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The conservation of arboreal marsupials in the Albury-Wodonga region of south-eastern Australia

By Damian R. Michael, Sam Niedra and Dylan McWhinney

Summary Urban expansion is a major cause of land use change and presents a significant threat to biodiversity worldwide. Agricultural land is often acquired by local councils and developers to expand urban growth boundaries and establish new housing estates. However, many agricultural landscapes support high biodiversity values, especially farmlands that feature mosaics of native vegetation and keystone habitat such as hollow-bearing trees. In south-eastern Australia, many arboreal marsupials including the threatened Squirrel Glider (*Petaurus norfolcensis*) have populations within peri-urban zones of expanding rural cities. A key challenge to planners, developers and conservation organisations is the need to maintain habitat for locally rare and threatened species as land undergoes changes in management. Critical to the sustainable development of peri-urban landscapes is a thorough understanding of the distribution, habitat requirements and resources available to maintain and improve habitat for species dependent on limited resources such as tree cavities. In this management report, we present background information on an integrated research programme designed to evaluate potential impacts of urban development on fauna in the Albury Local Government Area, NSW. We mapped hollow-bearing trees, erected nest boxes and monitored arboreal marsupials. Information presented in this report provides a blueprint for monitoring arboreal marsupials, including threatened species in other developing regions, and will assist the Albury-Wodonga local governments in future planning of sustainable living environments.

Key words: *Albury Conservation Company, environmental planning, hollow-bearing trees, monitoring, nest boxes, urban expansion.*

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Implications to Managers

- Land managers should invest in long-term ecological monitoring to guide sustainable development and urban expansion.
- The conservation of arboreal marsupials in peri-urban landscapes will involve retaining maximum number of hollow-bearing trees to maintain habitat connectivity within developing areas.
- Nest boxes are an important conservation tool but require ongoing maintenance and monitoring to maximise their effectiveness.

Introduction

Urban expansion is a major cause of land use change and presents a significant threat to biodiversity worldwide (Jetz *et al.*2007; Concepción *et al.*2015). The conversion of natural ecosystems though urbanisation has profound effects on biodiversity (McDonald *et al.*2008), yet even within heavily modified landscapes, the impacts of urbanisation of modified agricultural land have implications for maintaining biological diversity (Sol *et al.*2017). The conversion of agricultural land to housing estates is often accompanied by loss of native vegetation and keystone habitats (McKinney 2008; Le Roux *et al.*2014; Elmqvist *et al.*2016), loss of connectivity between habitat patches (Bierwagen 2007) and increased rates of predation (Haskell *et al.*2001; Fischer *et al.*2012).

In south-eastern Australia, widespread land clearing for agriculture has resulted in catastrophic declines in mammals (Woinarski *et al.*2015), birds (Ford *et al.*2001) and reptiles (Tingley *et al.*2019). However, agricultural landscapes are not devoid of biodiversity (Daily *et al.*2003) and play a key role in conservation. Landscapes retaining mosaics of landscape elements and keystone habitats, such as patches of vegetation and remnant mature trees, support rich levels of biodiversity (Haslem & Bennett 2008), including many threatened species (Manning & Lindenmayer 2009; Crane *et al.*2017). Maintaining ecological assets as agricultural landscapes undergo changes in management or ownership presents a major challenge to new land managers, planners and developers. Indeed, carefully planned cities can support significant populations of threatened species. For example, the threatened Powerful Owl (*Ninox strenua*) has become a common resident of metropolitan Melbourne (Raylen *et al.*2002; Carter *et al.*2019) and Sydney (Kavanagh 2004). The degree to which rare or threatened species habitat and populations are incorporated in the development of new housing estates varies

among municipalities, yet prime opportunities exist for town planners and developers to create more sustainable living environments for communities, increase awareness of native wildlife by new communities and land owners, and maintain or improve conservation outcomes for native wildlife.

In this management report, we present background information on an integrated research programme designed to evaluate potential impacts of urban development on fauna in the Albury Local Government Area (LGA), the second largest rural city in New South Wales, Australia. We mapped hollow-bearing trees, erected nest boxes and established an arboreal marsupial monitoring project. These integrated research projects were implemented by Albury Conservation Company (ACC), a not-for-profit entity established in 2006 to help protect and enhance the natural environment in Albury, as well as engage the local community in protecting biodiversity for future generations.

