Stage 2 Report

Review of likely eradicability of Asian honeybees (*Apis cerana*) in Queensland

Prepared for:
Biosecurity Queensland, Department of Employment, Economic Development and Innovation

25 October 2010

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Abbreviations

AHB	Asian Honey Bee
BQ	Biosecurity Queensland, Department of Employment, Economic Development and Innovation
DEEDI	Department of Employment, Economic Development and Innovation
IP	Infected Place (usually a nest or swarm)
PID	Positive identification (identification of one or more *A. cerana* bees at a location, not associated with a swarm or nest)
RA	Restricted Area for *A. cerana,* declared in an approximately 60 km radius around Cairns and district

Executive Summary

An established nest of Asian honeybees (*Apis cerana*) was first detected in North Queensland in 2007. A response was immediately implemented to establish the extent of the incursion with a view to eradicating this exotic bee species and any exotic parasites they might carry. By the end of 2007 the infestation was thought to have been eradicated and operations were scaled back to "proof of freedom" surveillance. However in July 2008 a nest was discovered 7 km south of the previous findings which led to further detections in the Cairns area. Since then a response has been maintained by Biosecurity Queensland, DEEDI, to detect and eliminate *A. cerana* nests. By 30 September 2010, 230 IPs (59 swarms and 171 nests) were detected and destroyed. This report presents the results of the analysis and interpretation of data collected during the response, with a view to determining the feasibility of successful eradication of this pest.

AHB detections continued sporadically until mid-2009, when numbers started to increase. During 2010, numbers of IPs detected have increased substantially, correlated with the increase in staff numbers during that time. AHB has now spread mainly south and west from Cairns, with foci detected at Mareeba, Lake Eacham/Atherton, Innisfail and south of Cairns between Gordonvale and Innisfail. Spread has also occurred to Yarrabah (east of Cairns) and the suburbs to the north of Cairns. However, all IPs detected to date (except for a single nest at Innisfail, just outside the RA) have been within the declared Restricted Area. Detection of nests and swarms during the incursion has relied on public reporting, supported by BQ surveillance, using a variety of methods. BQ has maintained an intensive surveillance program, which has increased with the availability of additional staff since early 2010, resulting in the dramatic increase in detections.

Seven indicators of likely eradicability of the incursion were identified and considered:

1. Extension of the incursion outside the RA
A. cerana has shown an ability to colonise and establish nests or swarms in a wide variety of locations and situations, including in vehicles, boats, containers and machinery, allowing spread to occur over considerable distances. To date, there has not been any identified spread to areas beyond the RA (other than Innisfail). Should such spread be detected it would indicate likely failure of eradication, unless there was strong evidence that the spread event was recent and that further local spread had not yet occurred.

2. Presence of undiscovered foci of infection within the RA
Currently, the extent of infection within the RA appears to be well defined. Detection of new, well established foci of infection in areas previously thought to be free of AHB would indicate failure of existing surveillance and probable failure of eradication.

3. Establishment of A. cerana within the rainforest
Currently *A. cerana* is thought not to persist within the rainforest, but will colonise at the margins so it can forage outside. Discovery of established nests within the rainforest would undermine this assumption and indicate probable failure of eradication.

4. Continued occurrence of isolated PIDs without detection of nests
There have been a small number of instances of single or small numbers of isolated PIDs being detected in an area and being unable to be traced to a nest (due to the failure to find additional bees to enable beelining). Continued occurrence of isolated PIDs in the absence of detectable nests would suggest that there are persistent undetected nests and swarms, leading to likely failure of eradication.

5. Numbers of detections
The numbers of nests and swarms detected have increased dramatically during 2010, reflecting the substantially increased staff numbers in the same period and the introduction of targeted sweeping, floral sweeping and bee traps since July 2010. Continued high numbers of detections in coming months would indicate an increasing bee population and likely failure of eradication. Conversely, decreasing numbers of detections could indicate likely success in eradication, but should be interpreted with caution due to the potential for confounding the issue due to a natural seasonal decline in numbers of bees foraging and hence numbers detected. Additional data over coming months is required to determine whether numbers will trend upwards or down.

6. Percentage or absolute number of swarms detected
The number of swarms present (and hence the number detected) is a function of the numbers of nests present, assuming that the efficiency of swarm detection remains unchanged. Therefore, a downward trend in the numbers (or percentage) of swarms each month would indicate potential for eradication, while an upward trend would indicate likely failure. Again this needs to be interpreted with care if seasonal effects are likely to be important. Currently, there is a downward trend since June 2010, but more data is required to confirm this trend.

7. Age of nests detected
Age of nests detected is another approximate guide to potential success of the eradication program. If the program is succeeding, we would expect to see the average age of detected nests getting progressively younger, to the extent that eventually nests will be consistently detected at an early age, before they have an opportunity to swarm, leading to eventual eradication. There is a slight downward trend in the mean age of nests detected since the beginning of 2010, although this is interrupted by an upward jump in August and September, associated with increased surveillance activity. Additional data is required to determine whether this trend will resume its downward direction or whether mean nest age will stay high, and also whether the range of ages will become narrower over time.

Conclusion and Recommendation

Based on the available data, eradication of AHB appears to be still feasible. However, given the widespread distribution of the incursion and the continuing detection of older nests and isolated bees which cannot be linked to a nest, successful eradication is not certain.

It is recommended that the current program continue for another six months to allow a clear trend in the above indicators to develop, with re-evaluation of progress at that time.

Background

An established nest of Asian honeybees (*Apis cerana*) was first detected in North Queensland in 2007. A response was immediately implemented to establish the extent of the incursion with a view to eradicating this exotic bee species and any exotic parasites they might carry. By the end of 2007 the infestation was thought to have been eradicated and operations were scaled back to "proof of freedom" surveillance. However in July 2008 a nest was discovered 7 km south of the previous findings which led to further detections in the Cairns area. A response plan was subsequently submitted to the Consultative Committee for Asian honeybees and to date has been based upon the principles of the AUSVETPLAN disease strategy. Up until June 2009 the response was fully funded by the Queensland Government and from then on through a national cost-sharing agreement until December 2010. Continuation of cost-sharing post-December 2010 depends on demonstration that eradication of the incursion is feasible.

AusVet Animal Health Services has been retained by Biosecurity Queensland to undertake a review and analysis of the surveillance data and make recommendations as to likely eradicability of the incursion. This review has been done as a 2-stage process. The first stage comprises a site visit to the Cairns incident control centre, a review of available surveillance data and development of a plan for completion of stage 2. Stage 2 includes an analysis and interpretation of the data collected in stage 1, to provide guidance on whether or not the incursion is still eradicable.

This report presents the results of the analysis and interpretation of data under stage 2 of the investigation.

