

THE NATURAL HISTORY OF UPPER STURT, SOUTH AUSTRALIA PART II: VERTEBRATES AND INVERTEBRATES OF A MESSMATE STRINGYBARK (*Eucalyptus obliqua*) FOREST

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ABSTRACT

An area of forest in Upper Sturt, Mt Lofty Ranges, South Australia was studied over a 38 year period. The area is now known to support 17 species of mammals of which 7 species are introduced, and 63 species of birds of which 3 are introduced. It also supports 9 species of reptiles, 4 species of frogs and 141 taxa of invertebrates of which at least 17 are introduced. Although there has been a significant change in the vertebrate and invertebrate fauna since European settlement of this area, the total block of vegetation of which the present study area is a part, still forms an important link and habitat corridor between Belair National Park and the Mark Oliphant/Scott Creek Conservation Park complex of conservation reserves.

KEY WORDS: Upper Sturt, fauna, mammals, birds, reptiles, frogs, invertebrates.

INTRODUCTION

This is the second of three papers describing revegetation of cleared land adjacent to areas of relatively natural remnant native vegetation. In this paper, elements of the fauna are described in a study area in and around 16 Pole Road, Upper Sturt in the Mt Lofty Ranges. The third paper describes the results of fauna and vegetation monitoring at sample sites established in both the natural vegetation and the revegetation in the Upper Sturt study area. A second series of three papers will cover the flora and fauna and a more extensive revegetation program on a study area on the western end of Kangaroo Island (in prep.).

LOCATION AND HABITAT

The land use history, vegetation communities, flora and macro-fungi of the Upper Sturt study area (**Fig. 1**) has been described in Robinson & Haska, (2018). Monitoring of this area is detailed in Robinson & Haska (2019b).

There are two major vegetation communities in the study area. South-facing slopes and deep gullies support *Messmate Stringybark Open Forest* while the more exposed north-facing slopes support a *Cup Gum Woodland* (Armstrong *et al.* 2003). The general observations used to compile the species lists in this paper cover both these habitats. More intensive observations and trapping has only been carried out in two quadrats established in the Messmate Stringybark Open Forest and in the area being re-vegetated from an original cleared paddock (**Fig. 1**) (Robinson & Haska 2019b).

METHODS

The range of flora and fauna described in this paper results from our 38 years of general observation both on our two properties and in the surrounding areas of natural vegetation stretching from Upper Sturt Road down to the Sturt Creek. In addition we have established two standard Biological Survey of South Australia sample sites (Heard and Channon 1997, Owens 2000). Details of location and sampling of these quadrats is described in Robinson & Haska (2019b). Some voucher specimens of vertebrates caught at these sites and all the invertebrates caught in the micro-pitfall and some from macro-pitfall traps have been lodged in the collections of the South Australian Museum.

Taxonomic treatment of the fauna is as follows: mammals, birds, reptiles and amphibians (Owens and Graham 2009), invertebrates (family order: CSIRO 2016, species names: ABRS 2016, Smith 2016).

From 1998 when we moved into house 2 (**Fig 1**), we have recorded monthly, the species of birds seen around the house and in the adjacent natural vegetation and revegetation areas. This has resulted in 225 monthly records between 1998 and 2016.

Rainfall has been recorded at both houses and so we have records from 1975 to 2016 and this data is presented in Robinson & Haska (2018).

RESULTS

Mammals

Seventeen species of mammals have been recorded from the Upper Sturt study area (**Table 1**). Seven of these are introduced species. Examples of some of the native mammals found in the area are shown in **Fig. 2** and some comments on the abundance and ecology of some of the species is outlined below.

Echidna (Tachyglossus aculeatus) (Fig. 2D)

Single echidna sightings have been made regularly throughout the period of observation with their characteristic feeding diggings being present at most times of the year but increasing in the spring and summer months.

Yellow-footed Antechinus (Antechinus flavipes) (Fig. 2A)

Only a single antechinus has been captured in 2,800 Elliot, 56 cage and 1,120 pitfall trap nights in the natural vegetation area quadrat (site 1 in **Fig. 1**). This animal was captured in a dense blackberry patch at the end of the Elliot trap line in March 2009 and was an adult male. Males are known to range widely during the mating season. In April 2018 a living antechinus was sighted twice in daylight hours in the vegetation around the dam just below House 2. This stringybark forest has very low productivity for invertebrates as indicated by the results of the invertebrate pitfall trapping and probably is only able to support very low density antechinus populations.

Southern Brown Bandicoot (Isoodon obesulus) (Fig. 2F)

A male and a female bandicoot were caught in October 2007 in a cage trap set in the same blackberry patch that produced the antechinus capture. None have been caught since. When we first constructed the dam (**Fig. 1**) in the late 1970's, the dam wall and much of the slope above were covered with a dense growth of periwinkle and blackberry and we

used to regularly see bandicoots when we were digging up these weeds. As we worked our way into the natural vegetation below the dam and cleared the dense blackberry along the creek, bandicoots were no longer seen and they now seem to be confined to the remaining area of very dense blackberry in the steep creekline down to the Sturt River and below the reach of the sample trapline.



Figure 1: Location of the Upper Sturt study area showing Section numbers (red), location of the two houses we have lived in (yellow) and the location of the two sample quadrats (blue). Background image from Google Earth, March 2017.

Koala (*Phascolarctos cinereus*)

The introduced koala population in the Mt Lofty Ranges has increased enormously in the 38 years that we have been living at Upper Sturt. They received a setback in the Ash Wednesday bushfires of 1983, but have well and truly recovered. We always have at least one koala and, during the breeding season in spring and early summer, we often have up to three individuals, usually two males and a female calling noisily around our house. A single Manna Gum planted in 1998 is now over 9 m tall and all the leaves, from the trunk out to where the branch ends are too thin to support a koala, have been completely stripped of their leaves. During very hot weather in summer the local koalas descend and

sit at the base of the trees in the revegetation area above House 2 and they also come and drink from a small pond near the house and from our dam.

Common Brushtail Possum (*Trichosurus vulpecula*)

Common Brushtails are very rare in the stringybark forests of this area. It may be because none of the trees are old enough to have developed hollows. We have only seen one young brushtail on the ground at night in the whole time we have lived in this area.

Common Ringtail Possum (*Pseudocheirus peregrinus*) (Fig. 2C)

Ringtail possums are common in the area making their leaf nests in the canopy of the trees. They particularly favour the dense canopies of the Blackwood Wattle we have planted in the revegetation above House 2. In some years young inexperienced possums have made rudimentary leaf nests in the beams of our carport right under the steel roof (Fig. 2C), but they are generally forced to abandon this area when it gets too hot in summer.

Western Grey Kangaroo (*Macropus fuliginosus*) (Fig. 2E)

Like the koalas, kangaroo numbers have increased significantly since we have lived in the area. In earlier years we only saw very large old males that had been ejected from a mob that lived predominantly along Hilltop Drive. One actually died on our property. These days however there are always kangaroos moving through and they graze right up to the edge of House 2. These increased populations are undoubtedly keeping the understorey in these forest areas much more open than it would have been on pre-European times when there would have been no drinking water this high up the slopes in areas now supplied by the many small dams on virtually every watercourse in the hills.

Bats

For a number of years a small colony of Southern Freetail Bats (*Mormopterus planiceps*) occupied a roof space on a house on Hilltop Drive. We installed two bat nest boxes on House 2 in 2009 in the hope of attracting either this species or the other two that can be seen hunting insects over our dam on most summer nights, but to date they have not been taken up.

Rodents

Bush Rats (*Rattus fuscipes*) (Fig 2B)

Bush Rats have been caught in nearly every trapping session. They are always caught only in the last few traps on the trap line in the dense blackberry. In the rest of the trap line where we have cleared the blackberries, the natural understorey is not yet dense enough to support a population. Introduced Black Rats (*Rattus rattus*), are only caught in cage traps and as these are only placed at the beginning and end of each trap line, there is less chance of capture than Bush Rats which are regularly caught in Elliot traps. Black Rats however are common around our fruit trees and vegetable garden and regularly invade the roof space of House 2. The introduced Brown Rat (*Rattus norvegicus*) is only known from the area as a single road kill on Pole Road near the junction with Upper Sturt Road collected in June 2001, which was donated to the SA Museum (SAM M22211).



