A report on an inventory of nest boxes at the Charles Sturt University campus in Thurgoona NSW

Recommendations for future maintenance and monitoring of nest boxes

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A pair of Squirrel Gliders on the CSU campus in Thurgoona, NSW (12-08-11, I. Brom)

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1. Executive Summary

The Squirrel Glider (*Petaurus norfolcensis*) is a small native arboreal marsupial considered "Vulnerable" in NSW. A significant population of this species occurs in the Thurgoona region and is threatened by past habitat clearance and rapid urban and industrial development, including the Hume Highway upgrade (Mulvaney, 2009; Gordon, 2011). Whilst artificial nest boxes can't replace natural tree hollows, they have the potential to be a valuable conservation and management tool for the Squirrel Glider and may contribute to long-term species viability.

This report evaluates the current condition of the nest boxes on the Charles Sturt University (CSU) campus in Thurgoona NSW and makes recommendations for their future monitoring and maintenance, in context of a potential Thurgoona-wide nest box program. The recording of the functionality of the nest boxes has been carried out on behalf of the Albury Conservation Company (ACC) by the Nature Conservation Trust of NSW (NCT) in collaboration with CSU Environmental Science students. This study is an important first component of the broader ACC goal to develop a better understanding of the monitoring effort of threatened species across Thurgoona, and to identify current gaps and future opportunities.

Of the 99 boxes currently installed on the CSU campus 50 boxes (50.5%) are in need of maintenance, repair or replacement to ensure they are fully functional. Occupancy by introduced Honey Bees (*Apis mellifera*) is one of the major maintenance problems, with 27.3% of all the boxes containing active bee hives.

Monitoring the nest box contents was not the main focus of this project. However, randomly checked boxes showed evidence that Squirrel Gliders are present in the study area and are using the boxes as habitat. Three gliders were found in two different locations; at 6 Mile creek (TTSCS) and in Zone 2A (Appendix 1, Map1). There was also evidence of chewing marks and nesting material in a number of other boxes.

Key recommendations

1. Large Hollow Bearing (LHB) trees on campus need to be recorded and protected as a first priority. Nest boxes are only a short term solution for providing homes for hollow dependent fauna, and should only be considered as a bridging tool;
2. Establish a long-term nest box monitoring and maintenance program at the campus, preferably as part of a broader Thurgoona-wide program involving other key stakeholders;
3. Install additional nest boxes in strategic areas to compliment natural hollows and facilitate movement of Squirrel Gliders across campus, and adjacent areas;
4. Undertake a detailed analysis of threatened species habitat (vegetation) at the campus and invest in further research into nest box design and installation; and,
5. Future infrastructure development and landuse on campus should take into account records of Squirrel Gliders using nest boxes, and necessary actions taken to mitigate impacts.

2. Introduction

Thurgoona is a key area for Squirrel Glider conservation effort as it supports one of the largest and most dense populations known of the vulnerable species in NSW (Mulvaney, 2009). They are mainly found in remnant and re-growth Eucalyptus woodland, much of which now remains along creek lines and other conservation reserves (e.g. Bell TSR). The region of Thurgoona is currently subject to rapid urban growth and development, which poses a significant threat to Squirrel Gliders through the potential for further habitat fragmentation and increased exposure to risks including habitat removal, domestic cats and dogs, and traffic.

In order to protect the species from becoming locally extinct immediate measures are considered necessary. There is a strong need for objective, scientifically based information for decision making processes about land and its distribution between human development and nature conservation (Steward & van der Ree, 2009, p. 10).

The scarcity of LHB trees in the area of Thurgoona due to land clearing for agriculture and urban development requires a conservation tool that can substitute tree-hollows artificially on a short-term basis. Nest boxes provide hollows for shelter, nesting and breeding of hollow-reliant fauna such as gliders, bats and birds. In addition to providing habitat, nest boxes can also be used as a monitoring tool. It is important to mention that nest boxes are only meant to be a short-term solution with the primary conservation goal being the protection, recovery and enhancement of hollow-bearing trees (Douglas, 2003, p. 1; Beyer & Goldingay, 2006, p. 170-171; D. Michael, November 2011, pers comms.).

3. Nest box inventory at the Charles Sturt University campus in Thurgoona

The CSU campus in Thurgoona contains substantial areas of habitat which are potentially suitable for Squirrel Gliders, and is therefore a priority site for further investigation regarding monitoring of the species. In July 2007, 100 nest boxes were installed by CSU staff around the campus, including along 6 Mile Creek; land currently owned by the Albury Wodonga Corporation (AWC). At the time of installation the location of each nest box was recorded using a GPS and the coordinates mapped using GIS (Appendix 3, Maps 1-5). However, there is a lack of evidence that these nest boxes have been monitored or maintained since as the person responsible for the installation (Peter Taylor) no longer works at CSU. The main objective of this nest box inventory on the CSU campus, carried out during August 2011, was to evaluate the condition and maintenance needs of the boxes. Ideally a long-term maintenance and monitoring program for the nest boxes will be established based on an analysis of the data collected and supporting information derived from scientific resources.

3.1. About the CSU campus

The CSU campus at Thurgoona covers a total area of 88.5ha, with an adjoining 20ha of land along 6 Mile Creek owned by the AWC and managed by CSU. Established in 1993, the campus is located on former AWC land north-east of Albury. It has been built and designed according to Environmentally Sustainable Development (ESD) principles with respect to natural resources on the campus and the surrounding landscape (Davidson, 2009, p. 4, 7, 20).

The original native vegetation of the area is primarily Box-Gum Grassy Woodland, which is an Endangered Ecological Community (ECC) under NSW legislation. Most of the original vegetation was cleared for agriculture over a century ago, however small patches of this remnant woodland are still present and represent one of many habitat values of the campus. Other key environmental values on campus include the Forward Tree Plantations (FTPs) undertaken by the AWC throughout Albury-Wodonga between 1970-1990, scattered remnant paddock trees, farm dams, the David Mitchell wetlands and associated run-off capture and grey-water treatment systems (Davidson, 2009, p. 7).

The importance of the campus in relation to biodiversity conservation is not only significant on CSU and AWC land but in its contribution to the adjoining conservation areas and biodiversity linkage corridors such as the Albury Ranges, Mitchell Park Estate, and the region of Thurgoona (Davidson, 2009, p. 4).

3.2. Nest boxes on the CSU campus

Exactly which species the nest boxes on campus were intended for is unclear, since the design of the boxes seems relatively non-specific. They are nonetheless suitable for Squirrel Gliders, which were recorded using the boxes during this study.

The nest boxes are marked with an ID number (written on side of box) and have similar dimensions (40cm in height, 20cm in width and 28cm in depth). The boxes are installed between 3m and 7m above ground, with the majority of them at a height of 3-4m**.**

The nest boxes have been placed in five different locations on and around the campus, described in the following section. Maps 1-5 in Appendix 3 show the exact locations of the nest boxes. Map 1 also shows the biodiversity zones according to the "*Charles Sturt University Thurgoona Campus- Biodiversity Conservation Management Plan"* (Davidson, 2009).