Study Area

This study was conducted in the suburbs of Thurgoona and Wirlinga within the Albury Local Government Area, New South Wales (Fig. 1). The population of Albury is 53,249, and the growth rate averages 1.1% per year. The city covers 64.1 km^2 (30,674 ha), equating to 822 people per km^2, making it one of the most densely populated regional centres in NSW. Demand for rural residential development within Albury and surrounds is high. Approximately 75% of native vegetation within the LGA is cleared with remaining vegetation occurring alongside roadside reserves, drainage areas and parklands. The remnant vegetation is represented by the endangered Box Gum Grassy Woodland and Derived Grassland ecological vegetation community. The now abolished Albury-Wodonga Development Corporation undertook extensive forward tree plantings between 1975 and 1997 to improve the aesthetic values of the local landscape and offset environmental impacts associated with increased urbanisation. This environmental foresight resulted in 3 million trees, covering 2000 ha, being planted in peri-urban zones across Albury-Wodonga. The combination of remnant native vegetation and forward tree plantings supports significant populations of the threatened Squirrel Glider (*Petaurus norfolcensis*) (Box 1).

Case Study 1. Hollow-bearing Tree Mapping Project

More than 300 native animals are dependent on hollow-bearing trees (HBTs) in Australia (Gibbons & Lindenmayer, 2002). In NSW, at least 46 mammals, 81 birds, 31 reptiles and 16 frogs are reliant on tree hollows (Gibbons & Lindenmayer, 2002). Of these, 40 species are listed as threatened under the NSW Threatened Species Conservation (TSC) Act 1995. Loss of HBTs is listed as one of the 36 key threatening processes under the TSC Act and is implicated in the decline of many arboreal marsupials (Lindenmayer *et al.*1997), including the Squirrel Glider which uses up to twelve dens within their home range (Crane *et al.*2010). Tree characteristics such as size, health and species are important determinants of den use (Crane *et al.*2008) and can be used as a guide to protect trees from being removed during development. In relatively undisturbed woodland, the number of HBTs varies between seven and 17 ha^{-1} (NSW Scientific Committee 2020) and in urban remnants in metropolitan Melbourne HBTs average 5.8 ha^{-1} (Harper *et al.*2005a).

Methods

In July 2011, a project focusing on HBTs in the suburbs of Thurgoona/ Wirlinga was initiated. The main aim of the project was to survey and map HBTs in partnership with key stakeholders and community groups. Tree hollows were identified using ground-based surveys with the aid of binoculars. Tree characteristics such as geographical co-ordinates, elevation, eucalypt species, diameter at breast height, number of hollows, whether the tree was alive or dead, and presence of the introduced European Honey Bee (*Apis mellifera*) were recorded and stored as a digital spatial layer along with photographic images of each tree.

Results

A total of 650 HBTs were located and mapped (Fig. 1) and over 1000 ha of native vegetation was surveyed, including 35 km of roadside reserves. The highest density of HBTs in the study area was 3.5 ha^{-1} from a Travelling Stock Reserve (zoned E2 – Environmental Conservation).

Box 1 Squirrel Glider

The Squirrel Glider is a medium-sized arboreal marsupial that is dependent on hollow-bearing trees for denning and shelter. It is primarily associated with open eucalypt forests and woodlands on fertile soils across south-eastern Australia, a region that has been significantly cleared for agriculture. It is listed as Vulnerable in New South Wales under the *Threatened Species Conservation Act* 1995, threatened in Victoria under the *Flora and Fauna Guarantee Act* 1988 and endangered in South Australia under the *National Parks and Wildlife Act* 1972. In agricultural landscapes, the mean home range size of the Squirrel Glider ranges from 1.4 ha to 7 ha (van der Ree & Bennett 2003; Sharpe & Goldingay, 2007; Brearley *et al.*2011), although estimates vary among studies according to habitat configuration, landscape context and the methodology used to determine core area of occupation. Incremental loss of large hollow-bearing trees presents a major threat to the persistence of this species in NSW (Claridge & van der Ree 2004), and the loss and degradation of habitat as a direct result of urban development is recognised as a key threatening process for this species in NSW (NSW Scientific Committee 2020).