Fig. 2A: Yellow-footed Antechinus,
Antechinus flavipes



Fig. 2B: Bush Rat, *Rattus fuscipes*



Fig. 2C: Common Ringtail Possum,
Pseudocheirus peregrinus



Fig. 2D: Echidna, *Tachyglossus aculeatus*



Fig. 2E: Western Grey Kangaroo
Macropus fuliginosus



Fig. 2F: Southern Brown Bandicoot,
Isodon obesulus

Figure 2: Mammals from the Upper Sturt study area.

Birds

Sixty three species of birds (three of them introduced) have been recorded from the Upper Sturt study area (**Table 2**). The mean number of bird species seen each month has varied from year to year through the study (**Fig. 3**). In addition there has been consistent variation in the mean number of sightings each month over the whole study period (**Fig. 3**). In general, more bird species are recorded in spring and early summer when birds in general are at their most active and there are a number of summer visitors which will be discussed below. The number of species observed in a particular month has varied from 20-36.

Of the 63 species recorded over the whole observation period, 26 species, such as Pacific Black Ducks (**Fig. 4A**), Maned Ducks (**Fig. 4B**), Common Bronzewings, Yellow-tailed Black Cockatoos (**Fig. 4D**), Kookaburras, a variety of honeyeaters, Red-browed Firetails, Australian Magpies and Grey Currawongs, have been recorded in most months (**Table 2**) and have well-established breeding populations in the area. The remaining species are more irregular visitors and some of these are discussed below.

White-necked Heron (*Ardea pacifica*) (Fig. 4G)

White-necked Herons have been irregular visitors to our dam with sightings in December 2001 to Feb 2002, October 2011 and October 2012. White-faced Herons are much more regular visitors with sightings in most years, while we have had a brief visit from a single Intermediate Egret in October 2012.

Little Pied Cormorant (*Microcarbo melanoleucos*)

The Little Pied Cormorant is a more regular visitor to the dam while Little Black Cormorants (*Phalacrocorax sulcirostris*) visit less frequently. Both species hunt frogs and generally only stay around for a few hours at a time.

Collared Sparrowhawk (*Accipiter cirrocephalus*) (Fig. 4F)

A Collared Sparrowhawk has visited in December 2008 and then again in January and July 2014. From May, 2001 to December 2010 a Brown Goshawk (*Accipiter fasciatus*) was regularly sighted hunting birds in the valley below the house and was most recently seen in May 2018. The other birds of prey recorded in Table 3 were only seen flying overhead.

Spotted Dove (*Spilopelia chinensis*)

A small population of the introduced Spotted Dove began to become established around the house from January 1999. As they ate from the seed we put out for the Red-browed Firetails it was decided to attempt to eradicate them by trapping and killing them. It took a number of years as they were breeding in the area and became very trap shy once one of their number had been trapped, but the last bird was trapped in January 2010 and none have re-established to date (November 2018).

Yellow-tailed Black Cockatoo (*Calyptorhynchus funereus*) (Fig. 4D)

A pair of black cockatoos has been present in the area throughout the study period. They breed in a large dead hollow tree deep in the gully leading down to the Sturt River. In most seasons a single young has been produced. Outside the breeding season a large flock of Yellow-tailed Black Cockatoos used to fly over the site each morning and evening.

When we first began living in the area in the mid 1970’s this flock numbered several hundred birds. In recent decades the flock size has declined below 50 birds and is not seen as regularly as before.

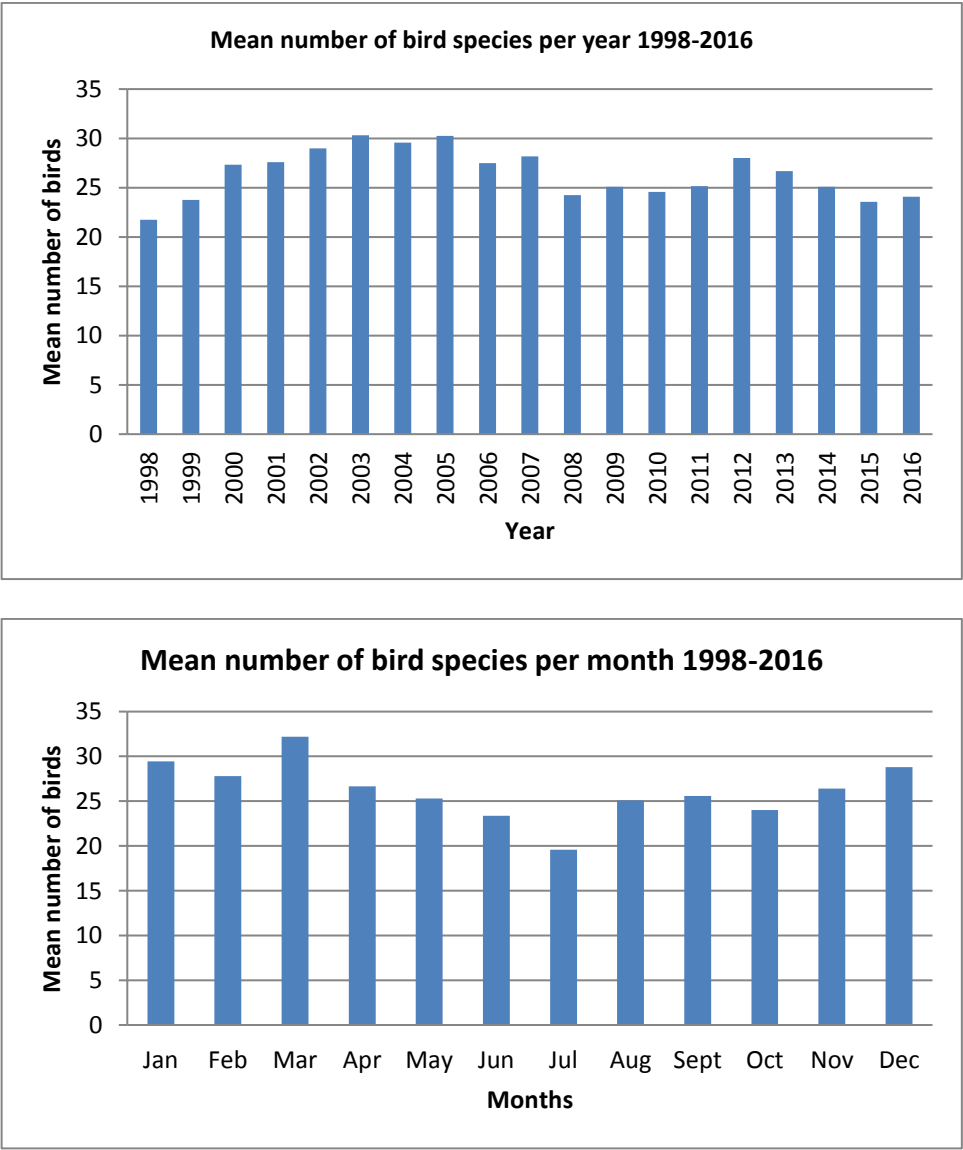


Figure 3: Numbers of bird species for the Upper Sturt study area 1998-2016.



Fig. 4A: Pacific Black Duck, *Anas superciliosa*



Fig. 4B: Maned Duck, *Chenonetta jubata*

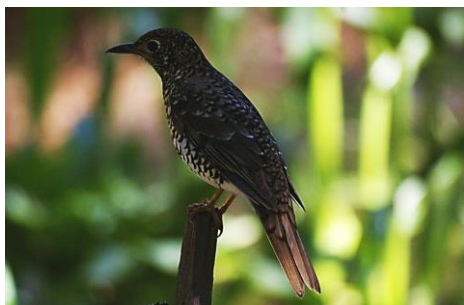


Fig. 4C: Bassian Thrush, *Zoothera lunulata*



Fig. 4D: Yellow-tailed Black Cockatoo, *Calyptorhynchus funereus*



Fig. 4E: Sacred Kingfisher, *Todiramphus sanctus*



Fig. 4F: Left, Collared Sparrowhawk, *Accipiter cirrocephalus*



Fig. 4G: Right, White-necked Heron *Ardea pacifica*

Figure 4: Birds from the Upper Sturt study area.