- **6 mile Creek (TTSCS)**:
  64 boxes are installed along 6 Mile Creek adjacent to the David Mitchell Wetlands (Map 3). This land is owned by the AWC and is managed by CSU primarily for conservation, in accordance with the campus biodiversity management plan (Davidson, 2009, p. 12).

- **Zone 2A**:
  10 nest boxes are installed behind the Learning Commons / Library (Map 2). This FTP area contains many non-indigenous Eucalypts (e.g. Manna Gum, Blue Gum) and is earmarked as a future campus development zone. It is suggested by Davidson that some individual remnant trees are retained (2009, p. 10).

- **Zone 2C**:
  5 boxes are installed in the remnant linear grassy woodland in front of the new University residences (Map 5). The area is degraded through the current and past construction and requires active management, such as weed control and revegetation with understorey species (Davidson, 2009, p. 10).

- **Zone 3:**
  10 boxes are installed in the FTP between the Division of Facilities Management building and the Division of Information Technology building (Map 5). This FTP is planned to be retained and active management for woodland birds and Squirrel Gliders is currently taking place including revegetation of understorey (Davidson, 2009, p. 11).

- **Zone 1B:**
  5 boxes are located in the FTP along the St. Johns road next to the Childcare center (under construction at time of inventory) (Map 4). The scattered old remnant trees and native grass patches along the eastern boundary are being protected from potential impacts of construction (personal observation). Open areas should be re-vegetated with shrubs and natural regeneration should be enhanced through weed control (Davidson, 2009, p. 10).

3.3. Methodology of project

As part of the ACC contract, the NCT has developed a Nest box Condition Record Form and, for future monitoring activities also a Nest box Fauna Monitoring Form (Appendix 1 and 2) to help assess and track the functionality (and contents) of the boxes. The data collected with the condition record form has been compiled and interpreted to get an inventory of the nest boxes and to assist with the following:

- Coordinating nest box maintenance activities;
- Developing a consistent monitoring program; and,
- Identifying opportunities for new/more nest boxes at specific sites

The forms were trialed in August 2011 on the CSU campus in collaboration with CSU Environmental Science students and have been developed and improved according to user feedback. The subsequent standard form is planned to be made available to other stakeholders in the Thurgoona region to monitor and maintain their nest boxes.

The Nest box Condition Record Form captures the condition and maintenance requirements of the boxes, documenting such information as GPS location, date, nest box ID, precinct and site no. (according to the "*Thurgoona Threatened Species Conservation Strategy*" by Davidson et al., 2004), site details (e.g. nearest road), aspect of site, hole and box, details of functionality and measurements of the box. In addition, details about the habitat (e.g. canopy, tree species) and the landscape context (e.g. proximity to fencing and infrastructure) can be captured.
As part of this study the 99 boxes were recorded in six sessions within a two week period. Two sessions were carried out with students of the CSU Environmental Science course as part of a "Wildlife Ecology and Management" tutorial. In the first session on 12/8/2011 ten students participated in recording the condition of boxes along 6 Mile Creek and gave important feedback. In the session on 19/8/2011 five students contributed to the field work. The other sessions have been carried out by NCT staff members. Both data sheets have been considerably modified and adapted during this period.
After the field work the data collected through the record and monitoring sheets has been compiled and stored in an excel spreadsheet. Required fields on the sheets that have not been filled out during the fieldwork have been marked as "Null". The analysis and interpretation of the compiled data has led to the results presented in the following subchapters.

In a further step the GPS waypoints of the nest boxes on campus (provided by S. MacDonald) have been turned into a point shapefile on the ArcGIS 10 program. The data spreadsheet has then been joined up with this map as an attribute table in order to connect each nest box waypoint with its specific data. The nest boxes with some form of maintenance requirements are symbolized with a different icon than fully functioning boxes. After underlying this updated shapefile with an aerial photograph of the campus area it has been turned into a map by adding a measured grid, a legend, a north arrow, a scale bar and a map title. In future this map can be modified in the ArcGIS program to highlight nest boxes with specific characteristics (e.g. containing bee hives) to complement maintenance and monitoring activities.

In addition to maintenance the monitoring of nest box contents is an essential part of a successful conservation program. Regular checking is recommended to find the extent of local populations, get information on the preferred habitat of certain species, their breeding success, barriers to movement across the landscape and also to get data on unwanted species (e.g. European Honey Bees) which take advantage of boxes (Thomas et al., 2004-2007). Checking boxes too frequently on the other hand, should be avoided. Animals get disturbed in their natural habitat and can eventually abandon a nest box.

During monitoring activities the minimum data that should be recorded is the date, location, nest box ID, signs of animal presence (e.g. scratches, fur etc.), probable species, number and sex of individuals (Freegard & Richter, 2009, p. 3). In addition, the GPS location of each box should be registered, allowing the nest boxes to be mapped and easily located for future inspection and maintenance (see Nest box Fauna Monitoring Form, Appendix 2).

3.4. Results

The following two sections discuss the condition and maintenance needs as well as the contents of the nest boxes on CSU campus.

3.4.1. Condition of nest boxes

Of the 99 nest boxes located and assessed:

- 4 nest boxes show an either cracked front or back. This can happen due to inadequate positioning of the box on the tree, e.g. on top of a branch that will grow over time and can eventually crush the box (Fig. 1). Also falling branches can damage boxes (personal observation);
- 14 nest boxes have lids that require replacement or maintenance – Of these, 8 boxes are missing a lid or their lid needs replacing (Fig. 1). The lid of at least one box is stuck closed (not all boxes have been subject to opening). The lids on 5 boxes don't close properly;
- 4 nest boxes are insufficiently attached to the tree and require re-attaching (e.g. using metal straps) (Fig.4);
- 3 nest boxes are damaged beyond repair and require removal /replacement (Fig.3);
- 20 nest boxes are missing a baffle, important for deterring unwanted birds (e.g. Indian Myna);
- 1 nest box (No. 266) is attached to a fallen tree and needs to be installed to a new tree (Fig.2);
- 9 nest boxes were recorded as having scratch marks. It's worth noting that this characteristic was not commented on 7 of the record sheets, indicating that there may have been more (personal observation);
- 69 nest boxes (69.7%) showed chewed entrances in varied degrees. Chewing marks around the entrance hole are known to be an indicator of use by gliders or other species of the possum family (Fig. 7), and also by certain types of birds including Galahs and Rosellas (Pell & Tidemann, 1997, p. 151). Some nest boxes show very heavy chewing around the entrance hole, up to a degree where a round hole as such is not recognisable anymore. If necessary gliders and other species chew the hole to allow entrance to the box;
- 31 nest boxes (31.3%) contain evidence of European Honey Bees. Of these, 27 boxes (27.3%) contained active hives and 4 boxes contain old honeycombs (inactive hives) (Fig. 5, Fig. 6, Fig. 15).