Deliverables

Project deliverables were specified for the two stages as:

1. An interim report delivered at the completion of Stage 1, describing the data available and outlining proposed analyses (completed).
2. A final report will be provided at the completion of stage 2, providing detailed analysis of the data and recommendations as to likely eradicability and on any other issues identified during the analysis, as appropriate (this report).

Methods

Site visit

A site visit to the Cairns control centre was undertaken from 13-16 September 2010. Key activities undertaken during the site visit included:

- Tour of parts of RA for familiarisation with operational aspects of the program and nest detection/destruction
- Identification and collection of data sources to be used and collection of copies of selected data
- Discussions with Wim De-Jong, Russell Gilmour and other staff at the control centre on:

- program operations and surveillance activities
- specific data requirements and aspects of data management related to the proposed analyses and
- *A. cerana* biology and potential for modelling the incursion

Data available

Data at Cairns is managed in a combination of systems, including Excel spreadsheets (IP and PID lists and details and negative surveillance data), Nor Sqcr (surveillance data up to August 2010) and BioSIRT (positive surveillance data from August 2010). ArcGIS is used for mapping based on these data sources.

The following data sources were obtained for analysis in stage 2:

- Excel spreadsheet of IPs location and destruction
- Excel spreadsheet of all positive identifications
- Excel spreadsheets of negative surveillance data
- Excel spreadsheet of surveillance data to 1 August 2010 extracted from Nor Sqcr
- Excel spreadsheet of positive surveillance data from BioSIRT
- Summary of field staff numbers from SitReps
- Other miscellaneous data and maps

Planned analyses

Proposed analyses to be undertaken as part of stage 2 were (subject to data availability):

- Analysis of spatial and temporal patterns of IPs and PIDs for outbreak
- Comparison and trends of numbers of swarms vs numbers of nests detected
- Analysis of age of nests detected and changes over time
- Comparison of detections between different surveillance methods
- Evaluation of surveillance coverage of the RA
- Evaluation of positive identifications not leading to subsequent nest detection
- Simulation modelling to estimate potential outbreak size
- Other analyses, as appropriate

Results

Overview of the response

The initial incursion was detected in Cairns port area in May 2007. Since then a response has been maintained by Biosecurity Queensland, DEEDI, to detect and eliminate *A. cerana* nests. By the end of 2007 the infestation was thought to have been eradicated and operations were scaled back to "proof of freedom" surveillance. However in July 2008 a nest was discovered 7 km south of the previous findings which led to further detections in the Cairns area. At this time the response was fully funded by the Queensland Government, which limited the number of staff that could be devoted to the response. For a time only sporadic detections were made but from mid-2009, numbers of detections started to slowly increase and in early 2010 national agreement was reached to fund the response until December 2010, allowing employment of additional staff specifically for the response. By 30 September 2010, 230 IPs (59 swarms and 171 nests) were detected and destroyed.

Detection of *A. cerana* nests and swarms relies on two primary surveillance mechanisms:

1. Public reporting

Throughout the response there has been very strong public support and a local educational and promotional campaign to encourage public reporting of unusual bees, nests or swarms by the general public. This has received strong support, with about 50% (117/230) detections being directly reported by the public (88% for swarms and 38% for nests).

2. Surveillance by Biosecurity Queensland staff

The other main means of detection is based on a range of surveillance activities undertaken by BQ staff. These activities include:

- Grid sweeping – inspection of areas based on a defined 2 x 1 km grid, with sweep netting of any bees or similar insects for identification.
- Targeted Sweeping – inspection of specific areas where *A.cerana* is known to occur, with sweep netting of any bees or similar insects for identification using a planned and mapped system.
- Bee-eater pellets – examination of regurgitated pellets of bee-eater birds at known roosts for presence of *A. cerana* wing fragments. This provides an indicator of bee activity (or lack thereof) in an area but is of little value for detecting nests or swarms.
- A variety of swarm and bee traps to attract and contain bees.
- Floral sweeping – recording of floral species where *A. cerana* was detected in early grid-sweeping data and analysis of this data has allowed targeting of specific floral species for sweep netting, with significant success.
- Revised bee trapping – based on problems and lack of success experienced with early traps, modified bee traps were developed and implemented from June 2010. These traps appear to be much more successful for the detection of forager bees than earlier attempts.
- Beelining – once a forager bee is detected, either by sweep netting or trapping, beelining is undertaken to identify the location of the nest(s) of origin of the bees.
- Odour detection dog – a dog has been trained and a dog handler appointed and both will commence surveillance in early November 2010.

Surveillance activities have occurred throughout the Restricted Area which covers a range of environments e.g. urban areas, coastal lowlands, rainforests and savannah etc.

Rainforests have proved the most difficult area for surveillance, due to density and terrain (mountains), but where possible rainforests have been surveyed. Some examples are:

- Rainforest behind Cairns (west) – by surveying 14.5 kilometres along a road that goes through rainforest to Copperlode Dam.
- Rainforest north west of Cairns through to Kuranda – by surveying at stops along the "skyrail" tourist attraction.
- Rainforest between Goldsborough Valley and Babinda – by surveying along an old forestry track and walking paths.
- Rainforest on the tablelands – by surveying old forestry tracks, roads through rainforest and walking paths.

No *A. cerana* activity was found in this surveillance.

Overall, 75% (108/144) of initial positive identifications were made by grid, targeted or floral sweeping.

Once detected, nests and swarms are immediately destroyed.

Temporal pattern of the outbreak

The first nest (IP1) was discovered in May 2007, as were an additional four IPs. In total, 7 IPs were detected by the end of 2007, 18 (including 2 swarms) by end of 2008 and 57 (16 swarms) by the end of 2009. During 2010, numbers have increased substantially, as shown in Figures 1 & 2, to a total of 230 by the end of September, of which 59 were swarms.