Musk Lorikeet (*Glossopsitta concinna*)

This species is more characteristic of the lower altitude woodlands than the stringybark forests of the Mt Lofty Ranges and a single bird was seen once in the study area in July 2001.

Cuckoos

Three species are summer visitors to the area. The most commonly recorded is the Fan-tailed Cuckoo which is often first observed feeding on the caterpillars of the vine moth (Fig. 9B) on the trellised grapevine at the front of our house. Horsefield's Bronze Cuckoo, (*Chrysococcyx basalis*) more often heard than seen and the least commonly recorded species is the Pallid Cuckoo (*Cacomantis pallidus*).

Sacred Kingfisher (*Todiramphus sanctus*) (Fig. 4E)

An irregular visitor to the study area either as a single bird or, sometimes, as a pair. It has been recorded in most years, often staying for several months. It does not appear to breed in our area however. It was most recently seen in February 2018.

Tawny-crowned Honeyeater (*Gliciphila melanops*)

A bird more characteristic of dense sclerophyll shrublands or of drier mallee areas, it has only been seen in September 2001, September, October 2002 and May 2007. Historically it has been recorded in Belair NP (McGilp 1953 in Baxter 1980).

White-naped Honeyeater (*Melithreptus lunatus*)

This is another predominantly summer visitor, with sightings of small flocks of 3-5 individuals from January to May. They were however recorded in every month from February to September in 2003 and again in 2005.

Restless Flycatcher (*Myiagra inquieta*)

A rare visitor seen on only three occasions in July, August 2001 and January 2002.

White-winged Chough (*Corcorax melanoramphos*)

A flock of 11 choughs visited the area for two days in January 2018.

Bassian Thrush (*Zoothera lunulata*) (Fig. 4C)

This species is seen in late summer when the young disperse. Single birds have been seen in January 2003, February, March 2007, January, March 2008, January, March 2009, January, February 2010 and April 2013. When cutting a track through dense blackberry in the steep gully leading down to the Sturt River, several old nests of this species were found attached to horizontal tree trunks that had fallen across the gully indicating that there is a breeding population here.

Reptiles

Nine species of reptiles have been recorded from the Upper Sturt study area (Table 3). Examples of some found in the area are shown in Fig. 5 and comments on the abundance and ecology of some of the species is outlined below.

Eastern Three-lined Skink (*Acritoscincus duperreyi*) (Fig. 5A)

This species is much less common than the abundant Garden Skink (Fig. 6B) and it seems

to prefer more open habitat than the stringybark forest natural vegetation in this area. It has only been caught in pitfall traps in the early days of the revegetation area when the habitat was effectively a grassland.

Eastern Bluetongue (*Tiliqua scincoides*) (Fig. 5C)

Although we only have a single observation of a Eastern Bluetongue over the study period, and only a single observation of the Sleepy Lizard (**Fig. 5D**), bluetongues are probably more common than the sleepy lizard as the latter prefer more open habitat than the bluetongue.

Red-bellied Black Snake (*Pseudechis porphyriacus*)

Red-bellied Black snakes are commonly seen around the dam hunting frogs, and we have even had a juvenile inside the house. Eastern Brown snakes have only been seen on two occasions and prefer more open habitats than the stringybark forest.

Frogs

Four species of frogs have been recorded from the Upper Sturt study area (**Table 3**). Examples of some of these found in the area are shown in Fig. 5 and some comments on their abundance and ecology is outlined below.

Spotted Marsh Frog (*Limnodynastes tasmaniensis*) (Fig. 5F)

This species is the least common of frogs using the dam in the study area for breeding. The most abundant species by far are the common froglet and brown tree frog (**Fig. 5E**). It is interesting that the Banjo frog (*Limnodynastes dumerili*) has never been heard in the study area even though it is a common inhabitant of dams throughout the Mt Lofty Ranges.

Brown Toadlet (*Pseudophryne bibroni*)

This frog breeds away from standing water in a small nest that it makes in damp leaf litter. They begin calling and breed following the first heavy rain in late summer, much earlier than the other frogs in this area. The male stays with the eggs until the advanced tadpoles hatch after heavy rain, dispersing into water bodies on rivulets of water.

Invertebrates

Invertebrates recorded from the study area are shown in **Table 4**. They were identified to species level whenever possible, but some could only be placed in an appropriate Family. The number of different 'taxa' identified was one hundred and forty one. Of these 17 were introduced species. This is a tiny fraction of the total invertebrate fauna that would be expected to inhabit a relatively natural area of stringybark forest such as that represented by the study area and so this list therefore only provides examples of some of the larger and more obvious species. Examples of some of those found in the area are shown in **Figs. 6-9** and some comments on the abundance and ecology of some of the species is outlined below.

Bednall's Shrubland Snail (*Cupedora bednalli*) (Fig. 6A)

This large native Australian land snail is characteristic of the stringybark forests of the southern Mt Lofty Ranges and occurs in small scattered populations in areas where there is good leaf litter or rock outcrops for it to burrow beneath, and seal itself off to aestivate



Fig. 5A: Eastern Three-lined Skink, *Acritoscincus duperreyi*



Fig. 5B: Garden Skink, *Lampropholis guichenoti* mating pair



Fig. 5C: Eastern Bluetongue, *Tiliqua scincoides*



Fig. 5D: Sleepy Lizard, *Tiliqua rugosa*

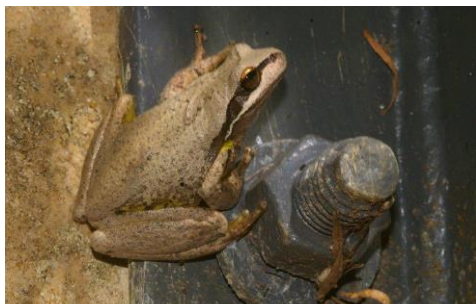


Fig. 5E: Brown Tree Frog, *Litoria ewingi*



Fig. 5F: Spotted Marsh Frog, *Limnodynastes tasmaniensis*

Figure 5: Reptiles and Amphibians from the Upper Sturt study area.



Fig. 6A: Bednall's Shrubland Snail, *Cupedora bednalli*



Fig. 6B: Mt Lofty Carnivorous Snail, *Emmalena gawleri*



Fig. 6C: Slater, *Porcellio scaber*



Fig. 6D: Marbled Scorpion, *Lychas marmoreus*



Fig. 6E: Adelaide Trapdoor, *Blackistonia aurea*



Fig. 6F: Wolf Spider, *Venetrix roo*

Figure 6: Invertebrates from the Upper Sturt study area.

through the hot summer months. It only becomes active again after heavy winter rains. It is a vegetarian, eating moss, fungi and bacterial films. It is preyed upon by the less common Mt Lofty carnivorous snail (**Fig. 6B**).

Marbled Scorpion (*Lychas marmoreus*) (Fig. 6D)

This small flattened scorpion can be quite active on warm humid evenings and often comes under the doors into our house.

Adelaide Trapdoor (*Blackistonia aurea*) (Fig. 6E)

The females are long-lived and sedentary, spending their whole lives in deep silk-lined burrows with a well camouflaged hinged lid which they can lift and pounce on passing insect prey. The much smaller males only live for a year and become active on warm humid nights when they roam widely in search of mates.

Australian Duskhawker (*Austrogynacantha heterogena*) (Fig. 7B)

This is the most common dragonfly that lives in our dam. When it is ready to emerge as an adult, the nymphs leave the water and can often be found clinging to the outer walls of our house where the adult form emerges and flies off.

Robber Fly (*Neoaratus hercules*) (Fig. 8F)

This large diurnal fly is a fierce predator of other flying insects and is often seen during the summer months.

Helena Gum Moth (*Opodiphthera helena*) (Fig. 9A)

The 75mm long bright green caterpillar of this species is a specialist feeder on eucalypt leaves and usually lives right up in the tree canopy. One was found on the lower leaves of a small stringybark in the revegetation area and was kept until it pupated and then hatched into this spectacular moth with a wingspan of 150 mm.

Common Brown (*Heteronympha merope*) (Fig. 9C)

As the caterpillars of this butterfly species feed on a variety of both native and introduced grasses, the adults can become extremely common in good breeding years. On some hot summer days our whole valley can be filled with these butterflies.

