a task to dig them out, not hard, just a bit time consuming)
    - For guaranteed exposure, we’ll pay
    - Specific campaigns (e.g. rewards, ‘find the last fire ant’, ‘look check call’)

    - To support on ground engagement activity (e.g. ads that 'match' the posters that match the postcards all in the same area)
    - To promote other program activity (e.g. public meetings)
    - Public notices (e.g. aerial treatment, road closure for treatment)
- Mailouts (records exist but are inconsistent)
    - To tell residents/landholders they are in a restricted area (and what this means)
    - To tell them there is an infestation nearby
    - To tell them they are in a treatment zone
    - To tell them they are in a surveillance zone
    - To ask them to respond to us
        - Check your yard and tell us if you have suspect ants
        - And if you don't have suspect ants!
        - Give us your property information so we can come and treat/inspect
- Doorknocks (residents)
    - To let them know we're here to treat/inspect (records in FAIS)
    - To ask for aerial treatment consent
    - For volunteers to offer to inspect (one off)
- Letterbox (residents) (records exist but are inconsistent)
    - To let them know we need access to treat/inspect
    - To let them know we're no longer active in the area but they still should be (so, operations complete but awareness still required) (one off)
    - To provide program updates (no longer happening)
- Telephone calls (residents) (records mostly in FAIS)
    - To let them know we need access to treat/inspect
    - To ask for aerial treatment consent
    - To give them details of when we will be aerially crossing their property (for treatment, proximity, overflight)
    - To let them know we're planning to fly over for remote sensing data capture
- Signage (proofs and estimates are saved on the server)
    - Signs on cars identifying them as 'Biosecurity Qld' and 'Fire ant program'
    - Large signs placed in strategic spots for short periods to notify of helicopter activity in the area
    - A frame signs to notify of operational activity in the area (i.e. treatment or surveillance)
    - Metal roadside signs reminding drivers of movement restrictions
    - Corflute signs raising fire ant awareness ('protect your suburb')
    - Corflute signs confirming businesses are fire ant savvy
    - Bumper stickers and ARMP stickers for high risk businesses
    - Variable message signs (big LED things, under contract, not yet received)
- Elected representatives (three levels of government, all parties) (records in CCS)
    - We tell them when we're attending a display or event in their area (so they can come along or promote our appearance through their usual channels)
    - We tell them when we're doing something unusual such as remote sensing or if we have a major detection in their area (this often means they can deal with enquiries or complaints made to their office from a position of confidence in what is going on and they're less likely to refer them to us or Minister's office)
    - We send them regular updates on what is happening in the program (if they are engaged in what we are doing they are more likely to publicly and privately support us)
- Volunteers (Fire Ant Volunteer Rangers) (records in CCS)
    - Receive training, program updates, workshops
    - Conduct surveillance in public areas outside operational areas and can collect ant samples
    - Act as a link between community and BQCC's programs and distribute information and give talks
    - Staff or assist at fire ant and other BQCC displays in SEQ
    - Provide administrative assistance to Community Engagement when required (mail-outs, updating data bases, contacting stakeholders)
    - Respond to new alerts and emergencies (Mexican feather grass, Equine Influenza) by providing information tables at key sites and letter box drops.

- Online tools
    - Pages on DEEDI website (current) (Google analytics shows number of visits)
    - Tweets through Biosecurity Qld twitter account (current)
    - Sniffer dogs facebook page (seeking approval)
    - Youtube videos (in planning, not yet seeking approval)

Campaigns/strategies (plans, surveys, some write ups)

- Find the Fire Ant Week/Day
- Beyond SWETA/Rural protection program/Beyond Amberley (western geographic focus)
- South East Community Area (Logan geographic focus)
- Find the Last Fire Ant
- Reward Scheme

Results – how do we know if we're getting the message through? (and how can we measure this)

- Reports of suspect ants (CCS)
- Sample submission (CCS)
- Feedback (complaints and compliments) (FAIS)
- Media response (CCS – basic info, clips will show circulation and 'tone' of report)
- Access to properties (FAIS)
- Market research (various formats of information available)
- Queensland Householder Survey (through Treasury, reports available)
- Feedback forms from training/talks
- Direct enquiries resulting from signage (anecdotal, e.g. aerial signs)
- Site inspection requests (FAIS)
- Visits to web (Google analytics top pages – e.g. maps of restricted areas and identification)
- General enquiries through call centre (CCS, some double up of the above)

12. Appendix C: UNE Data Request Document

UNE DATA WISH LIST
4 February 2011

The tables below assume that it is possible to get from the geo-referencing of individual items in the Client Contact System (CCS) and FAIS to a Census Collector District (CCD) code for the CCD that contains the particular point associated with an item.