Since not all of the boxes have been checked for their content it is possible that more boxes contain inactive hives which will need to be (partly) removed to allow more space for fauna. Boxes containing active European Honeybee hives are considered unsuitable for arboreal marsupials (Durant et al., 2009, p. 568).

3.4.2. Content of nest boxes

The contents of the nest boxes at the CSU campus were only checked randomly during this study, primarily where access using a ladder was safe and practical. Out of the approximately 15 nest boxes that were checked for their content, two boxes contained Squirrel Gliders. They were:

- Box 229 - located at 6 Mile Creek, contained a pair of adult Squirrel Gliders when checked on 12th of August 2011 (Fig. 10).
- Box 297 - located behind the CSU Learning Commons (library) - contained a single Squirrel Glider when checked on the 19th of August 2011 (Fig. 13). Box 297 was installed on a planted Blue Gum and was well shaded by foliage.

During a random check of nest boxes on the 29th of November 2011 another two Squirrel Gliders were found in nest box 904 in Zone 10 (Map 5) by a staff member of NCT and a work experience student.

All five animals could be confidently identified as Squirrel Gliders based on the length of snout, the shape of ears (long and narrow), a bushy tail with no white tip (D. Michael, November 2011, pers comms.).
In addition to live animals other clear indicators of nest box occupancy by Squirrel Gliders have been found, including nests and nesting material. Cup-shaped nests made out of fresh Eucalyptus leaves, typical of Squirrel Gliders, were found in several boxes (Fig. 9).
Evidence of other native fauna species were also found in the checked nest boxes. Box 256 (located along 6 Mile Creek) contained a live Gecko, a live Tree Frog, and a deceased Skink when checked on 12th August 2011 (Fig. 8).
Evidence of birds using the boxes (e.g. nests, nesting material, feathers, scats) couldn't be established, however a more comprehensive nest box fauna monitoring program is required to confidently determine which species may be using the boxes.

Fig. 1: A nest box with cracked front and a missing lid (12-08-2011, I. Brom)

Fig. 2: A nest box on a fallen tree (19-08-2011, I. Brom)

Fig. 3: A nest box crushed by a growing branch (12-08-2011 I. Brom)

Fig. 4: An insufficiently attached nest box (19-08-2011, I. Brom)

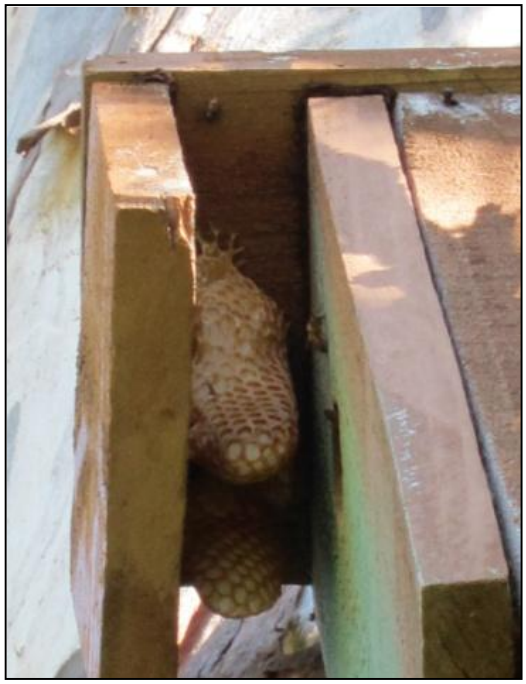

Fig. 5: An active bee hive attached to the baffle of a nest box (12-08-2011, I. Brom)

Fig. 6: The interior of a nest box with old honeycombs (12-08-2011, S. Niedra)

Fig. 7: A heavily chewed entrance hole (19-08-2011, I. Brom)

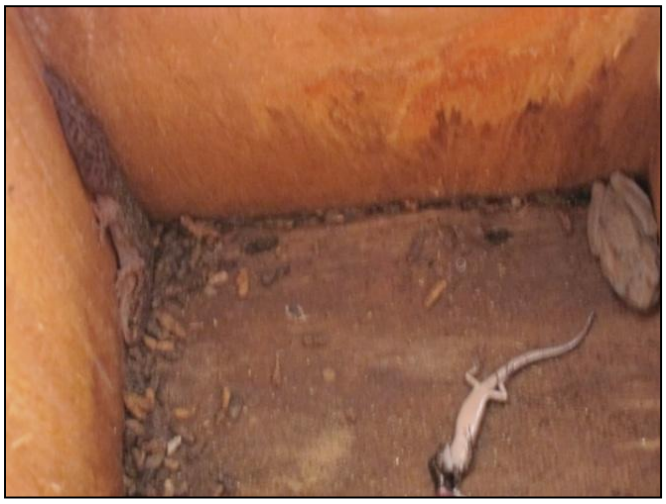

Fig. 8: A nest box occupied by a live Gecko and frog and a dead skink (12-08-2011, I. Brom)

Fig. 9: A typical cup-shaped nest of Eucalyptus leaves, indicative of Squirrel Gliders (19-08-2011, I. Brom)

Fig. 10: A pair of Squirrel Gliders at the 6 Mile Creek section of CSU (12-08-2011, I. Brom)

3.5. Recommendations for future nest box maintenance and monitoring

To ensure the nest boxes on campus are functional and last for as long as possible, regular monitoring and maintenance is recommended. The following recommendations have been made based on the data collected during the nest box inventory and a review of scientific literature. The recommendations are presented in subchapters, and have been listed in descending priority according to the author's assessment of the issues.

3.5.1. Nest box repair and re-installation

a) Repair damaged boxes to maximise the potential of each nest box to provide habitat for native fauna.

50.5% of the nest boxes currently require some form of maintenance in order to regain functionality, either by repairing or replacing damaged parts, re-attachment to the tree, or full replacement. Boxes that aren't fully functioning are less likely to be of value as habitat for native species. After performing maintenance on a nest box consider re-installing the box in a location taking into account the following factors b), c), d), e) and f) to optimise its effectiveness.

b) Re-position boxes which currently face west to reduce over-exposure to the sun.

Currently 49 of the boxes (49.5%) face either due west or have a westerly aspect, which may encourage overheating especially during afternoons in summer. Boxes that are hot may be less attractive as habitat for gliders and other native fauna species. It is recommended to install the nest boxes on the south- through to the east-side of trees to reduce overheating and potentially make them more attractive to native wildlife (Goldingay & Sharpe in: Beyer & Goldingay, 2006, p. 168).

c) Re-locate boxes to locations which enhance their efficiency as (temporary) replacement of natural hollows.

After a certain time span of monitoring, the boxes should be evaluated according to their occupancy. If nest boxes show no evidence of being used, re-location should be considered. This is in order to maximize their use as a conservation tool. It is recommended that the boxes should be installed in retained habitat areas as close as possible to where large hollow bearing trees have been removed and natural hollows are most limited (Davidson et al. 2004, p. 30).

d) Take into consideration influential factors such as access for monitoring, height, bushfire risk, and exposure to predators when installing repaired or additional boxes.