DISCUSSION

As outlined in Robinson and Haska (2018), this area of remnant Stringybark forest, although one of the larger continuous patches, is recovering from a long history of past clearing, logging and grazing and it clearly faces many challenges into the future from ongoing weed invasion, *Phytophthora*, grazing of the understorey by over-abundant kangaroo populations and wildfire. It no longer supports some of the species of native mammals that would have been found in this area at the time of European settlement and its birds, reptile and invertebrate faunas have been similarly affected and are still in the process of significant change. In addition to the weed invasion, there are now many introduced vertebrate and invertebrate species well established here.



Fig. 7A: Blue Skimmer,
Orthretum caledonicum female



Fig. 7B: Australian Duskhawker,
Austrogynacantha heterogena



Fig. 7C: Bark Cockroach, *Laxta* sp.



Fig. 7D: Hump-backed Katydid,
Elephantodeta pinguis



Fig. 7E: *Carenum elegans*



Fig. 7F: *Secatophis australis*

Figure 7: Invertebrates from the Upper Sturt study area.



Fig. 8A: *Carneodon pecuaris*



Fig. 8B: *Saragus interruptus*



Fig. 8C: Common Spotted Ladybird
Harmonica conformis



Fig. 8D: Fungus-eating Ladybird
Illeus galbula



Fig. 8E: Hover Fly, *Simosyrphus grandicornis*



Fig. 8F: Robber Fly, *Neoaratus hercules*

Figure 8: Invertebrates from the Upper Sturt study area.



Fig. 9A: Helena Gum Moth,
Opodiphthera helena)



Fig. 9B: *Periscepta polystriata*

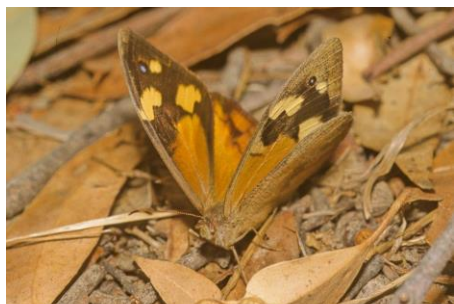


Fig. 9C: Common Brown
Heteronympha merope, female

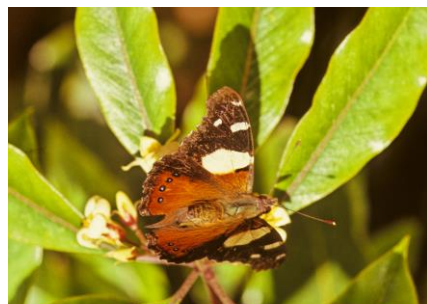


Fig. 9D: Australian Admiral, *Vanessa itea*



Fig. 9E: Bull Ant, *Myrmecia nigriscapa*



Figure 9F: Banded Sugar Ant,
Campanotus consobrinus

Figure 9: Invertebrates from the Upper Sturt study area.

Table 1: A list of mammals for the Upper Sturt study area, compiled between 1976 and 2018.

*Introduced species are marked with an asterisk.

FAMILY	SCIENTIFIC NAME	COMMON NAME	NATIVE BUSH	CLEARED LAND
TACHYGLOSSIDAE	<i>Tachyglossus aculeatus</i>	Short-beaked echidna	X	X
DASYURIDAE	<i>Antechinus flavipes</i>	Yellow-footed Antechinus	X	
PERAMELIDAE	<i>Isodon obesulus</i>	Southern Brown Bandicoot	X	
PHASCOLARCTIDAE	* <i>Phascolarctos cinereus</i>	Koala	X	
PHALANGERIDAE	<i>Trichosurus vulpecula</i>	Common Brushtail Possum	X	
PSEUDOCHEIRIDAE	<i>Pseudocheirus peregrinus</i>	Common Ringtail Possum	X	
MACROPODIDAE	<i>Macropus fuliginosus</i>	Western Grey Kangaroo	X	X
LEPORIDAE	* <i>Oryctolagus cuniculus</i>	Rabbit		X
MOLOSSIDAE	<i>Mormopterus planiceps</i>	Southern Free-tailed Bat	X	X
VESPERTILIONIDAE	<i>Chalinolobus gouldii</i>	Gould's Wattled Bat	X	X
	<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat	X	X
FELIDAE	* <i>Felis catus</i>	Domestic Cat		X
CANIDAE	* <i>Vulpes vulpes</i>	Fox	X	X
MURIDAE	* <i>Mus musculus</i>	House Mouse		X
	<i>Rattus fuscipes</i>	Bush Rat	X	
	* <i>Rattus norvegicus</i>	Brown Rat		X
	* <i>Rattus rattus</i>	Black Rat	X	X

The Mount Lofty Ranges has the highest proportion of declining bird species in Australia (Szabo, Vesk, Baxter and Possingham 2011) with eight species already extinct, a further 8 species predicted to follow them over the next 50 years and a further 16 species in the next 200 years if nothing is done to increase the available habitat and linkages. Five of these sixteen, which occur in this study area, include the Tawny-crowned Honeyeater, Pallid Cuckoo, Tawny Frogmouth, Restless Flycatcher and Bassian Thrush.

Reptiles and frogs seem to be faring slightly better. While little is known of the status and direction of change in our native invertebrates, they are clearly facing significant challenges.

In spite of these ongoing changes, there is still an interesting variety of native vertebrates and invertebrates living in this study area. Although the remaining natural vegetation is owned by a number of different land owners, the total block of vegetation of which the present study area is a part, forms an important link and habitat corridor between Belair National Park and the Mark Oliphant/Scott Creek Conservation Park complex of conservation reserves. This area supports the largest remaining populations of Southern Brown Bandicoots in the Mt Lofty Ranges. Our experience in observing changes in our small part of this total area of natural vegetation over the last 38 years shows that there are no grounds for complacency in thinking that the vertebrates and invertebrates we have documented here will 'look after themselves', and without significant intervention and management, everything will not still be the same in another 38 years.

Table 2: A list of birds for the Upper Sturt study area, compiled between 1976 and 2018.

*Introduced species are marked with an asterisk. Breeding status codes: B resident and known to breed, R resident but not known to breed, U occasional visitor, O rare, few records.

FAMILY	SCIENTIFIC NAME	COMMON NAME	BREEDING STATUS	OCCURRENCE (% of months)	NATIVE BUSH	CLEARED LAND
PELECANIDAE	<i>Pelecanus conspicillatus</i>	Australian pelican	O	0.89	X	X
ANATIDAE	<i>Anas superciliosa</i>	Pacific black duck	B	47.56	X	X
	<i>Chenonetta jubata</i>	Maned Duck	B	33.78	X	X
ARDEIDAE	<i>Ardea intermedia</i>	Intermediate Egret	O	0.44		X
	<i>Ardea pacifica</i>	White-Necked Heron	U	2.22		X
	<i>Egretta novaehollandiae</i>	White-Faced Heron	R	25.33		X
PHALACROCORA-CIDAE	<i>Microcarbo melanoleucos</i>	Little Pied Cormorant	U	8.89		X
	<i>Phalacrocorax sulcirostris</i>	Little Black Cormorant	U	2.67		X
ACCIPITRIDAE	<i>Accipiter cirrocephalus</i>	Collared Sparrowhawk	O	2.67	X	
	<i>Accipiter fasciatus</i>	Brown Goshawk	O	8.89	X	
	<i>Aquila audax</i>	Wedge-tailed Eagle	B	9.78	X	X
	<i>Hieraetus morphnoides</i>	Little Eagle	O	4	X	X
FALCONIDAE	<i>Elanus caeruleus</i>	Black-shouldered Kite	O	0.44		X
	<i>Falco peregrinus</i>	Peregrine Falcon	O	2.67	X	X
COLUMBIDAE	<i>Columba livia</i>	Feral Pigeon	O	0.44		X
	<i>Phaps chalcoptera</i>	Common Bronzewing	B	97.33	X	X
	* <i>Spilopelia chinensis</i>	Spotted Dove	U	39.56		X
CACATUIDAE	<i>Cacatua galerita</i>	Sulphur-crested Cockatoo	B	76.89	X	X
	<i>Cacatua sanguinea</i>	Little Corella	O	0.44		X
	<i>Calyptorhynchus funereus</i>	Yellow-tailed Black Cockatoo	B	96.44	X	X
	<i>Eolophus roseicapilla</i>	Galah	U	48.89		X
PSITTACIDAE	<i>Platycercus elegans</i>	Adelaide Rosella	B	99.11	X	X
	<i>Glossopsitta concinna</i>	Musk Lorikeet	O	0.44		X
	<i>Melopsittacus undulatus</i>	Budgerigah	O	0.44	X	
	<i>Trichoglossus haematodus</i>	Rainbow Lorikeet	B	97.33	X	X
CUCULLIDAE	<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo	U	15.11	X	
	<i>Cacomantis pallidus</i>	Pallid Cuckoo	O	1.33	X	
	<i>Chalcites basalis</i>	Horsfield's Bronze Cuckoo	U	3.56	X	
STRIGIDAE	<i>Ninox boobook</i>	Southern Boobook	U	32.89	X	
PODARGIDAE	<i>Podargus strigoides</i>	Tawny Frogmouth	R	6.67	X	
ALCEDINIDAE	<i>Dacelo gigas</i>	Laughing Kookaburra	B	94.67	X	X
	<i>Todiramphus sanctus</i>	Sacred Kingfisher	R	24	X	
CLIMACTERIDAE	<i>Cormobates leucophaea</i>	White-throated Treecreeper	B	66.22	X	
MALURIDAE	<i>Malurus cyaneus</i>	Superb Fairy-wren	B	94.67	X	X