Figure 1. *A. cerana* nests and swarms detected and approximate field staff numbers by calendar quarter

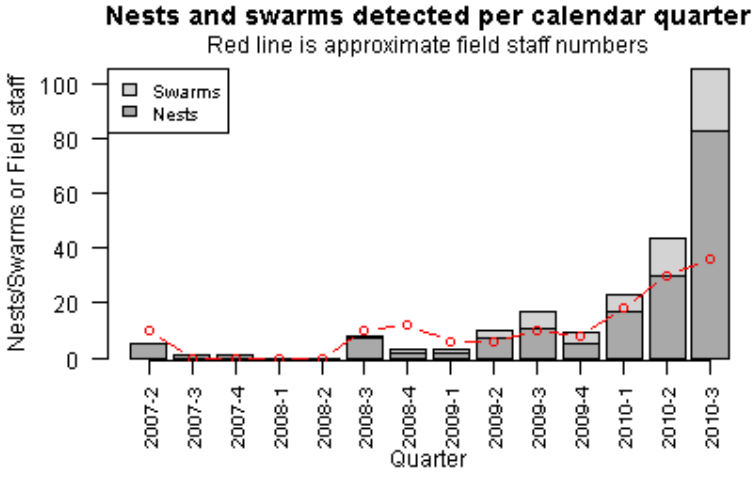
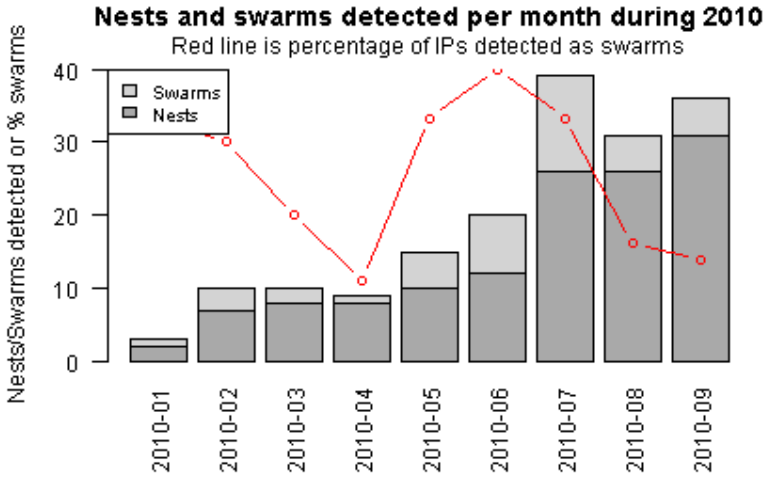


Figure 2. *A. cerana* nests and swarms detected and percentage of detections as swarms by month during 2010.

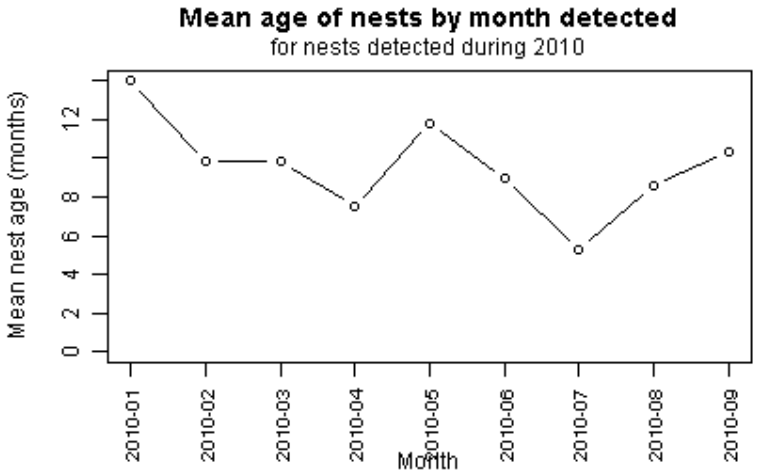


As is apparent from Figure 1, the rapid increase in the numbers of detections during 2010 has coincided with a substantial increase in field staff numbers over the same period. The major increase in detections in the third quarter of 2010 also coincided with the introduction of improved surveillance methods for detection of nests, particularly improved bee traps, targeted sweeping and "floral sweeping" from mid 2010. Inspection of the data also suggests that there may be some seasonality to detections, with more detections occurring during the middle of each year. However the low numbers of detections prior to 2010 make this difficult to interpret, as does the correlation with field staff numbers.

Although overall numbers of IPs detected increased dramatically during 2010, both the absolute numbers and the proportion of IPs that were swarms declined during August and September, compared to previous months, providing a possible early indicator of success. However, additional data over a longer period would be required to confirm this trend.

Where possible, nests were collected and examined following destruction to determine approximate nest age. Ages ranged from a few weeks to a maximum of about 2 years (detected in August 2010). Of 135 nests that were aged, 85% (114/135) were aged as being 12 months or less, while the remaining 15% (21/144) were estimated as between 13 and 24 months of age. Mean age of nests destroyed each month since January 2010 is summarised in Figure 3, and shows a general downward trend to about July, followed by an upward kick in August and September.