The text beside each CCD and/or FAIS data type is a preliminary indication of the data fields that would be useful for the UNE project.

Each data type has been assigned an importance level for the UNE project.
1: Regarded as essential, provided it is technically feasible to extract the data.
2: Nice to have if it can be easily extracted, but not absolutely essential.
3: Not required for the moment, but might be considered in the future, provided extraction is straightforward.

Data for constructing community response indicators
These are the indicators that attempt to quantify the level of public surveillance activity. We will probably subdivide these further for the analysis, separating indicators of actual surveillance behaviour, of intention to undertake surveillance, of knowledge as to how to undertake surveillance, of awareness of the existence of fire ants etc.

Importance	*Data type*	*Indicative data fields*
1	Reports of suspect ants (CCS)	Date, CCD, actual species, id? [1]
1	Sample submission (CCS)	Date, CCD, actual species, id? [1]
1	Direct enquiries resulting from signage (anecdotal, e.g. aerial signs)	Date, CCD [2]
1	Visits to top pages of website (Google Analytics)	Hits per day, click throughs per day. [3]
1	Counts of calls to call centre about fire ants	Date, CCD, count.
1	Volunteer surveillance (CCS)	Date, CCD, number of volunteers, duration.

Notes:
[1] If people reporting suspect ants are sent a sample kit and they submit a sample, we would like to treat this as a single response. If a report and a sample from the same person is assigned a unique id number, can we also have the id, so we can collapse reports and samples when they come from the same location.
[2] Is it possible to separate genuine community interest about fire ants from other reasons for making an enquiries (e.g. “Who made those neat signs you’re using? I want to get some made for my business.”)?
[3] If preferred and acceptable, we could extract what we need from Google Analytics ourselves if we can be given access.

Data for constructing intermediate response indicators
These are the indicators that attempt to quantify mediating factors that are not direct Program investment activities but which nevertheless might impact on the level of public surveillance activity.

Importance	*Data type*	*Indicative data fields*
1	Media response (CCS – basic info, clips will show circulation and ‘tone’ of report)	Date, type of media, tone, anything on circulation or audience area

Notes:
Media here is different from media in the table below. This one is for when the media takes the initiative. In the table below, media is when the Program takes the initiative by, for example, putting out a press release.

Data for constructing investment indicators

These are the indicators that attempt to quantify the level of public investment in encouraging public surveillance activity.

Importance	*Data type*	*Indicative data fields*
1	School activities (CCS)	Date, CCD, resources invested [1], number of pupils involved, type of activity.
1	Real estate agent partnerships (CCS)	Date, CCD, resources invested [1], type of activity.
1	Community talks (CCS)	Date, CCD, resources invested [1], type of audience, size of audience.
1	Volunteer training (CCS)	Date, CCD, resources invested [1], type of activity, number attending.
1	Volunteer talks (CCS)	Date, CCD, number of volunteers, type of audience, size of audience.
1	Volunteer display/event assistance (CCS)	Date, CCD, number of volunteers, type of activity, attendance estimate.
2	Events and displays (CCS)	Date, CCD, resources invested [1], attendance estimate
2	Static displays (CCS)	Date established, date removed, CCD, resources invested [1], type of display.
2	Media (CCS)	Date, resources invested [1], type of media, anything on circulation or audience area.
2	Paid advertising	Date, resources invested [1], type of media, anything on circulation or audience area.
3	Networking activities	To be discussed if needed.
3	Door knocking (FAIS)	Date, CCD, reason for contact, volunteer or staff.
3	Letter boxing	Date, CCD, reason.
3	Telephone calls	Date, CCD, reason.
3	Signage	To be discussed if needed.
3	Elected representatives	To be discussed if needed.
3	Twitter, facebook and youtube	To be discussed if needed.

Notes:
[1] This could be number of staff in attendance at an event, number of person days preparation for an event or activity, monetary outlays for event, display or activity. Whatever is available and easily extracted.

Data for context and interpretation

Importance	*Data type*	*Indicative data fields*
1	Market research (various formats of information available)	Just put reports in a zip file