FAMILY	SCIENTIFIC NAME	COMMON NAME	BREEDING STATUS	OCCURRENCE (% of months)	NATIVE BUSH	CLEARED LAND
MELIPHAGIDAE	<i>Acanthorhynchus tenuirostris</i>	Eastern Spinebill	B	83.56	X	
	<i>Anthochaera carunculata</i>	Red Wattlebird	B	93.78	X	X
	<i>Caligavis chrysops</i>	Yellow-faced Honeyeater	B	89.33	X	X
	<i>Gliciphila melanops</i>	Tawny-crowned Honeyeater	O	1.78	X	
	<i>Melithreptus lunatus</i>	White-naped Honeyeater	U	33.78	X	
	<i>Phylidonyris novaehollandiae</i>	New Holland Honeyeater	U	35.11	X	X
	<i>Phylidonyris pyrrhopterus</i>	Crescent Honeyeater	B	82.67	X	X
PARDALOTIDAE	<i>Pardalotus punctatus</i>	Spotted Pardalote	U	7.56	X	
	<i>Pardalotus striatus</i>	Striated Pardalote	O	4	X	
ACANTHIZIDAE	<i>Acanthiza lineata</i>	Striated Thornbill	B	93.78	X	X
	<i>Sericornis frontalis</i>	White-browed Scrubwren	B	77.78	X	
ARTAMIDAE	<i>Gymnorhina tibicen</i>	Australian Magpie	B	94.22	X	X
	<i>Strepera versicolor</i>	Grey Currawong	B	94.22	X	X
CAMPEPHAGIDAE	<i>Coracina novaehollandiae</i>	Black-faced Cuckooshrike	U	55.11	X	
PACHYCEPHALIDAE	<i>Colluricincla harmonica</i>	Grey Shrikethrush	B	81.78	X	X
	<i>Pachycephala pectoralis</i>	Australian Golden Whistler	B	56.44	X	
RHIPIDURIDAE	<i>Rhipidura albiscapa</i>	Grey Fantail	B	82.22	X	X
MONARCHIDAE	<i>Grallina cyanoleuca</i>	Magpielark	O	10.22		X
	<i>Myiagra inquieta</i>	Restless Flycatcher	U	2.22		X
CORVIDAE	<i>Corvus mellori</i>	Little Raven	B	95.56	X	X
CORCORACIDAE	<i>Corcorax melanorhamphos</i>	White-winged Chough	O	0.1	X	
PETROICIDAE	<i>Petroica boondang</i>	Scarlet Robin	U	20.89	X	
HIRUNDINIDAE	<i>Petrochelidon nigricans</i>	Tree Martin	O	0.44		X
TIMALLIDAE	<i>Zosterops lateralis</i>	Silvereye	B	47.11	X	X
TURDIDAE	* <i>Turdus merula</i>	Common Blackbird	B	96	X	X
	<i>Zoothera lunulata</i>	Bassian Thrush	U	4.44	X	
DICAETIDAE	<i>Dicaeum hirundinaceum</i>	Mistletoebird	U	4.89	X	
ESTRILDIDAE	<i>Neochmia temporalis</i>	Red-browed Finch	B	93.78	X	X
FRINGILLIDAE	* <i>Carduelis carduelis</i>	European Goldfinch	O	0.44		X

Table 3: A list of reptiles and amphibians for the Upper Sturt study area, compiled between 1976 and 2018.

FAMILY	SCIENTIFIC NAME	COMMON NAME	NATIVE BUSH	CLEARED LAND
GECKONIDAE	<i>Christinus marmoratus</i>	Marbled Gecko	X	
PYGOPODIDAE	<i>Aprasia striolata</i>	Lined Worm-lizard	X	
SCINCIDAE	<i>Acritoscincus duperryi</i>	Eastern Three-lined Skink		X
	<i>Hemiergis decresiensis</i>	Three-toed Earless Skink	X	X
	<i>Lanmpropholis guichenoti</i>	Garden Skink	X	X
	<i>Tiliqua rugosa</i>	Sleepy Lizard	X	
	<i>Tiliqua scincoides</i>	Eastern Bluetongue	X	
ELAPIDAE	<i>Pseudechis porphyriacus</i>	Red-bellied Black Snake	X	X
	<i>Pseudonaja textilis</i>	Eastern Brown Snake	X	X
HYLIDAE	<i>Litoria ewingi</i>	Brown Tree Frog	X	X
MYOBATRACHIDAE	<i>Crinia signifera</i>	Common Froglet	X	X
	<i>Limnodynastes tasmaniensis</i>	Spotted Marsh Frog	X	X
	<i>Pseudophryne bibronii</i>	Brown Toadlet	X	

Table 4: A list of invertebrates for the Upper Sturt study area, compiled between 1976 and 2018. *Introduced species are marked with an asterisk.

CLASS & ORDER	FAMILY	SCIENTIFIC NAME	COMMON NAME	NATIVE BUSH	CLEARED LAND
WORMS					
SERIATA					
O. Tricladida (Land Flatworms)	Geoplanidae	<i>Artiopsthia adelaidensis</i>	Land Planarian	X	
OLIGOCHAETA					
O. Clitellata (Earthworms)	Lumbricidae	* <i>Eisenia foetida</i>	Tiger Worm		X
	Megascolecidae	<i>Gemascolex stirlingi</i>	Giant Mt Lofty Earthworm	X	X
MOLLUSCS					
MOLLUSCA					
O. Gastropoda (Snails & Slugs)	Agriolimacidae	* <i>Deroceras invadens</i>	Invasive Field Slug		X

CLASS & ORDER	FAMILY	SCIENTIFIC NAME	COMMON NAME	NATIVE BUSH	CLEARED LAND
		<i>*Deroceras reticulatum</i>	grey field slug		X
	Arionidae	<i>*Arion ater</i>	European black slug	X	X
	Camaenidae	<i>Cupedora bednalli</i>	Bednall's woodland snail	X	
	Helicidae	<i>*Cornu aspersum</i>	European garden snail		X
	Hygromiidae	<i>*Cernuella virgata</i>	vineyard snail		X
	Limacidae	<i>*Lehmannia nyctelia</i>	striped field slug		X
		<i>*Limacus flavus</i>	yellow cellar slug		X
		<i>*Limax maximus</i>	leopard slug		X
	Rhytididae	<i>Emmalena gawleri</i>	Mt Lofty carnivorous snail	X	
CRUSTACEANS					
CRUSTACEA					
O. CRUSTACEA	Porcellionidae	<i>*Porcellio scaber</i>	European Slater		X
O. AMPHIPODA		Gn. Sp.	Amphipod spp.	X	X
SPIDERS, SCORPIONS, TICKS, MITES					
ARACHNIDA					
O. Araneae (Spiders)	Actinopodidae	<i>Missulena insignis</i>	Mouse Spider	X	
	Araneidae	<i>Araneus viridipes</i>			X
	Idiopidae	<i>Blakistonia aurea</i>		X	
		<i>Misgolas andrewsi</i>		X	
	Lycosidae	<i>Venatrix roo</i>		X	
	Miturgidae	<i>Uliodon tarantulinus</i>		X	
	Nemesiidae	<i>Aname tepperi</i>		X	
	Pholcidae	<i>Pholcus phalangeoides</i>	Daddy Long-Legs		X
	Sparassidae	<i>Isopeda woodwardi</i>	Huntsman Spider		X
	Stifidiidae	<i>Baiami loftyensis</i>		X	
	Theridiidae	<i>*Latrodectus hasseltii</i>	Redback	X	X
O. Scorpionida (Scorpions)	Scorpiones	<i>Cercophonius squama</i>		X	
	Scorpiones	<i>Lychas marmoreus</i>		X	
O. Pseudo-scorpionida (Pseudoscorpions)		Gn. Sp.	Pseudoscorpion sp.	X	