A nest box should be placed high enough to avoid hazards and low enough to allow regular monitoring and maintenance activities. The recommended height of nest box installation for Squirrel Gliders is between 3-4m; boxes installed below 2m are mostly avoided by all kinds of arboreal marsupials due to predation by cats and foxes (Davidson et al., 2004, p. 30; Beyer & Goldingay, 2006, p. 165, 168).

In addition, the vegetation and landscape context should be considered when determining the location for new nest boxes. Landscape features such as tree cover and connectivity of canopy, presence of understorey vegetation (e.g. wattles), and proximity of infrastructure (e.g. roads, barb wire fencing) should be considered when installing nest boxes. The tree on which the nest box will be placed should preferably be in a cluster of trees with gaps less than 30m (Beyer & Goldingay, 2006, p. 168).

e) New nest boxes should be placed in rough-barked trees (e.g. Yellow Box) with sufficient foliage where possible.

According to scientific studies rough-barked trees with sufficient foliage are preferred by Squirrel and Sugar Gliders. The animals found during this nest box study on the CSU campus have incidentally also been nesting in trees with lots of foliage and in fairly rough barked trees. Further it is recommended that boxes targeting Squirrel Gliders are placed in flat or gully locations (Durant et al., 2009, p. 568).

f) Consider trialing different nest box designs and monitor their effectiveness in pest control and providing specific habitat for native fauna.

Specific species such as Squirrel Gliders and woodland dependent birds can be targeted with particular nest box designs (see below, "*3.5.2 Pest control"*). The nest boxes currently installed at CSU are of one particular design with almost identical dimensions. There are significant species in Thurgoona which may be missed because the design is not appropriate to their habitat requirements. There are good opportunities at CSU to utilise students to undertake such research.

3.5.2. Pest control

Considering the relatively high percentage of the boxes occupied by active introduced Honey Bees (27.3%), additional measurements should be taken to reduce this barrier to occupation by native fauna. Possible solutions include:

- **Undertake regular and systematic control of introduced bees through physical removal of active hives.** Considering the OH&S risk of bee handling, this would ideally be undertaken by a professional apiarist or licensed pest controller.

- **Attach carpet or a thin plastic sheet to the underside of nest box lids to discourage bee hives.** Carpet has shown to be effective in discouraging bees from attaching their hives to the roof of the box (Beyer & Goldingay, 2006, p. 165). There is also evidence provided by apiarists that plastic could have a similar effect (M. Sutherland, November 2011, pers comms.). Carpet or a thin smooth plastic sheet (1mm) glued to the underside of lids could be retro-fitted to existing boxes immediately after active hives are removed, and should be included in the design of new boxes (D. Michael, October 2011, pers comms.).

- **Trial nest boxes with slit entries (such as nest boxes for bats) or rear-entries (entrance facing the trunk of the tree).** Studies have shown that nest boxes with an invisible entry are less likely to be occupied by non-target species (design by A. Franks, Hollow Log Homes, Kenilworth, Qld. in: Beyer & Goldingay, 2006, p. 165).

3.5.3. Nest box monitoring and maintenance

a) Develop an annual nest box monitoring and maintenance program

Nest boxes require on-going and regular maintenance to ensure they are functional as potential habitat for native animals, and to maximise their lifespan. Nest boxes should at least be checked for their condition and contents once or twice each year, depending on available resources (e.g. staff/volunteers, funds) and other factors (e.g. climate). Such a program should be supported preferably by the whole organisation and not be left to one individual to manage and maintain.

b) Consider participating in a Thurgoona-wide nest box monitoring program involving the broader community

In order to ensure the durability and continuity of a monitoring and maintenance program the broader Thurgoona community (e.g. Landcare, schools) could be involved in nest box monitoring and maintenance. For example, activities could be carried out in collaboration with CSU students and student groups (e.g. Green Adventure group). Local scout groups could be engaged as part of their environmental education and to go towards attaining their 'Landcare badge'. Nest boxes could be repaired and constructed with the support and involvement of local 'Men's sheds'. Any such program at CSU would ideally be part of a broader Thurgoona wide project, including other landowners, land managers, and volunteers. In line with this project a day each year could be devoted to a Thurgoona-wide fauna census, possibly coordinated by the Albury Conservation Company.

3.5.4. Funding for nest box programs

a) CSU could consider allocating an annual component of its budget to maintain and monitor nest boxes.

The costs for the production of nest boxes vary, according to the design and producer of the box. A sample of quotes obtained by the author showed a price range between $40-200 per box, depending on the species being targeted and the materials used. It would be beneficial if CSU could allocate a fix component per year of their budget to new nest boxes and installation as well as maintenance and monitoring of existing nest boxes.

CSU could also consider participating in a wider program involving collaboration with other stakeholders and / or seek to engage volunteers or students to assist with the program to potentially reduce costs.

b) Investigate funding opportunities from internal and external sources to support nest box monitoring and maintenance.

There are a number of funding opportunities which could help support a nest box monitoring and maintenance program at CSU, and for installation of new nest boxes in priority areas on the property. For example, 'CSU Green' has an annual green grants program specifically for projects on CSU campuses. CSU Green grants have an upper limit of $15,000 per project. External funding opportunities may also be available through the Murray Catchment Management Authority (Murray CMA) (e.g. community grants program - $2,500 maximum per project), the Federal Government's *Caring For Our Country* 'Community Action Grants' program ($20,000 maximum per project), or the Albury Conservation Company (funding details not confirmed at time of writing). The prospect of success in seeking funding from external sources is likely to be enhanced if the program was part of a broader landscape project involving other partners.

In relation to 6 Mile Creek, the land is currently owned by the AWC and is in the process of being handed over to the NSW Crown Lands Division. Funding for monitoring and maintenance of nest boxes, and other related biodiversity conservation activities along 6 Mile Creek could potentially be sourced from the Crown Lands Division and should be investigated.

3.5.5. Infrastructure development and nest boxes

a) Before construction on campus takes place in areas containing nest boxes, the boxes should be relocated to suitable neighboring habitat to enable re-colonisation by native fauna.

For example, Zone 2A (Appendix 3, Map 1) contains nest boxes which are currently being utilised by Squirrel Gliders, evidenced by a sighting of an individual glider and glider nests as part of this study. The zone is declared a future development zone and actions such as relocating the boxes into adjacent woodland habitat should be implemented to mitigate potential impacts.