Figure 3. Mean age of nests detected each month during 2010



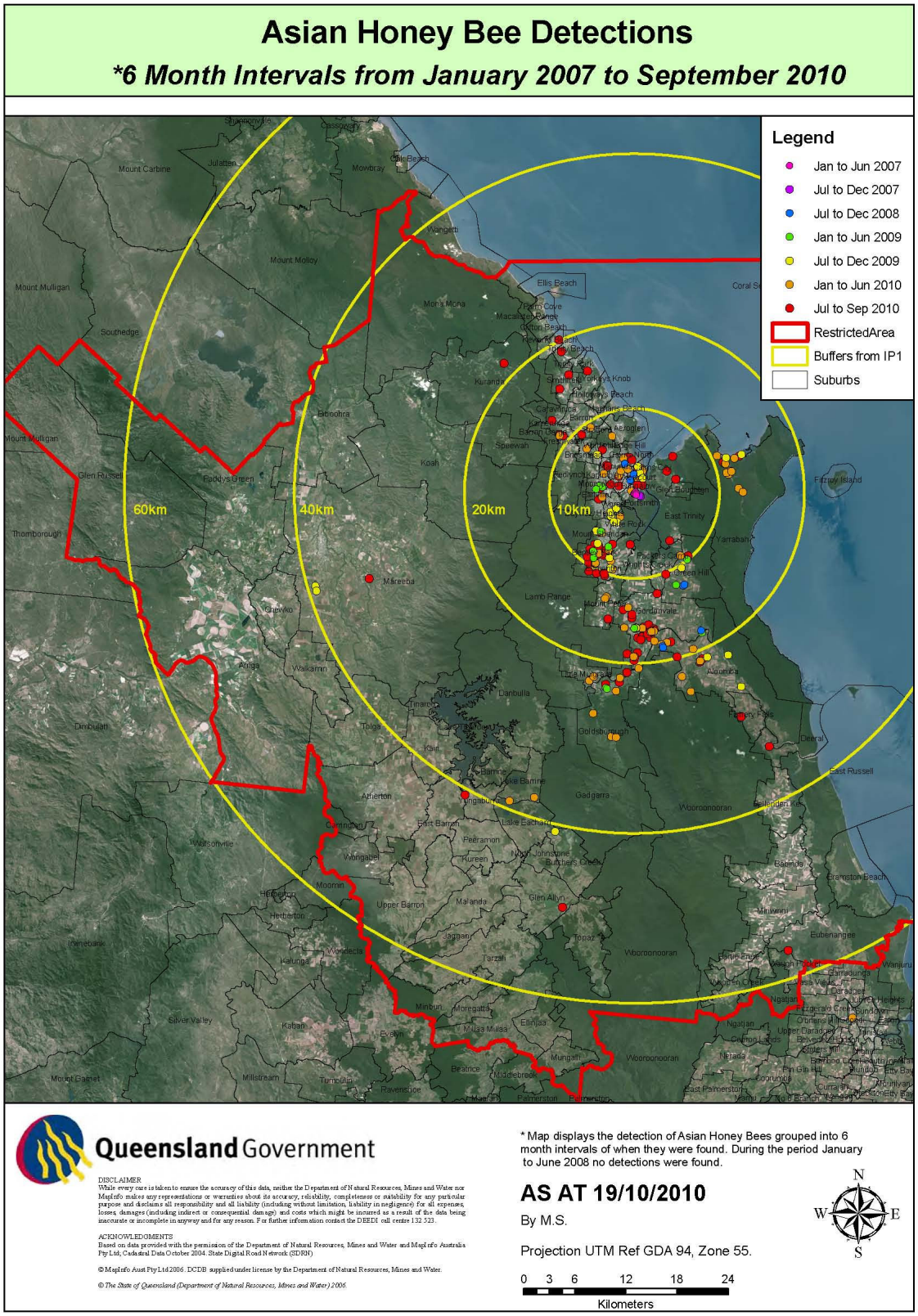
Spatial patterns of the outbreak

The locations of all IPs detected are displayed in Figure 4, summarised according to the period in which they were detected., In addition, detections during each six-monthly period are shown in Appendix 1. All of the early IPs detected were located within a few kilometres of IP1, in and around Cairns City. It wasn't until the second half of 2008 and early 2009 that IPs were detected up to 20 km away in the Green Hill (IPs 8 & 9) and Aloomba areas (IP 18 and 19), south of Cairns along the Bruce Highway.

Up to mid 2009, detections remained localised to Cairns City and within 20-25 km south of the city along the Bruce Highway and into the Goldsborough valley. However, in the second half of 2009, the first IPs outside this area were detected at Mareeba, 40 km west of Cairns (IPs 40 and 43, August 2009) and Lake Eacham, 45 km south-west of Cairns, where a single swarm (IP 57) was detected in December 2009. In the first half of 2010, the infested area extended further up the Goldsborough Valley and additional outlying nests were detected at Lake Eacham (IPs 73 and 114, March and June 2010) and Innisfail (70 km south of Cairns and outside the Restricted Area; IP 84, April 2010). In addition, a single PID was detected at Atherton, about 8 km west of the closest known IPs at Lake Eacham. A small number of detections also occurred at Yarrabah, to the east of Cairns in late 2009, extending southwards during 2010. Similarly, a small number of detections occurred to the north of Cairns for the first time in June 2010, with increasing numbers detected in the second half of the year.

Finally, between July and September 2010, IPs were detected further south along the Bruce highway from Cairns, at Deeral, 35 km south (IPs 144 and 221) and Waugh's pocket, 60 km south (IP 212). Additional IPs were also detected at Lake Eacham (IP 150) and Mareeba (IP 179), as well as at Glen Allyn (south of Lake Eacham, IP 169). An isolated PID, which was the remnant of a dispersed swarm resulting from a public notification, was also detected at Malanda, about 9 km west of the nest at Glen Allyn.

Figure 4. *A. cerana* detections during each six-monthly period from January 2007 to September 2010



In summary, the great majority of detections have been in the immediate vicinity of Cairns City or within 20-30 km to the south of the city along the Bruce Highway or in the Goldsborough Valley. Outlying detections have occurred to the east in the Yarrabah area, which is largely surrounded by rainforest, to the south at Deeral, Waugh's Pocket and Innisfail and to the west on the tablelands at Mareeba, Lake Eacham, Atherton, Glen Allyn and Malanda. The infestation also appears to be slowly moving northwards from Cairns. Most of the detections outside the main area in and to the south of Cairns have occurred during 2010, except for Mareeba and the first detection at Lake Eacham, which were detected in late 2009.

Surveillance

As mentioned, the main surveillance activities for detection of nests and swarms, other than public notifications are grid or targeted net sweeping, floral sweeping and bee traps. Grid sweeping has been used throughout the response, as have various forms of lures and traps. However, targeted sweeping (targeted at known *A cerana* infested areas), floral sweeping (targeted at known preferred floral hosts) and modified bee trapping (improved over previous methods) only commenced from June/July 2010. Figure 5 shows the temporal pattern of surveillance activity from July 2009 to September 2010 and Figures 6 and 7 show the distribution of sweep activity (grid, targeted and floral combined), and bee traps, respectively, during 2010. Understandably, surveillance activity is correlated with staff numbers during the period (see Figure 1 for approximate staff numbers). Since April, the mean number of sweeps per month has been in the range of 4,000 to 5,000 plus.

Figure 5. Monthly surveillance activity from July 2009 to September 2010

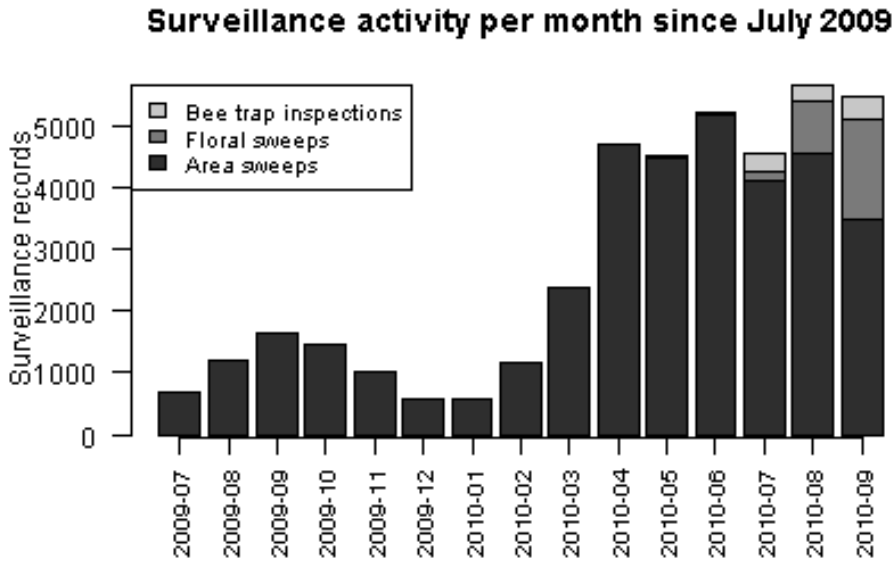


Figure 6. Distribution of AHB grid and floral sweeping activity from January to September 2010, by month