CLASS & ORDER	FAMILY	SCIENTIFIC NAME	COMMON NAME	NATIVE BUSH	CLEARED LAND
SC ACARINA O. Oribatida (Mites)	Oribatidae	Gn. Sp.	Mite sp.	X	
	Erythraeidae	Gn. Sp.	Mite sp.	X	
MYRIOPODS					
MYRIOPODA					
O. Diplopoda (Millipedes)	Julidae	<i>Ommatoiulus moreletii</i>	Millipede	X	X
O. Polydesmida	Paradoxosomatidae	<i>Oncocladosoma</i> sp.	Native Millipede	X	
O. Chilopoda (Centipedes)	Scutigerae	<i>Allothreua maculate</i>	House Centipede		X
O. Scolopendromorpha	Scolopendridae	<i>Scolopendra morsitans</i>	Centipede	X	X
SPRINGTAILS					
SC COLLEMBOLA					
	Poduridae	Gn. Sp.		X	
	Entomobryidae	<i>Willowsia australica</i>		X	
	Sminthuridae	Gn. Sp.		X	
INSECTS					
INSECTA					
O. Zygoptera (Damselflies)	Coenagrionidae	<i>Ischnura heterosticta</i>	Common Bluetail		X
O. Odonata (Dragonflies)	Aeschnidae	<i>Austrogynacantha heterogena</i>	Australian Duskhawker		X
	Hemicorduliidae	<i>Hemicordula tau</i>	Tau Emerald		X
	Libellulidae	<i>Orthretum caledonicum</i>	Blue Skimmer		X
O. Zygentoma (Silverfish)	?Lepismatidae	Gn. Sp			
O. Blattodea (Cockroaches)	Blaberidae	<i>Calolampra</i>			
		<i>Laxta</i> sp.	Bark Cockroach	X	
	Blatellidae	? <i>Robshelfordia</i>			
	Blattidae	* <i>Periplaneta americana</i>	American Cockroach		X
		<i>Platyzosteria</i> sp.	Black Cockroach	X	
O. Isoptera (Termites)	Rhinotermitidae	<i>Coptotermes acinaciformis</i>	Subterranean Termite	X	
O. Mantodea (Mantids)	Mantidae	<i>Orthodera ministralis</i>	Green Mantid	X	X

CLASS & ORDER	FAMILY	SCIENTIFIC NAME	COMMON NAME	NATIVE BUSH	CLEARED LAND
O. Phasmatodea (Stick Insects)	Phasmatidae	<i>Ctenomorpha marginipennis</i>	Margin-winged Stick Insect	X	
O. Dermaptera (Earwigs)	Forficulidae	<i>*Forficula auricularia</i>	European Earwig		X
O. Orthoptera (Grasshoppers & Locusts)	Acrididae	<i>Austroicetes cruciata</i>	Small Plague Grasshopper		X
		<i>Chortoicetes</i>		X	
		<i>Peakesia</i>		X	
	Gryllotalpidae	<i>Gryllotalpa</i> sp.	Mole Cricket		X
	Tettagoniidae	<i>Elephantodeta pinguis</i>	Hump-backed Katydid	X	
O. Hemiptera (True Bugs)	Cicadellidae	Jassinidae		X	
	Coccidae	Gn. Sp.			X
	Pentatomidae	Gn. Sp.	Stink Bugs		X
	Reduviidae	<i>Coranus</i>	Assassin Bug		X
O. Neuroptera (Lacewings)	Chrysopidae	<i>Chrysopa</i>		X	
O. Coleoptera (Beetles)	Bostrychidae	<i>Bostrychopsis</i>		X	
	Carabidae	<i>Carenum elegans</i>		X	
		<i>Platycoelus</i>		X	
		<i>Secatophus australis.</i>		X	
	Chrysomelidae?	Gn. Sp.			X
	Coccinellidae	<i>Coccinella</i>	Ladybird		X
		<i>Harmonica conformis</i>	Common Spotted Ladybird		X
		<i>Illeis galbula</i>			X
	Curculionidae	Amycterinae		X	
		<i>Cubicorhynchus</i> sp.		X	
		<i>Ips grandicollis</i>		X	
		<i>Leptopius</i>		X	
		<i>Sclerorinus</i> sp.		X	
		<i>Sitona humeralis</i>		X	
	Elateridae	<i>Conoderus</i>	Click Beetle		X
	Lycidae	<i>Porostoma</i>		X	
	Nitidulidae	<i>Carpophilus</i>			X
	Scarabaeidae	<i>Anoplognathus montanus</i>	Christmas Beetle	X	

CLASS & ORDER	FAMILY	SCIENTIFIC NAME	COMMON NAME	NATIVE BUSH	CLEARED LAND
O. Coleoptera cont.		<i>Carneodon pecuarius</i>		X	
		<i>Dasygnathus tuberculatus</i>		X	
		? <i>Heteronyx</i>		X	
		? <i>Metanastes</i>		X	
		<i>Scitala</i> sp.		X	
	Silphidae	<i>Ptomaphila lachrymosa</i>	Carrion Beetle		X
	Staphylinidae	? <i>Xylion</i>		X	
	Tenebrionidae	<i>Adelium brevicorne</i>	Bronzed Filed Beetle	X	
		<i>Adelium lindense</i>		X	
		? <i>Brises</i>		X	
		<i>Cardiothorax behri</i>		X	
		<i>Celibe australis</i>		X	
		<i>Ecnolagria grandis</i>	Honey Brown Beetle	X	
		<i>Saragus interruptus</i>		X	
		<i>Seirottrana parallela</i>		X	
O. Mecoptera (Scorpion Flies)		Gn. Sp			X
O. Diptera (Flies, Mosquitoes, Gnats)	Asilidae	<i>Neoaratus hercules</i>	Robber Fly	X	
	Calliphoridae	* <i>Calliphora nociva</i>	Blow Fly		X
	Cecidomyiidae	Gn. Sp		X	
	Chloropidae	Gn. Sp		X	
	Dolichopodidae	Gn. Sp		X	
	Ephydriidae	Gn. Sp		X	
	Lauxaniidae	Gn. Sp		X	
	Muscidae	* <i>Musca domestica</i>	House Fly		X
	Phoridae	? <i>Megaselia</i>		X	
	Psychodidae	Gn. Sp		X	
	Sciaridae	Gn. Sp		X	
	Simuliidae	Gn. Sp		X	
	Sphaeroceridae	Gn. Sp		X	
	Syrphidae	<i>Simosyrphus</i>	Hover Fly		X
	Tachinidae	Gn. Sp	Like Blow Flies	X	
	Tipulidae	<i>Gynoplistia</i>		X	