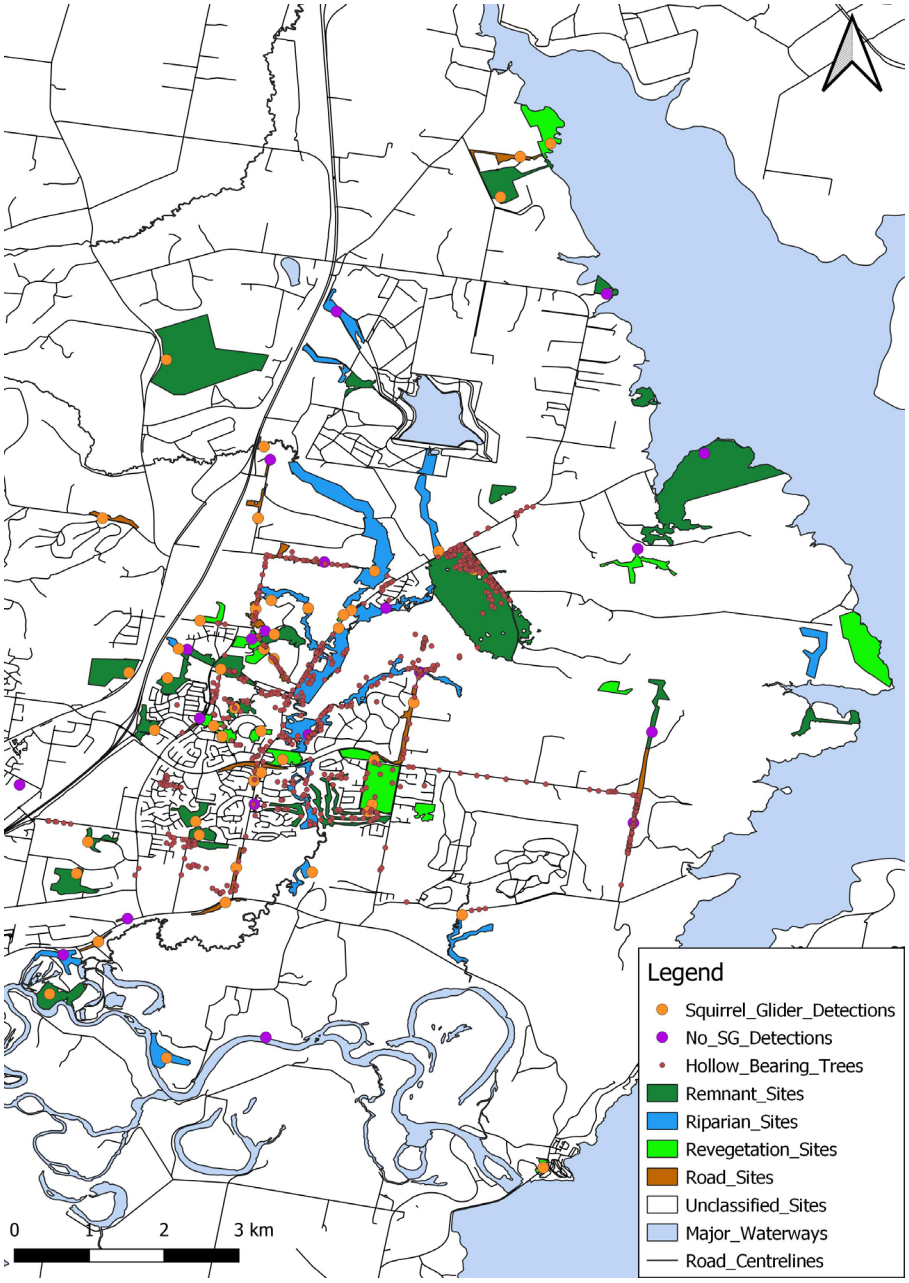

Figure 1. Location of mapped hollow-bearing trees and Squirrel Gliders within the Thurgoona Wirlinga study area, Albury, NSW.

The next highest density of two HBTs ha^{-1} occurred at two separate riparian sites. All data and photographs collected were supplied to Albury City Council for the establishment of a significant tree overlay on their internal mapping software. To date, the data have been used by the council's planning and environment staff to assist with assessing development applications and during the planning of infrastructure (e.g. construction of new roads). Importantly, development consultants working on behalf of land developers also have access to these data.

Case Study 2. Urban Nest Box Programme

Nest boxes are a popular management tool for providing supplementary denning and nesting sites for hollow-dependent fauna (Harper *et al.*2005b; Beyer & Goldingay, 2006). Nest boxes are effective in areas that support few mature trees, such as the forward tree plantings undertaken by Albury Wodonga Development Corporation. The nest box project began in 2011 when a pilot study was implemented to map and survey nest boxes on the Charles Sturt University (CSU) campus. Many nest boxes had been built and installed across the local landscape by various parties (e.g. Landcare groups, National Environment Centre). However, information on nest box location, design and condition was lacking. Furthermore,

there was no evidence of any coordinated monitoring or maintenance. With the aim of supplementing habitat, Thurgoona Men's Shed (TMS) was engaged to construct and install additional nest boxes in areas with low density of natural hollows.