3.5.6. Revegetation on campus

The CSU campus contains significant areas of native vegetation, and is also located within a landscape containing other significant vegetation patches, some linked and others isolated. The connectivity of these isolated patches is critical for the movement of Squirrel Gliders. Revegetation efforts on the CSU campus can fill gaps between habitat patches, enhance the connectivity through the landscape and upgrade habitat quality for local wildlife.

a) Undertake revegetation at the following sites on the CSU campus to improve Squirrel Glider habitat:

- Re-introduce a native shrub layer along 6 Mile Creek. An understorey vegetation layer is a beneficial habitat feature for arboreal mammals. For example, the sap of Silver Wattle (*Acacia dealbata*) is a known food source for Squirrel Gliders.
- Fill the vegetation gap along the 6 Mile Creek between the two habitat patches (Fig. 11, Fig. 12). Around the David Mitchell Wetlands the canopy and shrub layer are absent (Appendix 3, Map 3), presenting a current and future barrier to glider movement across campus.
- Fill vegetation gaps along St. Johns road. Squirrel Gliders are known to travel and forage along road sides and creek lines, which should therefore match their habitat preferences and have a contiguous canopy layer (Davidson et al., 2004, p. 24).
- Generally reconnect other isolated native vegetation patches throughout the campus where possible.

b) Undertake a detailed vegetation and habitat analysis throughout the CSU campus

A closer analysis of habitat is recommended to identify additional revegetation opportunities to those listed above, as well as identify sites for installation of new nest boxes on campus.

3.5.6 Glider Poles on campus

a) Investigate installing glider pole(s) in the vegetation gap along 6 Mile Creek adjacent to the David Mitchell Wetlands to facilitate Glider movement between isolated vegetation patches.

As discussed above, a significant gap in canopy (approx. 60m) occurs along the 6 Mile Creek between two habitat patches adjacent to the David Mitchell Wetlands (Fig. 11, Fig. 12). Both the canopy and shrub layer are absent, presenting a current and future barrier to glider movement across the CSU campus and the broader Thurgoona landscape. Even if the gap was revegetated today, it could be many years before Gliders could safely move between the two sites.

An option to help fill the gap quickly and enable gliders to cross safely is to install "Glider Poles"; large wooden poles with specially designed platforms which facilitate movement of Gliders between fragmented canopies acting as artificial trees (Ball & Goldingay, 2008, p. 141, 142). Examples can be seen at a number of locations along the Hume Freeway duplication in NSW, including Woomargama north of Albury.

AWC as land owner as well as Crown Lands Division should be consulted in relation to the prospect of installing a pole along 6 Mile Creek on the CSU campus. In order to mitigate the 60m gap (distance is approx.) the installation of one pole could be sufficient since gliders on average navigate gaps of 25m by gliding (Fig.12).

Fig 11: An aerial image of Fig. 12 with estimates of distances between individual trees (Photo provided by S. McDonald, modifications by I. Brom)

Fig. 12: Significant gap in canopy vegetation along 6 Mile Creek adjacent to the David Mitchell Wetlands (19-08-2011, I. Brom)

3.5.7 Additional recommendations

a) Remove barbed wire fencing and replace with plain fencing wire.

Barb wire is a known cause of mortality of Squirrel Gliders, with documented cases in Thurgoona. Barb wire used in fencing (particularly the top strands) near areas containing Squirrel Glider habitat and nest boxes should be removed and replaced with plain wire to reduce risk.

b) Undertake further research in relation to management of arboreal mammals and other hollow-dependent animals on campus.

CSU has the opportunity to engage students in further research on campus in relation to arboreal mammals and other hollow-dependent animals (e.g. birds, bats) and the influence of nest boxes and natural hollows on species populations. Further research could investigate:

- The influence of the abundance of natural hollows on the use of nest boxes by arboreal mammals;
- the influence of nest box design on the suitability for different fauna species (Beyer & Goldingay, 2006, p.165);
- the relationship between the distribution of natural tree hollows and nest boxes and their use by native fauna and pest species.

4. Background to project

The NCT has been contracted to provide co-ordination services to the ACC, commencing in July 2011. The ACC has a focus on the area of Thurgoona north of Albury, NSW, and on monitoring, on-ground works and community education in relation to threatened wildlife species, including the Squirrel Glider. The contract is guided by the ACC Strategic Plan 2011-16 and the "Thurgoona Threatened Species Conservation Strategy" by Davidson et al. (2004). The ACC strategic plan has the following four themes: research, on-ground works, education and governance.

This report forms part of the research theme which aims to develop a better understanding of the Thurgoona landscape as a priority area for conservation of Squirrel Gliders and other threatened species to help determine the best on-ground actions. Research seeks to identify who has done what, where and how and to recognise gaps in the monitoring activities in the area. The intended outcome is to give advice on future survey opportunities and prioritise management efforts concerning key monitoring areas, priority sites for habitat improvement, monitoring frequency, etc.

Also the establishment of a long-term threatened species monitoring program across Thurgoona is being considered in collaboration with key stakeholders in the area (ACC Strategic Plan, 2011).

4.1. Context of nest box management in Thurgoona

Management recommendations for wildlife conservation and specifically for the protection of the Squirrel Glider population in the area of Thurgoona have been published in various reports. Steward and van der Ree (*Population Viability Analysis for Squirrel Gliders in the Thurgoona and Albury Ranges Region of New South Wales*) recommend an analysis of the woodland habitat missing from the landscape to identify missing links in the landscape. This includes the filling of all gaps in existing woodland which are bigger than 30-40m, as this is the average gliding distance of a Squirrel Glider. Another high priority is the assessment of density and distribution of large hollow-bearing trees and of woodland structure, such as the presence and diversity of understorey shrubs, especially Acacia species such as Silver Wattle (*Acacia Dealbata*) (Steward & van der Ree, 2004, p. 48).

The Hume Highway Upgrade in Albury/Wodonga intersects the habitat of the local glider population and there is evidence suggesting it may be acting as a barrier to glider movement. As a result two smaller sub-populations developed within the Thurgoona Squirrel Glider population (Gordon, 2011, p. 23).

Recommendations of the "*Threatened Fauna Monitoring Program. Albury-Wodonga National Highway Maintenance Program Year 3*" (Gordon, 2011) discuss the options to reconnect the two sub-populations including investing future research in glider poles and road bridges to reconnect habitat patches and ensure long-term viability of the entire population. Another recommendation advises to "Undertake nest box maintenance and incorporate monitoring of their condition into the ongoing monitoring program." (Gordon, 2011, p. 23).

There are varying estimates of the overall number of nest boxes that have been installed across Thurgoona, ranging up to 1200. The actual figure is hard to ascertain because most boxes are not GPS located.

4.2. Nest Boxes as a monitoring and research tool

4.2.1. Purpose of nest boxes for arboreal mammals

Squirrel Gliders and numerous other wildlife species rely on natural hollows in trees for shelter and breeding sites. Nest boxes can act as a temporary replacement of natural hollows, enhance habitat connectivity and contribute to the maintenance and enhancement of biological diversity (Beyer & Goldingay, 2006, p. 16). Nevertheless, natural hollows are preferred to artificial hollows by most species, since they have better insulation and higher humidity (Beyer & Goldingay, 2006, p. 164).