CLASS & ORDER	FAMILY	SCIENTIFIC NAME	COMMON NAME	NATIVE BUSH	CLEARED LAND
O. Lepidoptera (Butterflies, Moths)	Agaristidae	<i>Phalaenoides glyciniae</i>	Grapevine Moth		X
	Anthelidae	<i>Oenochroma vinaria</i>	Grevillea Moth	X	
	Arctiidae	<i>Spilosoma glatignyi</i>	Glatigny's Tiger Moth	X	
	Cossidae	<i>Endoxyla</i> sp.	Giant Wood Moth	X	
	Danaeidae	<i>Danaus plexippus</i>	Wanderer		X
	Geometridae	<i>Niceteria</i> sp.		X	
		<i>Prasinocyma semicrocea</i>	Common Gum Emerald	X	
	Hepialidae	<i>Trictenia atripalpis</i>	Barti Moth	X	
	Noctuidae	<i>Dasypodia selenophora</i>	Granny Moth	X	
		<i>Grammodes ocellata</i>		X	
		<i>Periscepta polystriata</i>		X	
	Nymphalidae	<i>Geitoneura klugii</i>	Marbled Xenica	X	
		<i>Heteronympha merope</i>	Common Brown	X	X
		<i>Vanessa itea</i>	Australian Admiral		X
		<i>Vanessa kershawi</i>	Meadow Argus	X	X
	Oenochrominae	<i>Monectenia falernaria</i>		X	
	Pieridae	<i>Belenois java</i>	Caper White		X
		<i>Eurema smilax</i>	Small Grass Yellow		X
		<i>*Pieris rapae</i>	Cabbage White		X
	Saturnidae	<i>Antheraea helenae</i>	Helena Gum Moth	X	
	Apidae	<i>Amegilla chlorocyanea</i>	Blue-banded Bee		X
		<i>*Apis mellifera</i>	European Honey Bee	X	X
	Formicidae	<i>Camponotus consobrinus</i>	Banded Sugar Ant	X	X
O. Hymenoptera (Ants, Bees & Wasps)		<i>Iridomyrmex suchieri</i>		X	X
		<i>Myrmecia pilosula</i>	Hopper Ant	X	
		<i>Myrmecia pyriformis</i>	Bull Ant	X	
		<i>Myrmecia nigriscapa</i>	Bull Ant	X	
		<i>Pheidole</i> sp.		X	
	Vespidae	<i>*Vespula germanica</i>	European Wasp		X
		<i>Sceliphron laetum</i>	Mud-dauber Wasp		X

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THE NATURAL HISTORY OF UPPER STURT, SOUTH AUSTRALIA PART III: RECOLONISATION OF A REVEGETATED AREA AFTER 16 YEARS

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ABSTRACT

The plant, mammal, bird, reptile and invertebrate species and numbers of individuals in an area of relatively natural vegetation were compared with those of a revegetated cleared paddock in Upper Sturt, Mt Lofty Ranges, South Australia over a 16 year period. Methods used in the revegetation project are described, and a series of photopoints show development of the vegetation on both the control and revegetated sites. After 16 years in the revegetated area there were 18 native and 22 introduced plant species (reduced from 39 introduced species in the original paddock) compared with 55 native and 22 introduced species in the natural vegetation. Relative cover/abundance of the revegetation had increased from 3-16 over the period while in the natural vegetation it remained around 35 for the whole study period.

Mammal and bird species reached 4 and 29 respectively in the revegetation compared with 6 and 35 in the natural vegetation. Reptile and frog species and invertebrate Orders were similar in both the revegetation and the natural vegetation at the end of the study, but numbers were consistently greater in the natural vegetation throughout the duration of the study. Clearly the revegetated area does not yet support the same flora and fauna as the natural vegetation after 16 years of monitoring. The missing species include those with more specific habitat preferences in the area of natural vegetation sampled in this study.

KEY WORDS: Upper Sturt, revegetation, forest, plants, mammals, birds, reptiles, invertebrates.

INTRODUCTION

This is the third of three papers describing revegetation of cleared land adjacent to areas of relatively natural remnant native vegetation, in the Upper Sturt study area in and around 16 Pole Road, Upper Sturt in the Mt Lofty Ranges. In this paper the results of fauna and vegetation monitoring at sample sites established in both the natural vegetation and the revegetation are described. This part of the study follows 16 years of revegetation activity from 2000 to 2016. A second series of three papers will cover the flora and fauna and a more extensive revegetation program on a study area on the western end of Kangaroo Island (in prep.).

LOCATION AND HABITAT

The land use history and vegetation communities, flora and macro-fungi of the Upper Sturt study area (**Fig. 1**) has been described in Robinson & Haska (2018). The vertebrate and invertebrate fauna is described in Robinson & Haska (2019a).



Figure 1: Location of the Upper Sturt study area showing Section numbers (red), location of the two houses we have lived in (yellow) and the location of the two sample quadrats (blue). Background image from Google Earth, March 2017.

METHODS

A variety of methods were employed to revegetate the cleared areas both on the formerly grazed paddock and on the disturbed area of bare soil resulting from back-fill on and around our earth-sheltered house. The major part of the revegetation used tube stock trees grown by a neighbour who ran a wholesale plant nursery. He had a problem with seedlings, particularly, messmate stringybark seedlings, coming up in his plant tubes from the natural seed rain from the surrounding trees. He was able to transplant these into individual tubes and grow them on for us.

A number of methods were tried, with less success, to establish some native plant understorey.

Table 1. Numbers and species of tubestock trees and shrubs planted on the study area at Upper Sturt, and the numbers/percentage surviving at 5 and at 10 years after planting.

Common Name	Scientific Name	Number Planted	Survivors (5 years)	Survivors (10 years)
Messmate Stringybark	<i>Eucalyptus obliqua</i>	2149	1950	1182
Pink Gum	<i>Eucalyptus fasciculosa</i>	35	35	24
Cup Gum	<i>Eucalyptus cosmophylla</i>	30	27	20
Manna Gum	<i>Eucalyptus viminalis</i>	4	4	2
Prickly Tea-tree	<i>Leptospermum continentale</i>	263	263	58
Blackwood	<i>Acacia melanoxylon</i>	320	301	170
Kangaroo Thorn	<i>Acacia paradoxa</i>	84	81	55
Myrtle Wattle	<i>Acacia myrtifolia</i> var. <i>myrtifolia</i>	64	64	20
TOTAL (Planted)		2913		
Total & % survival (5 years)			2730 (93.7%)	
Total & % survival (10 years)				1531 (52.6%)

Trees

Tube stock sized trees were planted into a watering well, dug with a mattock, at 1 m spacing following the contours. This tree density followed the 10 year target numbers of between 500 and 2500 plants per hectare outlined in the Victorian Department of Sustainability and Environment (DSE 2006). A handful of blood and bone was dug into each hole before planting. All trees were watered in well and then, watered irregularly through their first summer and autumn. Weeds were hand pulled from around the base of the planted trees for at least the first year. Glyphosate was sprayed on growth between the trees for the first couple of years. No tree guards were used and no problems were experienced with kangaroo browsing. A small population of rabbits was removed before planting began.

In order to manage this revegetation program, planting was spread over 13 separate areas and took place from 1995 to 2009. The species composition and rates of survival of all tube stock plantings are shown in Table 1.

Understorey

Four methods were tried to establish understorey species beneath the planted tubestock trees and shrubs.

1) Leaf litter and soil from nearby areas of natural vegetation

Leaf litter was raked from beneath nearby scrub and bagged. The first 2-3 cm of topsoil from under this litter was collected and bagged separately.

In Autumn 2001 one bag of soil and 2 bags of litter were spread on a plot cleared of weeds in the revegetation area.

2) Transplants from nearby areas of natural vegetation

Small plants were dug up from scrub, to the depth of a spade cut, in late winter and directly planted into the revegetation area.

3) Seed Balls

Locally collected seeds were mixed with local clay, *Blood and Bone* and potting mix and rolled into balls and dried. 923 balls were made and planted May 1999. Seeds incorporated into the balls included: *Pultenaea daphnoides*, *Acacia myrtifolia*, *Daviesia leptophylla*, *Leptospermum continentale*, *Hakea carinata*, *Acrotriche fasciculiflora* and *Bursaria spinosa*. The balls were put on 1 m square, scraped areas of bare ground, and marked for future monitoring of any result.

4) Direct seeding

In November 2000 seeds collected in Summer 1999 were mixed with potting mix. Species were: *Acacia myrtifolia* and *Pultenaea daphnoides*. An area of ground approximately 3 m by 1 m, in four of the tree planted areas, was cleared of grass and the top 1 cm of soil and roots cut off. The seed mixture was spread thinly over this and covered with a scattering of topsoil and litter from the scrub. No other treatment or watering was applied and the seeds were not treated before sowing in any way. In March 2001 mature but green *Bursaria spinosa* seed pods were cut and scattered on these sites.