Methods

The pilot study mapped 99 nest boxes on the CSU campus and was used to develop an online methodology for checking nest boxes. In 2012, this methodology was extended to a nearby golf course, and an additional 60 purpose-built (entrance diameter 35–40 mm) nest boxes were constructed and installed to supplement habitat for Squirrel Gliders. Funding to TMS in 2014 resulted in construction of 20 glider nest boxes to engage the community in a local environmental project, which were subsequently installed as part of a Squirrel Glider project by Landcare (Fig. 2a). The TMS nest box construction project was a first for men's sheds in the region and one of the first in Australia. In 2014, a further 100 Squirrel Glider nest boxes were designed and constructed by TMS using their collective expertise and previous nest box models and these were installed at 54 urban and peri-urban properties around Albury. New innovations included a rubber baffle to allow ease of access with a pole-mounted camera and a two-piece metal bracket to reduce weight and increase ease of installation.

In 2017, after significant research and development, 15 nest boxes with built-in motion-sensing cameras (Fig. 2b) were installed in Thurgoona. To our knowledge, this project was a world's first to trial remote cameras in nest boxes. The aim of these nest boxes was to capture images via an in-built infrared camera of Squirrel Glider individuals moving inside and for the images to be sent via the Telstra 3G network from the box to a phone or computer. After months of testing, the first Squirrel Glider image was transmitted in September 2018. Also in 2017, a crowd-funding campaign raised funds to purchase 42 nest boxes from TMS which were installed along Thurgoona roadsides using data from the HBT mapping project.

Figure 2. (a) Thurgoona Men's Shed member (yellow top) and Albury City Council staff inspecting nest boxes before installation, (b) nest box with built-in motion-sensing camera powered by a solar panel, (c) and (d) image of an adult Squirrel Glider captured using a motion-sensing camera.

Results

The initial nest box pilot study found that 26% of the nest boxes were dysfunctional, and 27% contained active colonies of the European Honey Bee. When Albury City Council monitored the 42 'Edge Pledge' nest boxes along Thurgoona roadsides in August 2018, they found 19/42 (45%) of boxes had evidence of Squirrel Glider use (animals present, leaf nest or chewing of entrance hole), and 3/42 (7%) of boxes were occupied by Squirrel Glider individuals. These nest boxes were again monitored in November 2019, with 22/42 (52%) of nest boxes having evidence of glider use and 10/42 (24%) of boxes being occupied by Squirrel Gliders. No other arboreal marsupials were recorded in the glider nest boxes, suggesting the aim of providing supplementary shelter-sites for a threatened species while excluding aggressive species such as the Common Brush-tailed Possum (*Trichosaurus vulpecula*) was achieved. Lack of funding and resources has prevented a comprehensive assessment of all boxes installed to date.

Case Study 3. Arboreal Marsupial Monitoring Programme

The city of Albury supports four arboreal marsupial species, including the Common Ringtail Possum (*Pseudocheirus peregrinus*), Common Brush-tailed Possum, Squirrel Glider and Yellow-footed Antechinus (*Antechinus flavipes*), of which the latter two species are of conservation significance. The Yellow-footed Antechinus is known from five locations within the Albury LGA (ALA 2020). Records of the Squirrel Glider in Albury date back to 1954 (ALA 2020). Between 1990 and 1999, six records were reported and between 2000 and 2018, a further 180 sightings were reported (ALA 2020). However, several studies recognised the Albury Squirrel Glider population faced an uncertain future (van der Ree 2003; Stewart & van der Ree 2009). This highlighted the need to collate information from various studies and develop a monitoring programme to better understand the distribution of arboreal marsupials in Albury, especially across the urban growth areas.

Methods

Following a community consultation workshop held in Thurgoona, an arboreal marsupial monitoring programme was developed in conjunction with the now defunct Australian Research Centre for Urban Ecology. Native vegetation greater than 5 ha was mapped and stratified by habitat type: (i) roadside verges, (ii) patches of remnant vegetation, (iii) riparian corridors, and (iv) forward tree plantings; and land zone: (i) urban, (ii) peri-urban (future development) and (iii) rural (agricultural land). Eighty-five patches of native vegetation were delineated from this exercise, from which, sites were randomly selected weighted to locations with pre-existing Squirrel Glider records. A total of 68 sites were included in the final monitoring programme, although due to access constraints 62–65 sites were monitored during the first round of surveys (ACC 2018a,b; 2019).