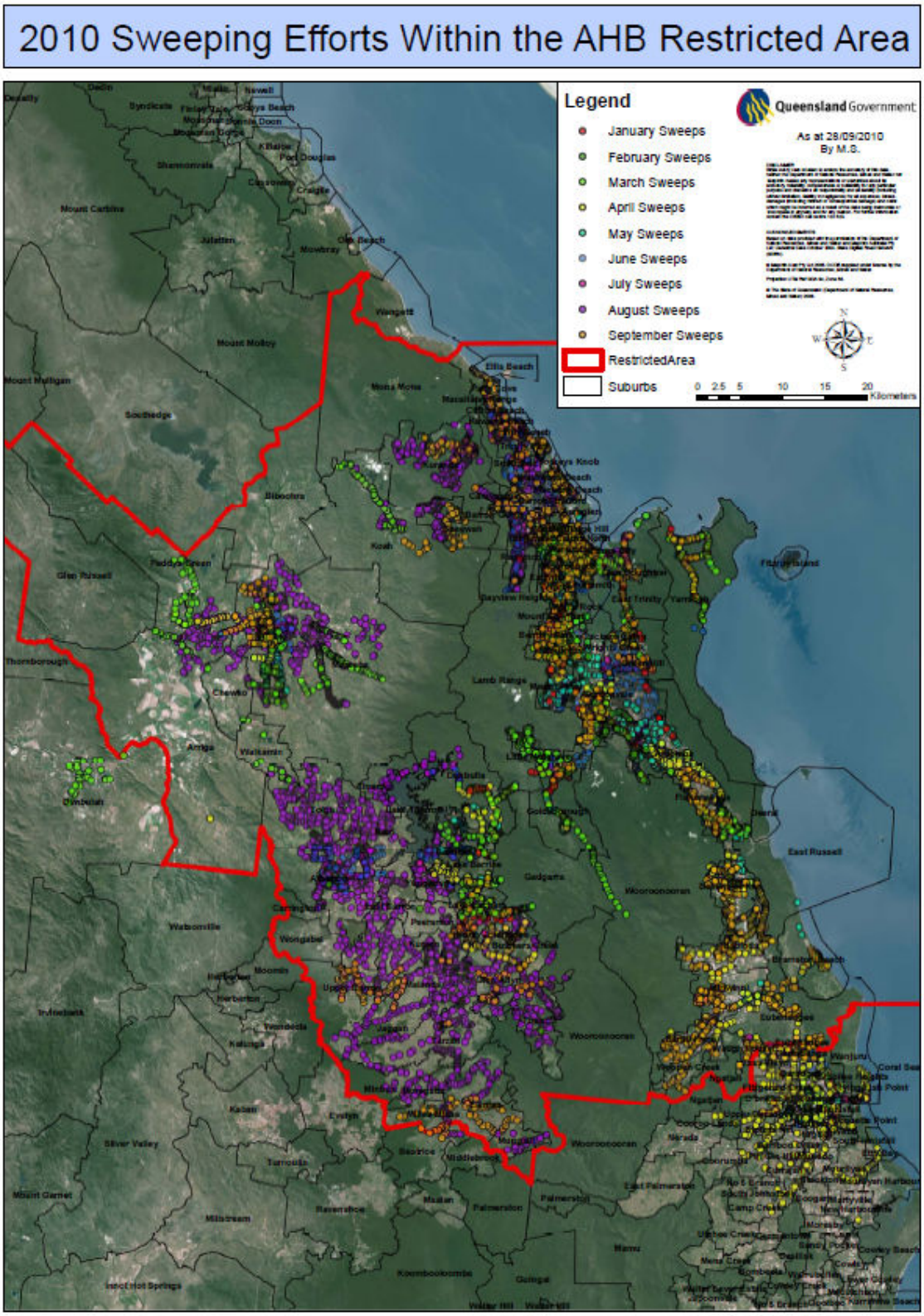
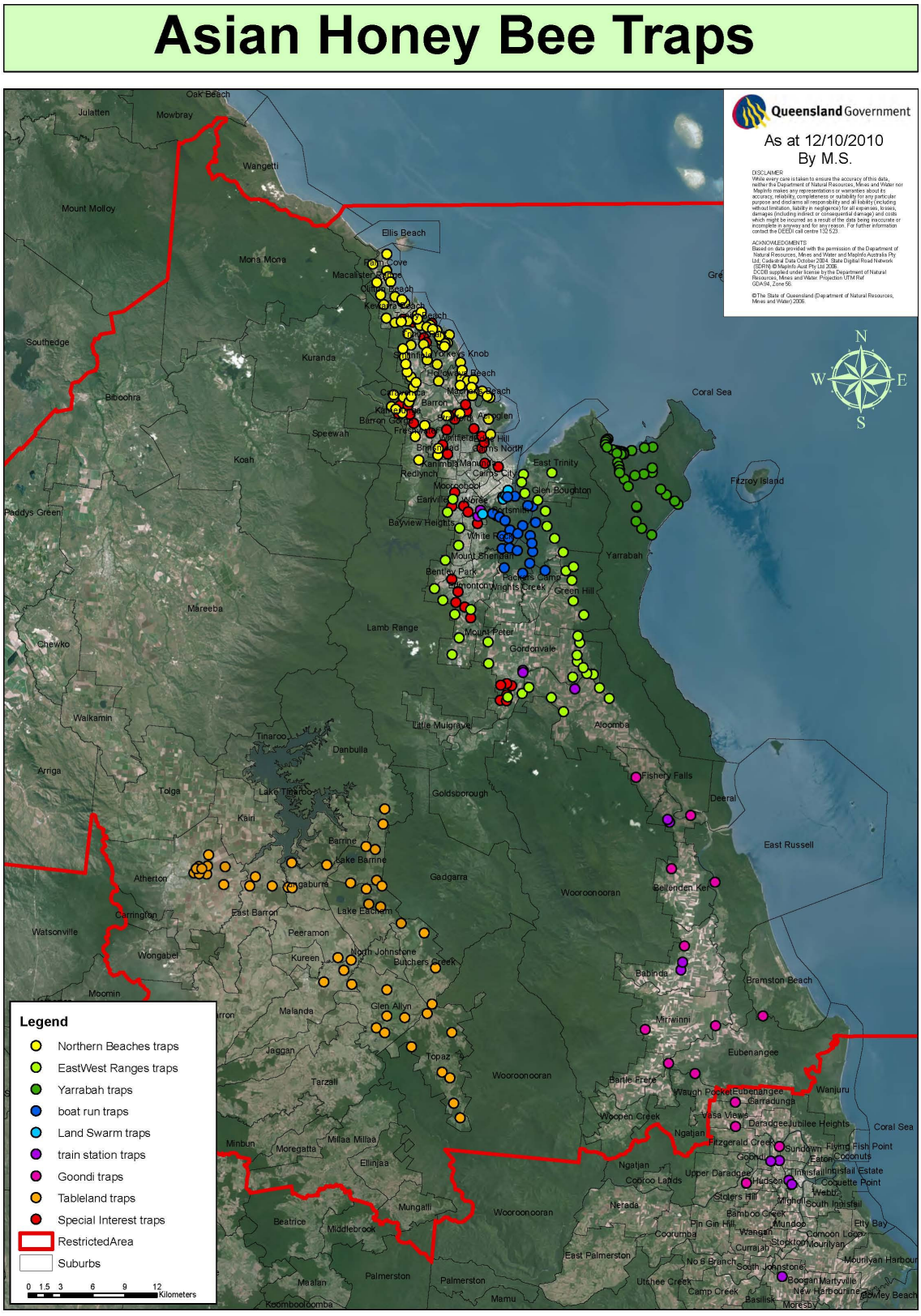