Fig. 13: Hollow bearing White box along 6 Mile Creek (24-08-11, I. Brom)

Large hollow bearing trees (Fig.13) occur right across Thurgoona, including in crown reserves (e.g. Bell TSR), along creek lines and roadsides, as scattered paddock trees, and in suburban backyards. Eucalyptus trees generally form hollows when they are at least 80-100 years old. Since European settlement many of these trees have been cleared for agriculture and more recently for urbanisation and industrial development. Hollow-bearing trees have often been removed without adequate replacement. In addition native hollow dependant fauna (e.g. Squirrel Glider) must compete with introduced species such as the introduced Honey Bee (*Apis mellifera*) or Indian Mynas (*Acridotheres tristis*) for the fewer hollows that remain. It has been estimated that five nest boxes are required to replace hollows of one tree removed; three for gliders and one each for possums and bats (Davidson et al., 2004, p. 25, 30; TVWC 2009-2011, p. 2).

Because of the substantial reduction of hollow-bearing trees in the landscape, artificial nest boxes are an important tool to improve habitat quality for arboreal mammals and to help ensure their long-term population viability. In Australia nest boxes are used for basic research and glider population management. Research purposes include the detection of species, detailed ecological studies of individual species, and investigations of preferred designs of nest boxes. In terms of threatened species management, the strategic placement of nest boxes can be useful for species introduction and the support of populations (Beyer & Goldingay, 2006, p. 166). Brush-tailed Phascogale (*Phascogale tapoatafa*), Yellow-footed Antechinus (*Antechinus flavipes*) and Western Pygmy Possum (*Cercartetus concinnus*) are some of the mammals that generally can't be caught in cage traps, however they can be observed through their use of nest boxes (Freegard & Richter, 2009, p. 1).

4.2.2. Nest box features

The use of nest boxes by native wildlife can be affected by factors such as the box design, location, season, occupation by pest animals, the abundance of natural hollows in the surrounding vegetation and competition with other species for hollows. The design of a nest box can vary according to the species it is intended for and can reduce competition with non-target species (Beyer & Goldingay, 2006, p. 164).
The most commonly used material for nest boxes is plantation pine, pine plywood or a mixture of plywood and hardwood. A thick-walled box (min. 1.5cm) provides better insulation and therefore a smaller range of internal temperatures (Calder et al. 1983 in: Beyer & Goldingay, 2006, p. 164). The size of a box targeting Squirrel Gliders is recommended to be at least 40cm in height and 20cm in width and depth (TVWC, 2009-2011, p. 2). Calder et al. (1983) found in their study that boxes with less than 20cm between entrance and floor have not been used by any arboreal marsupials. Furthermore, a deeper box ensures better insulation. The size of the entrance hole can attract or repel certain species to the box. Gliders prefer hollows which are just big enough for them to fit through. Entrances that are too small will be enlarged through chewing. Entrances for Squirrel Gliders can range between 2 - 8cm in diameter, with the most common being between 3-4cm (Beyer & Goldingay, 2006, p. 165, 167). The lid of a nest box should overlap the box and be hinged in order to allow easy opening for monitoring and maintenance. The application of a baffle covering the entrance can prevent the box from getting used by introduced birds such as Indian Myna, Sparrow, and Starling, since these birds prefer to see the entrance in order to enter the boxes (TVWC, 2009-2011, p. 2; Beyer & Goldingay, 2006, p. 165).

4.2.3. Nest box maintenance: common problems and guidelines

Depending on the design and materials used it can be anticipated that nest boxes will last at least five years after installation, however maintenance is required to maintain functionality and can help prolong the lifespan of the nest box (Beyer & Goldingay, 2006, p. 165). Maintenance activities include pest management, re-attachment, repair or replacement of damaged parts, or of entire boxes. Common causes of deterioration of nest boxes include falling trees or branches, crushing or fire (Lindenmayer et al., 1991 in: Beyer & Goldingay, 2006, p. 165, 166).

Specific pest management problems include the following:

a) Introduced Honey Bees

Introduced Honey Bees construct hives in nest boxes and exclude preferred native fauna. Nest boxes occupied by bees need to be poisoned and the honeycomb removed. Parts of the honeycomb can be left in the box. Evidence suggests that gliders tend to occupy boxes with parts of remaining old honeycombs, since they provide additional insulation and a source of food (Fig. 14, Fig. 15)(Beyer & Goldingay, 2006, p. 165).

To avoid bees in nest boxes, carpet can be attached to the underside of the lid, which discourages bees from attaching their hives (D. Michael, November 2011, pers comms.). Also insecticide pest strips attached on the inside of the nest box can help to prevent the invasion by bees (Soderquist et al. 1996 in: Beyer & Goldingay, 2006, p. 165).

Fig.14: Squirrel Glider in a box containing old honeycombs (19-08-2011, I. Brom)

Fig. 15: Honeycomb attached to a nest box lid (19-08-2011, I. Brom)

b) Exotic birds

Introduced birds such as Indian Mynas, Starlings and Sparrows compete with targeted native species for the nest boxes and increase in numbers through occupying them. The previously mentioned baffle can reduce the impact on the nest box program through these non-target species (Beyer & Goldingay, 2006, p. 165). Removal of the nests of introduced birds, their chicks and eggs from nest boxes should be part of a maintenance program (Gould League, 2003, p.2).

c) Ants

Ants are often found in nest boxes, although some species do not exclude the co-habitation with arboreal marsupials.

4.2.4. Monitoring: Analysis of nest box content

When checking nest boxes, key features to look at include whether or not animals are present, which species are observed, numbers (count), and other signs that indicate the use of the nest box. Presence of nesting materials such as eucalypt leaves will suggest a glider. Cup-shaped nests are an indicator for Squirrel or Sugar Gliders, their nests are often indistinguishable. Nests formed like a giant ball can be signs for Sugar or Feathertail Gliders (*Acrobates pygmaeus*). Nesting material made from Stringybark, fur, feathers and leaves indicate either a Brush-tailed Phascogale (*Phascogale tapoatafa*) or an Antechinus (*Antechinus stuartii*)

(Beyer & Goldingay, 2006, p. 162). The age of leaves and pellets in a box are a way to judge how long ago the nest was used. Other signs that a nest box is in use include chewing around the entry hole and dark staining of the entry which occurs from the oils in their fur rubbing up against it (K. Soanes, September 2011, pers comms.).

With nest boxes effectively acting as traps ecological studies can be carried out. This can provide information on the estimate of abundance and extent of a glider population, their social behavior, and group composition, breeding behavior, habitat preferences, diet, and many other aspects.

Monitoring of the nest box contents can be carried out by climbing up a ladder to each nest box and lifting the lid and checking the inside of the box. Another and more practical method comprises the use of a flexible telescopic pole camera (with an extendable tube) which can be applied from the ground.