Arboreal marsupials were surveyed using motion-sensing wildlife cameras (Little Acorn LTL-5610 Series) during June 2018, October 2018 and March 2019 (Fig. 2c,d). Cameras were installed on an auxiliary branch or limb of eucalypt trees at a height of between 3 and 10 m and facing a target area on an adjacent tree trunk or branch which was sprayed with an attractant consisting of water, honey and sugar. The distance from camera to the target area varied from 0.5 to 2 m. All cameras were left undisturbed for ten days before being retrieved after which all images were manually processed by volunteer community members under the supervision of an experienced ecologist.

Results

The motion-sensing cameras captured all three possum species, although the Squirrel Glider was the most frequently detected species (>80% of all detections). A single Yellow-footed Antechinus was detected within a large urban remnant. During the first year of the monitoring programme, a total of 68 sites were monitored at least once, and Squirrel Glider was detected on 45 (66.17%) sites (Fig. 1). Brush-tailed Possum was detected on nine sites (13.2%), and Common Ringtail Possum was detected on three sites (4.4%). Table 1 shows the number of sites each species was detected during the baseline survey.

Brush-tailed Possum was found in all habitat types but primarily from the peri-urban zone. Across the three seasons, Squirrel Glider individuals were not detected in urban riparian sites, although they were detected in riparian peri-urban and rural sites. In the peri-urban zone, Squirrel Glider individuals were detected more frequently on roadside reserves in winter and less frequently in spring and autumn. In rural sites, Squirrel Glider individuals were detected in revegetation sites in winter and remained stable in other seasons (Fig. 3), although observed differences were not statistically significant.

Table 1. Number and proportion of sites arboreal marsupials were detected across three survey periods in the Thurgoona – Wirlinga study area

Survey	No sites surveyed	Species	No. sites detected	% of sites detected
Winter 2018	65	Squirrel Glider	27	41.5
		Brushtail Possum	6	9
		Ringtail Possum	2	3
Spring 2018	64	Squirrel Glider	21	33
		Brushtail Possum	5	7
		Ringtail Possum	0	0
Autumn 2019	62	Squirrel Glider	20	32
		Brushtail Possum	5	8
		Ringtail Possum	0	0

Discussion

Achieving high standards of human welfare and ensuring the long-term viability of the natural world are fundamental goals of sustainable human development (United Nations 2015). However, critical to maintaining biodiversity is a thorough understanding of species distributions, habitat requirements and resource availability. Ecological monitoring provides an effective way to track changes in the environment, and understand how management actions or disturbance events affect different organisms (Burns *et al.*2018). Carefully planned monitoring programmes can therefore provide land managers with information to ensure future living areas provide sustainable conditions for both humans and wildlife.

We recognised the need to collate information on common and threatened species, and develop an integrated research programme to document the availability of critical resources for arboreal marsupials across a major growth corridor in Albury. One project, which predates the national Hollows as Homes project (www.rbgsyd.nsw.gov.au), resulted in over 650 hollow-bearing trees being mapped and highlighted a major deficiency in the density of HBTs across the study area. The highest density of HBTs was 3.5 ha^{-1} recorded from a travelling stock reserve (zoned E2 – Environmental Protection) within the Albury LGA, which is below the reported range of seven to 17 HBTs for temperate woodlands (NSW Scientific Committee 2020). Travelling stock reserves represent some of the highest-quality and least degraded remnants of threatened temperate woodland in south-eastern Australia (O'Loughlin *et al.*2018). However, even these reserves may support low numbers of critical resources for arboreal marsupials. Hollow-bearing trees are being incrementally lost in the Albury LGA as a result of natural attrition, dieback, selective removal and land