Figure 7. Distribution of AHB bee traps from June to September 2010

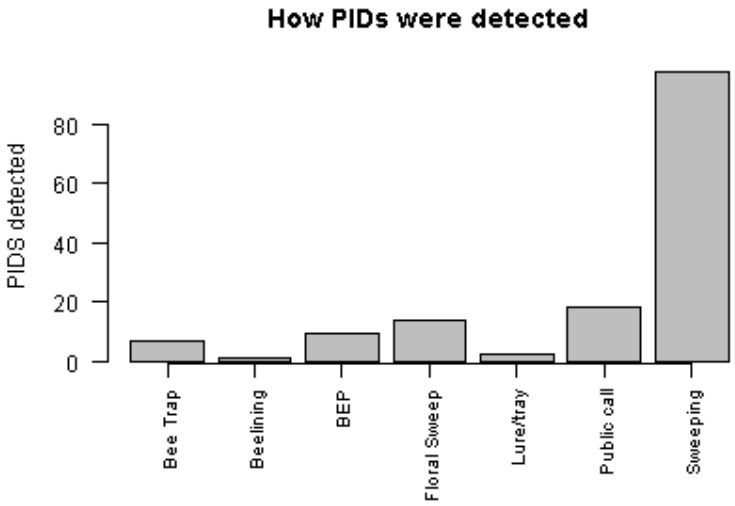


As can be seen, surveillance efforts have been widespread throughout the RA, but particularly focussed in areas where bees are known to be active (around Cairns), where isolated IPs and PIDs have been detected and in built up areas generally. In recent months, a substantial effort has been put into sweeping and bee traps in the Mareeba, Atherton, Malanda, Lake Eacham and Glen Allyn areas on the tablelands, the area between Innisfail and south of Cairns and also the beach suburbs to the north of Cairns.

Also obvious from the distribution of surveillance activities is the fact that there are large areas of mainly tropical rainforest where only limited surveillance has been undertaken. This is based largely on the assumption that *A. cerana* is unlikely to establish and persist in the rainforest ecosystem because of the lack of a reliable year-round feed source to maintain a nest, as well limited surveillance in some areas. To date, the only nests found in the rainforest have been within a few hundred metres of the forest edge and have been detected by picking up foragers feeding on plants at or outside the forest margin. Lack of surveillance in these areas is compounded by poor accessibility into the rainforest, particularly with the unusually wet winter and spring experienced this year.

Not surprisingly, grid sweeping is responsible for the greatest number of detections (Figure 8). However, proportionally, bee traps (0.6% of trap inspections positive) and floral sweeping 0.6% positive) have been more effective than grid sweeping (0.3% positive) in the period since July 2010, when modified bee traps and floral sweeping were introduced.

Figure 8. Numbers of *A. cerana* positive detections by method of detection



Summary of specific geographic areas

To assist in understanding and interpreting the incursion, the outbreak has been subdivided into a number of discrete areas, each of which is summarised separately below. Detailed maps of the areas are provided in Appendix 2.

Mareeba (IPs 40, 43 and 179)

A single swarm and a nearby nest (thought to be the origin of the swarm) were detected near Mareeba (40 km west of Cairns) in August 2009. This nest was thought to most likely have been accidentally transported to Mareeba from the Cairns area. Ongoing surveillance was undertaken in the area, but no additional *A. cerana* were detected until a PID and associated nest were identified in August 2010. This nest was >12 months old and was suspected of being the source for IP43, discovered 12 months earlier. No further sightings have been made since, despite intensive surveillance activity during August and September.

Lake Eacham, Malanda, Atherton and Glen Allyn (IPs 57, 73, 114, 150, 169 and PIDs Malanda and Atherton)

This area is to the south-west of Cairns, on the southern end of the Atherton Tablelands. The initial detection in this area was IP57, a swarm detected south of Lake Eacham in December 2009. Ongoing intensive surveillance in this area since then has found additional detections at:

- Lake Eacham – IPs 73, 114 and 150 (March, June and July respectively), between about 5 and 12 km from IP57.
- Glen Allyn – IP 169, August 2010, about 9 km south of IP57 and between 13 and 18 km from the other IPs
- PID Atherton, May 2010, about 8 km west of IP 150.
- PID Malanda, September 2010, about 9 km west of IP 169.

PID Atherton was a single bee detected in a house, while PID Malanda was the remnant of a swarm notified by the public. Ongoing surveillance has not detected any nests in the vicinity of either PID, or any additional detections in this part of the RA. The original incursion into this area was suspected to be by flight of one or more swarms directly across from the top of the Goldsborough Valley (IPs 62 and 66), a distance of about 30 to 35 km, with further local spread once established. This area remains a high priority for continuing surveillance because of the very scattered nature of the IPs found to date and the unexplained PIDs.

Note: an additional nest was detected in this area in mid October 2010.

Innisfail (IP 84)

IP 84 was detected at Innisfail, just outside the RA in April 2010. Despite intensive and ongoing surveillance in the surrounding area since the detection, no further detections have been made. This nest was assumed to be the result of being accidentally transported from the Cairns area. It was close to the rail line and stock handling area. It is worth noting that a number of swarms have been detected in the Cairns rail stock handling yards and a nest was detected at Deeral next to a train lay-by section of track. This remains a high priority for surveillance, particularly since the detection of another IP at Waugh's Pocket, about 10 km to the north in September 2010 (see below).

Waugh's pocket (IP 212)

A new IP (IP212) was detected at Waugh's Pocket, about 60 km south of Cairns in September 2010. This IP was in a narrow section of rainforest lying between and close to the Bruce Highway and the main Brisbane-Cairns railway line. This IP was about 12 km from the nearest

known IP (IP84 at Innisfail) and 28 km south of the closest known IP in the Gordonvale-Deeral area to the south of Cairns. Surveillance since has not found any additional nests in the immediate vicinity. The source of this nest is unclear. It could have been an accidental transportation, or could have been a long-distance jump from further up the valley towards Cairns. Surveillance is continuing in this area as a high priority.