5. Conclusion

This study of nest boxes at the CSU campus at Thurgoona has demonstrated the following:

- Squirrel Gliders are present on the CSU campus.
- Squirrel Gliders are using the nest boxes on campus as habitat.
- 50.5% (50 of 99) of the nest boxes on campus are in need of some form of maintenance.
- The targeted species of the nest boxes is unclear; however they show obvious signs of use by arboreal mammals. Use of the boxes by woodland birds is less obvious and was not observed during this assessment.
- Evidence suggests that the boxes are have not been maintained or monitored in a coordinated way since their installation in 2007.
- The nest boxes are in various states of functionality, from being fully operational and housing Squirrel Gliders at the time of the study, to having lids missing, being broken or containing active colonies of introduced Honey Bees (27.3% of the boxes).

The recording of all the boxes, their condition and functionality, as well as the surrounding landscape context demonstrate that there are gaps in the landscape where nest boxes could be installed. The installation of nest boxes in specific areas on campus could help increase habitat quality and improve the ability of arboreal mammals to move across the campus into adjacent habitat areas, particularly along 6 Mile Creek and 8 Mile Creek.

The fact that the nest boxes are being used by Squirrel Gliders may indicate that the area is lacking in natural hollows to support the current population. It should be a long-term aim to protect and where possible to enhance large hollow bearing trees across Thurgoona to ensure the long-term viability of Squirrel Gliders and other hollow-dependent fauna.

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Appendix 1

Nest Box Condition Record Form

1. General

Assessor (Name / Organisation): _____/_____

Date _____ Time _____

Nest Box ID _____ Code _____

Precinct _____ Site No. _____

(for precinct and site no. see: Thurgoona Threatened Species Conservation Strategy 2004)

GPS Location *E:* _____ *N:* _____

2. Site information

Nearest Road _____ Nearest Landmark _____

***Aspect** (eg. N, NW, NNE)*

Aspect of site _____ Box Aspect on tree _____

Orientation of Opening _____ Height above Ground _____ *m*

☐ *Box is shaded by foliage* ☐ *Box is exposed to sun*

Box

Dimension of box _____x_____x_____ Diameter of hole _____ *mm*

☐ *estimate* ☐ *exact*

Tree Species

☐ *Red Box* ☐ *Yellow Box* ☐ *Grey Box* ☐ *White Box*

☐ *Blakely's Red Gum* ☐ *Apple Box* ☐ *River Red Gum* ☐ *Iron Bark*

☐ *Other* _____

Is the tree: a) ☐ remnant ☐ planted b) ☐ rough-barked ☐ smooth-barked

c) ☐ isolated ☐ in a cluster with gaps less than 30m ☐ in a cluster with gaps more than 30m

Position in landscape

a) ☐ Creekline / Riparian ☐ Flats ☐ Slopes ☐ Hilltop/Rocky outcrop

b) Extent of contiguous canopy (m) ☐0-25 ☐25-60 ☐60-150 ☐150 +

c) Proximity of nearest barbed wire fencing (m) ☐0-50 ☐50-100 ☐100-200 ☐200 +

d) Proximity of nearest infrastructure (m) *eg. road* ☐0-50 ☐50-100 ☐100-200 ☐200 +

Vegetation around box

	Remnant	*Planted*	*Native*	*Exotic*	*Absent*
Canopy	O	O	O	O	O
Shrub Layer	O	O	O	O	O
Ground Layer	O	O	O	O	O

Are there logs / fallen timber on the site? ☐ *a little* ☐ *some* ☐ *alot* ☐ *none*

Notes _____

Proximity of hollow bearing tree (m) *none* ☐ 0-50 ☐50-100 ☐100-200 ☐200 +

Other (please specify) _____

3. Condition of Box

Chewed entrance	*Yes*	☐	*No*	☐	Bee hive	*Yes*	☐	*No* ☐
Scratch marks	*Yes*	☐	*No*	☐	*If yes:*	*Old*	☐	*Active* ☐
Baffle	*Yes*	☐	*No*	☐	Draining holes	*Yes*	☐	*No* ☐
Ladder	*Yes*	☐	*No*	☐	Dark stains at entry	*Yes*	☐	*No* ☐

Maintenance required *Yes* ☐ *No* ☐

If yes please specify _____

4. Photo Photo taken? *Yes* ☐ *No* ☐

Appendix 2

Nest Box Fauna Monitoring Form

1. General

Assessor (Name / Organisation): _____/_____

Date _____ Time _____

Nest Box ID _____ Code _____

Precinct _____ Site No. _____

(for precinct and site no. see: Thurgoona Threatened Species Conservation Strategy 2004)

GPS Location *E:* _____ *N:* _____

2. Nest box content

Nest

☐ *Yes* ☐ *No* ☐ *cup-shaped* ☐ *flat* ☐ *ball-shaped* ☐ *Other*_____

Material

☐ *leaves* ☐ *bark* ☐ *feathers* ☐ *shredded wood* ☐ *pellets* ☐ *Other* _____

Animals

	Present	***Absent***	***Species (if known)***	***Number (estimate)***
Squirrel Glider	○	○	_____	_____
Sugar Glider	○	○	_____	_____
Tuan (Brush-tailed Phascogale)	○	○	_____	_____
Bats	○	○	_____	_____
Birds	○	○	_____	_____
Wasps	○	○	_____	_____
Ants	○	○	_____	_____
Frogs	○	○	_____	_____
Lizard	○	○	_____	_____
Introduced bees	○	○	_____	_____
Other *(please specify)*	○	○	_____	_____