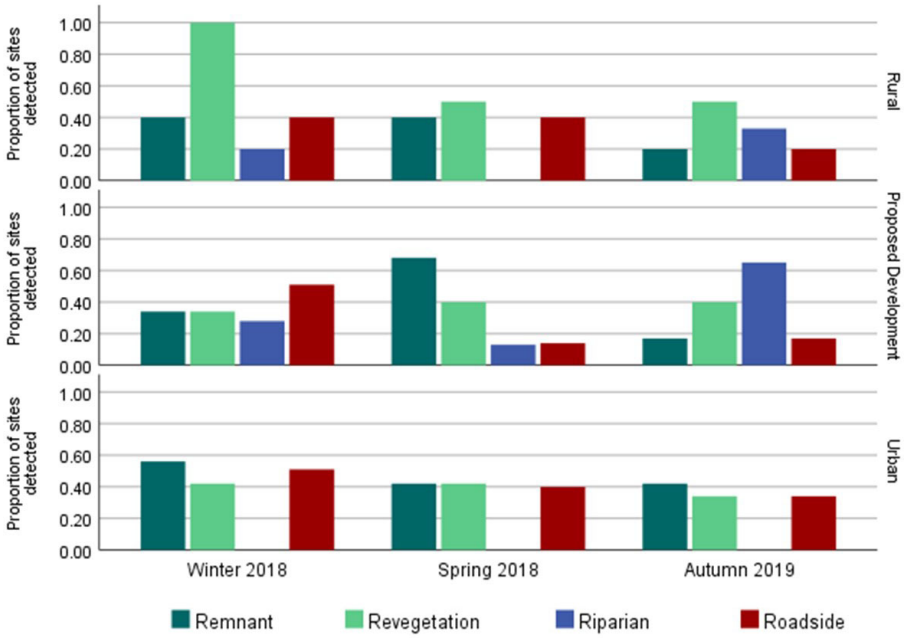

Figure 3. The proportion of sites at which the Squirrel Glider was detected across habitat and land use zones during three survey periods between winter 2018 and autumn 2019.

development. As many eucalypt species take more than 100 years to produce suitable cavities for denning or nesting (Gibbons & Lindenmayer 2002), the extensive tracts of forward tree plantings established during the 1970s to 1990s are unlikely to produce hollows for at least 50 years.

Installing nest boxes in places that lack tree hollows can facilitate dispersal and occupancy of suitable habitat by arboreal marsupials (Harper *et al.*2005b). The development of the nest box programme was driven primarily by the need to supplement and enhance denning sites for the Squirrel Glider. To date, Thurgoona Men's Shed have constructed in excess of 700 nest boxes. TMS pride themselves on using high quality materials to maximise their lifespan, and incorporating design principles that they have fine-tuned over the years. Their efforts have gained regional and national media attention, and now the construction of nest boxes is commonplace in Men's Sheds across Australia, particularly following the unprecedented bushfires of summer 2019-20. Although a systematic approach to monitoring next box occupancy has yet to be employed across the study area, many boxes are periodically inspected by private land owners, Woolshed Thurgoona Landcare Group, Albury City Council, ACC and others. However, a significant funds and resources are required to inspect and maintain the large number of nest boxes in the study area. Despite the lack of comprehensive nest box monitoring in Albury, occupancy rates in forward tree plantings are often high, reiterating the value of supplementing habitat in areas with low densities of naturally occurring tree hollows.

The nest box project has produced numerous Squirrel Glider records over the past 10 years (ALA 2020). However, there was a need to implement a monitoring programme to track changes in detection rates of both threatened and non-threatened arboreal marsupials across the major growth area, and assess potential impacts of urban development. Based on motion-sensing camera data, our preliminary findings indicate that the Squirrel Glider is one of the most widespread arboreal marsupials across the study area, with high detection rates along roadsides in urban environments. The cameras also frequently detected Squirrel Glider individuals in revegetation areas, including forward tree plantings where numerous purpose-built nest boxes have been installed. The monitoring programme is currently funded by the Albury City Council until June 2021, after which temporal trends in site occupancy will become evident and used to target areas where management interventions such as understorey enhancement and nest boxes are likely to be most effective. Furthermore, the arboreal marsupial monitoring programme has recently expanded into Victoria in partnership with Wodonga Council. This expansion into a cross-border programme embodies the vision of the Regional Natural Environment Strategy, currently being developed by Albury and Wodonga councils, and will greatly assist both councils in future planning and threatened species management.

A fundamental aspect of the projects outlined in the report is the engagement of the local community, including developers, council and future landholders in various aspects of the projects, including the consultation and implementation phases. Indeed, the nest box project would not have been as successful without community involvement and an organisational champion to take a key role in research and development. Involving community members in processing motion-sensing camera images gives the community an immediate appreciation of the kinds of species living in their 'backyards', and for many participants, provides the stimulus to become involved in other environmental projects. Many positive conservation outcomes can be achieved by empowering communities to make positive environmental decisions. ACCs philosophy of engaging the local community and applying scientific principles to research projects provides a blueprint for monitoring threatened species which could be transferred to other developing peri-urban regions in Australia.

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