Aloomba/Deeral (IPs 36, 37, 144 and 221)

The first IPs detected in this area were IPs 36 and 37 (29 km south of Cairns), in August 2009, and for a long time this was the most southerly extent of AHB to the south of Cairns. Subsequently, IPs 144 (July 2010, 4 km) and 221 September 2010, 7 km) were detected further south in the Deeral area, in addition to IP 212 at Waugh's Pocket. Further intensive surveillance in the Aloomba, Deeral and Waugh's Pocket areas is continuing, to determine whether there are additional undiscovered nests in this area.

Goldsborough Valley (numerous IPs)

The Goldsborough Valley is a semi-rural valley running south-westwards from Gordonvale (south of Cairns) towards Atherton and Lake Eacham. The first IP detected in this area was IP 31 in June 2009. Since then additional IPs were detected in January-February 2010 (IPs 59, 62, 63, 66) and then sporadically since then. IPs 62 and 66, at the head of the valley, are the most south-westerly detections in this area to date. Surveillance in this area is continuing and new IPs are still being detected sporadically. Additional surveillance around IPs 62 and 66 and into the rainforest to the south has not yet detected any additional nests in the immediate area.

Yarrabah (numerous IPs)

Yarrabah is a settlement on the peninsula to the east of Cairns. Tis area is reasonably isolated, as it is surrounded by the bay to the north and rainforest on other sides and a mountain range to the west, separating it from the Cairns area. A road south through the rainforest provides access to the coast on the southern side of the peninsula. The first IP in this area (IP 48) was detected in September 2009. Since then there have been periodic detections through to September 2010, with about 15 IPs detected in the area to the end of September 2010. Most of the IPs have been within 1-2 km of the coast, although several were up to 5 km inland along the road to the south. In April 2010, two isolated PIDs were detected, further south, close to the southern coast and 2 to 4 km from the nearest known nest. Despite further surveillance in this area additional nests have not been detected.

Note: an additional nest (IP241) was detected close to one of the above PIDs in October 2010.

North of Cairns (numerous Ips and PIDs)

Up until June 2010, there was no evidence of AHB having established in the area to the north of Cairns, although only limited active surveillance was undertaken in this area prior to that time. During June, three IPs (IPs 107, 110 and 180) were detected just to the north of the city. Since then intensive surveillance has been undertaken and a total of 16 IPs have now been identified in this area. In addition, up to eight single PIDs have been identified which have not been traceable

to nests (because additional bees to use for tracing could not be detected). This suggests that there could be a number of small and/or weak nests persisting unidentified in this area and intensive surveillance is continuing to try and identify them.

Note: two more nests were detected in this area during October 2010.

Cairns city and south to Gordonvale and Aloomba (numerous IPs)

This is the main outbreak area, containing the majority of IPs. Surveillance is continuing in this area on a daily basis with floral sweeping, bee traps and grid sweeping, and new nests are still being detected regularly, although numbers are declining.

Modelling the *A. cerana* population

One common approach to evaluating progress and potential scale of an incursion response is to use modelling. For AHB, we could model the population growth over time, including births into the population (swarming), and removals from the population (detection and destruction or nest/swarm failures) to arrive at estimates of the likely population (numbers of nests and swarms present) over time. Key issues to be considered in developing such a model include:

Issue	Comment
Starting time	When should the model start from, the estimated time of initial incursion, or the time of detection, or some other time to be determined?
Starting population	How many nests/swarms were present at the start of the modelled period? Presumably one, if modelling from the incursion date, but perhaps multiple nests if using a later date.
How frequently do nests swarm?	Suggested as being anywhere from 4 to 12 months and will depend on strength of the nest, feed availability and other factors. Anecdotally, *A. cerana* in nests Cairns appear to be swarming every 8-12 months and this is possibly seasonal, with swarming more likely in the winter/spring months than in summer/autumn
What percentage of swarms survive to establish a nest?	This is not known but would be affected by climate, availability of food sources and environmental factors, in addition to detection and reporting by the public resulting in swarm destruction.
How long does a nest survive?	Again, the likely survival of nests is unknown and would be affected by environmental, seasonal and other facors. However, the oldest nest discovered to date was estimated at about 2 years old. Several of the nests discovered appeared to be failing (or had failed). A suggested life span of 2-3 years appears not unreasonable.
What should be the internal time period of the model?	Should the model attempt to model events on a daily, weekly or monthly basis? Given the time scale of the outbreak and other factors, a monthly time period appears appropriate.
Surveillance activity	It is essential that nests and swarms that are detected and destroyed are included in the model, as this is a critical path for removal from the population
Seasonality, climate and	Are there seasonal and environmental effects that need to be

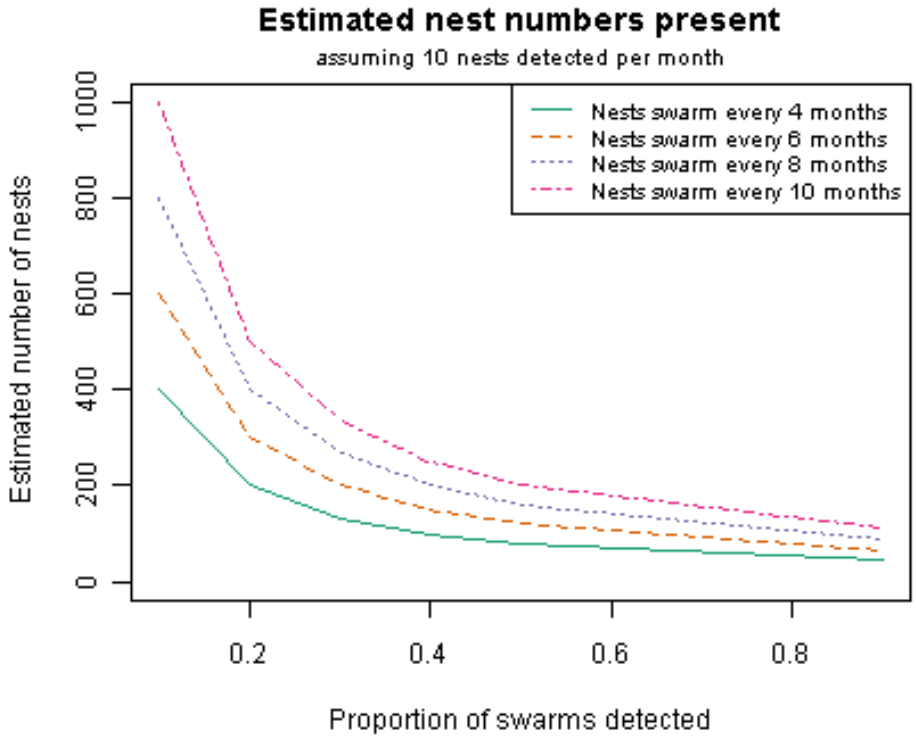
environment	included? This is still unclear but bee populations are likely to be affected by seasonal and environmental factors affecting feed availability and types.