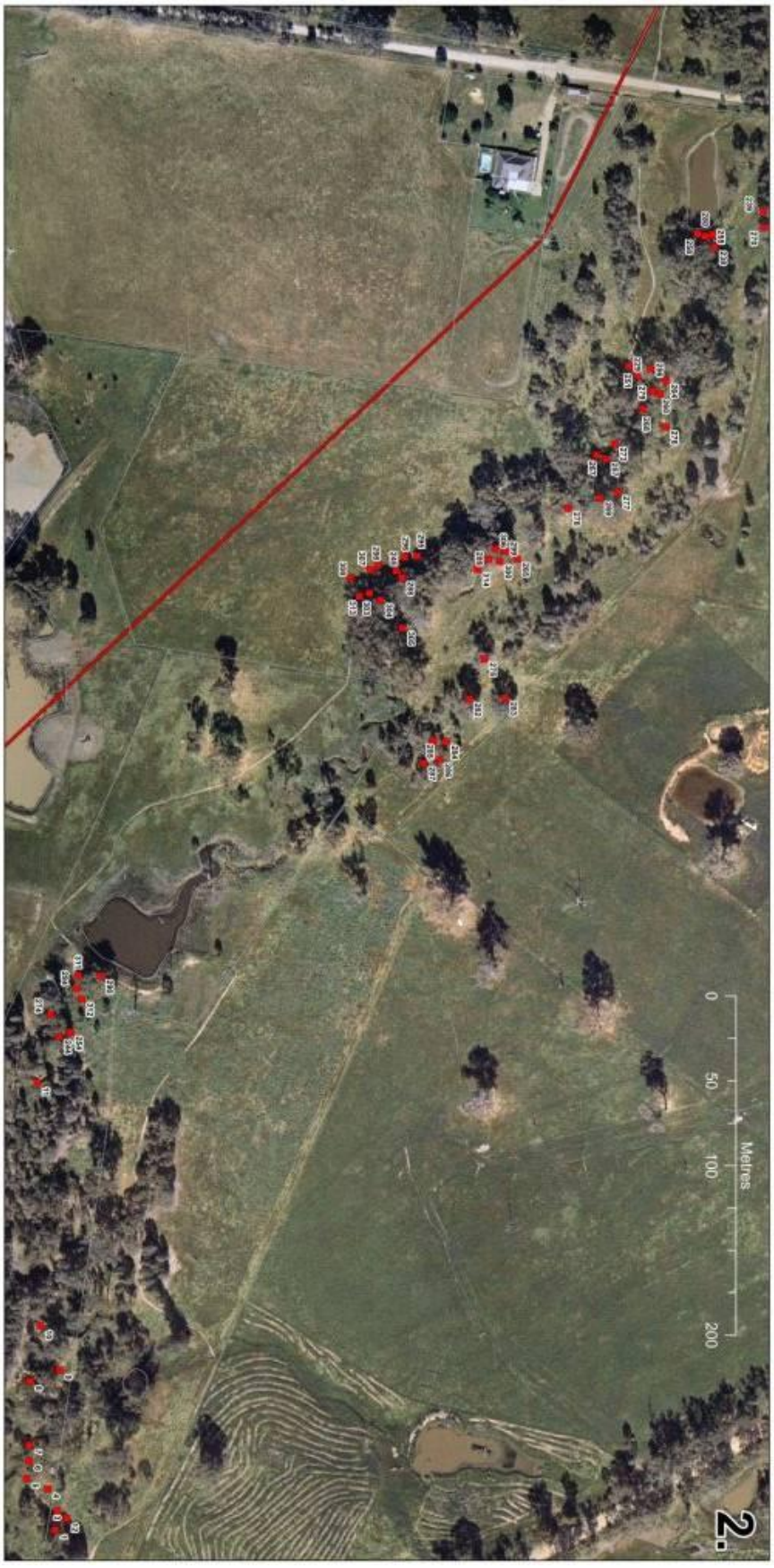
Notes _____

3. Photo Photo taken *Yes* ☐ *No* ☐

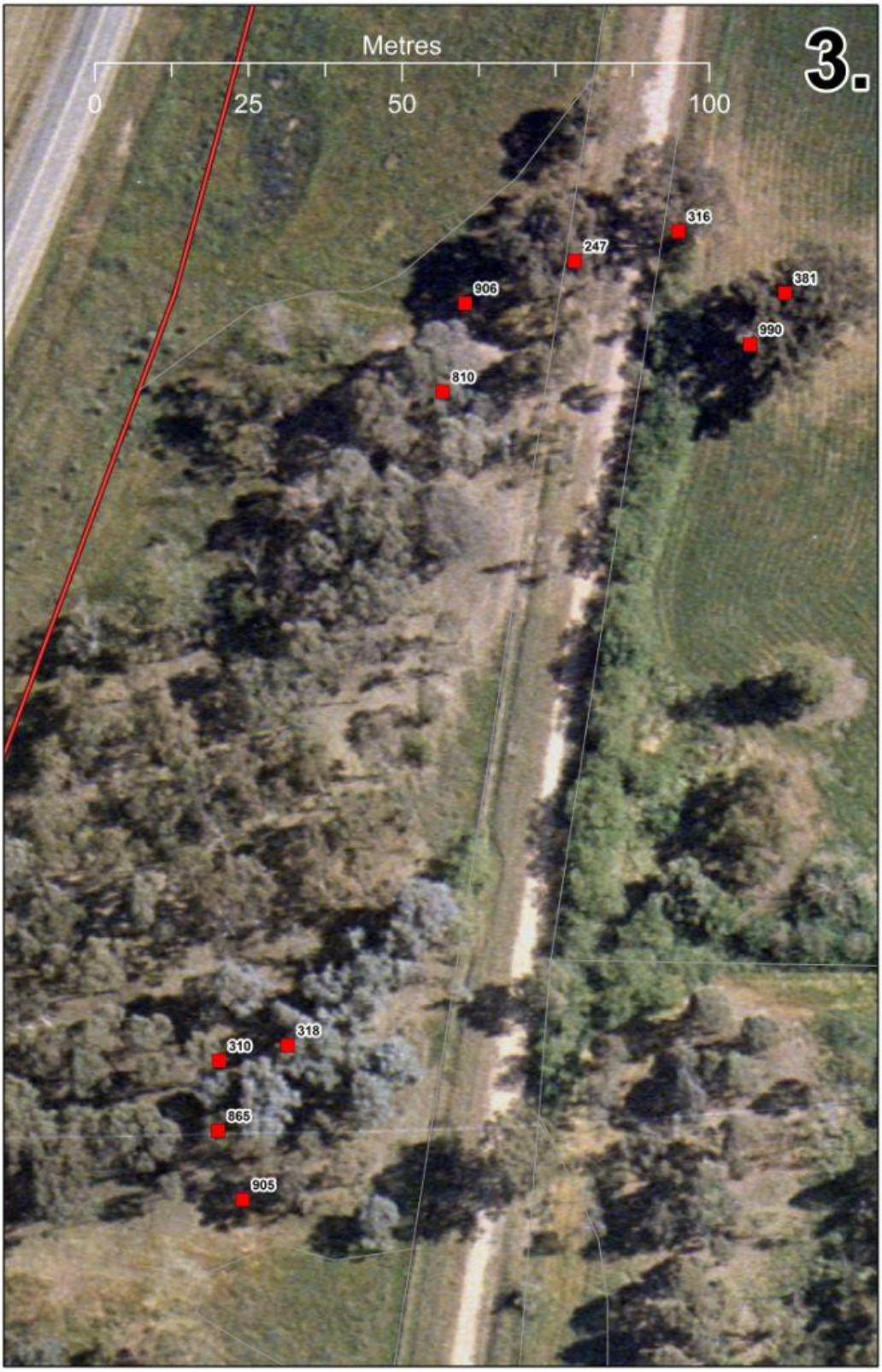
Appendix 3: Maps

Map 1: Overview of the Thurgoona Study Area, including nest boxes, LHBs and Biodiversity Units

Map 2: Nest boxes behind the Learning Commons (CSU Library) and along St. Johns Road



Map 3: Nest boxes along 6 Mile Creek



Map 4: Nest boxes along St. Johns Road

Map 5: Nest boxes in re-vegetated land patch on southeast side of campus and in front of the new University residences

Map 1 created by I. Brom, November 2011, with inputs from Liam Grimmett, Simon MacDonald and Ian Davidson
Maps 2-5 created and edited by Simon McDonald, Spatial Analysis Officer SPAN at Charles Sturt University, Albury-Wodonga