Several different approaches were used in an attempt to model the AHB population over time. However all models were extremely sensitive to modest changes to some of the parameter values, particularly starting time, incursion size at the start and swarming frequency. As a result, model results varied from successful eradication (either already or within the next 6-12 months) through to several thousand undetected nests for small and realistic changes in the inputs.

An alternative model

To overcome the difficulties in the population model, an alternative, simpler, approach was used. In this approach, instead of trying to model the population over time, the one piece of hard data available was used to estimate the likely number of nests present at any given time. Essentially, if we know the swarming frequency and the number of nests present, we can predict the number of swarms that will occur on a daily or monthly basis. Conversely, given that we know the number of swarms detected each month and can estimate the efficiency of detection and the swarming frequency, we can estimate the number of nests present. Figure 9 presents summary results for such an analysis, based on 10 swarms detected per month (23 swarms were detected in the period July-September 2010, for a mean of about 8 swarms per month).

Figure 9. Estimated number of nests present assuming 10 nests detected per month for varying detection efficiency and swarming frequency



From Figure 9, and assuming a detection efficiency of 20% and swarming frequency of 6 to 8 months, there are an estimated 300 to 400 nests present, of which about 28 per month were being detected over the same period. Obviously, the true efficiency of swarm detection is unknown. However, 20% seems a reasonable (and possibly pessimistic) estimate. Halving this to 10% would double the estimated number of nests to 600 to 800, but would also mean that there were up to 90 swarms per month that were not being seen or reported, despite strong public support for notification and high levels of cooperation received.

Indicators of eradicability

In determining likely eradicability (or otherwise) of the infestation a number of issues need to be considered:

1. Extension of the incursion outside the RA

A. cerana has shown an ability to colonise and establish nests in a wide variety of locations and situations, including in vehicles, boats, containers and machinery. In addition, swarms can lodge temporarily in similar locations, enabling rapid dispersal over potentially long distances through movement of infested vehicles or materials. To date, spread to Mareeba and Innisfail have been attributed to accidental transport of nests or swarms. However, there has not been any identified spread to areas beyond the RA (other than Innisfail). Should such spread be detected it would indicate likely failure of eradication, unless there was strong evidence that the spread event was recent and that further local spread had not yet occurred.

2. Presence of undiscovered foci of infection within the RA

Currently, the extent of infection within the RA appears to be well defined. Detection of new, well established foci of infection in areas previously thought to be free of AHB would indicate failure of existing surveillance and probable failure of eradication.

3. Establishment of A. cerana within the rainforest

Currently *A. cerana* is assumed not to persist within the rainforest, but will colonise at the margins so it can forage outside. Discovery of established nests within the rainforest would undermine this assumption and indicate probable failure of eradication. To date only limited surveillance has been undertaken within the rainforest, with no nests detected.

4. Continued occurrence of isolated PIDs without detection of nests

As noted above there have been a small number of instances of single PIDs being detected in an area and being unable to be traced to a nest (due to the failure to find additional bees to enable beelining). This has occurred at Malanda, Atherton, the southern end of Yarrabah and in the beach suburbs to the north of Cairns. These isolated PIDs could be stray foragers that are a long way from their host nest, or could be an indicator of small and/or weak nests that are only foraging in small numbers. In either case the small numbers and inability to detect additional bees in the locality make nest detection difficult. Continued occurrence of isolated PIDs in the absence of detectable nests would suggest that there are persistent undetected nests and swarms, leading to likely failure of eradication.

5. Numbers of detections

The numbers of nests and swarms detected have increased dramatically during 2010. This obviously reflects an increase in the population over time, but also is attributable to the substantially increased staff numbers in the same period and the introduction of targeted sweeping, floral sweeping and bee traps since July 2010. A continued increase in numbers of detections in coming months would indicate an increasing bee population and likely failure of eradication. Conversely, decreasing numbers of detections could indicate likely success in eradication, but should be interpreted with caution due to the potential for confounding the issue due to a natural seasonal decline in numbers of bees foraging and hence numbers detected. Total numbers of detections have remained relatively stable from July to September 2010, with a slight increase in numbers of nests and a corresponding decrease in numbers of swarms. Additional data is required to determine whether numbers will trend upwards or down.

6. Percentage or absolute number of swarms detected

As discussed previously, the number of swarms present (and hence the number detected) is a function of the numbers of nests present, assuming that the efficiency of swarm detection remains unchanged. Therefore, a downward trend in the numbers (or percentage) of swarms each month would indicate potential for eradication, while an upward trend would indicate likely failure. Again this needs to be interpreted with care if seasonal effects are likely to be important. Currently, there is a downward trend since June 2010, but more data is required to confirm this trend.

7. Age of nests detected

Age of nests detected is another approximate guide to potential success of the eradication program. If the program is succeeding, we would expect to see the average age of detected nests getting progressively younger, to the extent that eventually nests will be consistently detected at an early age, before they have an opportunity to swarm, leading to eventual eradication. Assessing any trend in nest age is also complicated by the sometimes wide spread of nest ages in any month and the fact that a proportion of nests are in inaccessible locations and therefore unable to be aged. There is a slight downward trend in the mean age of nests detected since the beginning of 2010, although this is interrupted by an upward jump in August and September. Additional data is required to determine whether this trend will resume its downward direction or whether mean nest age will stay high, and also whether the range of ages will become narrower over time.

Conclusion and recommendations

Based on the above considerations, eradication of the current *A. cerana* incursion still appears feasible. However, given the scale and extent of the incursion, successful eradication is not certain. Given that the increased level of response has only been at full capacity for three months, it is also too early to predict the likelihood of successful eradication.

Of the indicators discussed above, there is a possibility (but no evidence of) spread of the incursion outside its existing distribution. Similarly there is a possibility but no evidence of either undiscovered foci of infestation in the RA or within the rainforest areas. Evidence from the numbers of detections, numbers of swarms detected and age of nests is inconclusive at this stage and all require more data over coming months to develop a clear trend. The most concerning evidence against eradicability is the occurrence of isolated PIDs for which nests have not been identified. Continuation of this phenomenon, particularly in larger numbers or in areas previously though to be clear would provide an indicator of likely failure of eradication.

Recommendation

It is recommended that continuation of the current program for another six months be considered, with re-evaluation at that time based on the above criteria.

Appendices

Appendix 1. Distribution of *A. cerana* detections during each six-monthly period from January 2007 to September 2010

Attached separately

Appendix 2. Distribution of IPs, PIDs and surveillance activities in selected geographic areas

Attached separately