Weed Management

Weed control was carried out throughout the 16 years of the study, both in the revegetation area and in approximately 2 ha of the natural vegetation both on our property and the neighbours where our control quadrat (NOA01001) was situated. The most intensive weed control was carried out in the early years as there were extensive areas of Blackberry (*Rubus* sp.), Portuguese Heath (*Erica lusitanica*) or Tree Heath (*Erica arborea*), English Broom (*Cytisus scoparius*), Montpellier Broom (*Genista monspessulana*) and Three-corner Garlic (*Allium triquetrum*) in both the cleared area and the natural vegetation. In addition, there were extensive stands of Periwinkle (*Vinca major*) in the cleared area. More scattered weeds that were also controlled in the natural vegetation included St John's Wort, Boneseed, Olive, Sweet Pittosporum, Cotoneaster, Hawthorn, Dog Rose and Coastal Wattle. Extensive stands of woody weeds were first sprayed with *Triclopyr* (broadleaf and woody weed herbicide) and then the dead wood was slashed and left to rot. Herbaceous weeds were spot-sprayed with *Glyphosate* (broad leaf and grass herbicide). Periwinkle and Cotoneaster (*Cotoneaster glaucophyllus*) proved particularly resistant to herbicide and these were mostly dug up by hand. Once a degree of control of the major infestations was achieved most subsequent weeding was by hand-pulling or spot spraying any new weeds while they were small.

Photopoint Monitoring

A standard Biological Survey of South Australia photopoint (Owens, 2000) was established at quadrats 1 and 2 (**Fig. 1**). These photos were taken annually in November from 2001 to 2016 (**Figs. 2, 3**). A photograph looking SW across the general area of the revegetation (site 3 in **Fig. 1**) was also taken. This photo (**Fig. 4**) duplicated a general view of our property first taken in 1979 and was taken annually in summer from 2001 to 2016 once the revegetation had begun.



2001



2006



2010



2016

Figure 2: Changes in the natural vegetation at Quadrat NOA01001 between 2001 and 2016.

Plant, Vertebrate & Invertebrate Monitoring

To monitor the response of the flora and fauna to the revegetation of the study area two standard Biological Survey of South Australia sample sites (Heard and Channon 1997, Owens 2000) were established. The first (coded NOA01001 and called Quadrat 1 in this report) was a control established in the area of natural vegetation. The second, (coded NOA01002 and called Quadrat 2 in this report) was established in the revegetation area. The location of these two quadrats is shown in **Fig. 1**. These quadrats were sampled for vertebrates and invertebrates twice a year in spring and autumn from 2001 to 2010 and then for four additional sampling periods in spring 2012, 13, 15 and 16.

For the purposes of analysis in this report the spring and summer results for the vertebrate and invertebrate trapping are amalgamated to produce annual data showing the maximum number of individuals and total species diversity over the two sampling periods.

Vegetation sampling at these quadrats was carried out annually over the study period from 2001 to 2015. Each year the vegetation data from these two quadrats was analysed for species richness and the sum of the cover/abundance scores for the species in a quadrat. Weights were assigned for the cover/abundance codes as follows: 'N' = 0.25, 'T' = 0.5, '1 (<5%)' = 1, '2 (5-25%)' = 2, '3 (25-50%)' = 3 and '4 (50-75%)' = 4.

All quadrat data has been added to the Biological Databases of South Australia (BDBSA) as Survey no 178. Some voucher specimens of vertebrates caught at these sites and all



2001



2006



2010



2016

Figure 3: Changes in the revegetated area at Quadrat NOA01002 between 2001 and 2016.

the invertebrates caught in the micro-pitfall and some from macro-pitfall traps have been lodged in the collections of the South Australian Museum. Voucher specimens of all plants from the study area have been lodged in the State Herbarium.

Taxonomic treatment of the fauna is as follows: mammals, birds, reptiles and amphibians (Owens and Graham 2009), invertebrates (Family order: CSIRO 2016, species names: ABRS 2016, Smith 2016). Taxonomic treatment of the plants follows the Census of South Australian Plants Algae and Fungi (State Herbarium of South Australia 2015).

DATA ANALYSIS

Invertebrates

Individual invertebrate species that were captured in the standard pitfall traps and in the micro-pitfall traps were identified as far as possible. Each taxon was assigned a relative biomass (using total length) as follows: <2mm = 1, 3-10mm = 5, >10mm =10. Once total biomass had been calculated for each taxon at each trapping period, the data was amalgamated into the invertebrate Family and the total number of species and the total relative biomass was calculated for each trapping period. These figures were also calculated for all invertebrate Orders combined over the whole trapping period to produce the graphs presented here (**Figs 5-13**).



1979



2000



2002



2016

Figure 4: Changes in the revegetation in a general view SW across the area between 1979 and 2016.

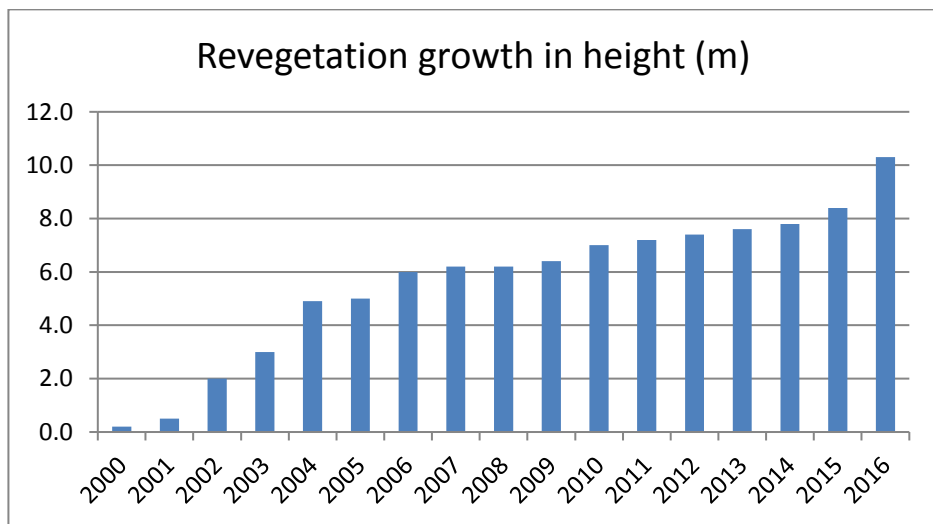


Figure 5: Increase in the mean height of the planted Messmate Stringybark trees within quadrat NOA01002 in the revegetation on the study area from 2000-2016.

RESULTS

Revegetation Methods

Trees

Overall survival of tube stock plantings after 10 years was 52% (Table 1). Plants died largely from overshadowing and root competition as they were originally planted at 10m spacings and naturally thinned out as some grew faster than others.

Understorey

There was minimal success in establishing understorey species, which was probably because the tube stock was planted so closely.

Spreading leaf litter and soil collected from nearby natural vegetation resulted in the establishment of some *Pultenaea daphnoides* and *Acacia myrtifolia* var. *myrtifolia*, but these were shaded out as the trees grew.

The seed balls went through the winter of 1999 and in many cases looked largely intact even though there was some very heavy rain. There was no evidence of any successful establishment by December 2000.

Transplanting of small plants from nearby natural vegetation was more successful, particularly on the earth-covered house roof where there was no shading from trees. Species grown from this method included: *Acaena novaeseelandiae*, *Oxalis perenans*, *Pimelea linifolia*, *Goodenia ovata*, *Arthropodium strictum*, *Microlaena stipoides*, *Poa clelandii*, *Gonocarpus tetragynus* and *Dianella revoluta* var. *revoluta*.

By March 2001 the only native plant established on the direct seeding areas was *Microlaena stipoides*, but weeds such as *Solanum nigrum* and *Anagalis arvensis* were favoured by the bare ground planting areas. The weeds were pulled out.

Ongoing Weed Management

The major weeds are now successfully controlled in both the revegetation area and the part of the natural vegetation where weeding took place. Blackberry and Montpellier Broom are still germinating and those plants with berries are also being spread into the area by foxes and birds such as Currawongs and Blackbirds. Although much reduced, there is still a problem with control of Three-corner Garlic in some parts of the natural vegetation where spot-spraying is difficult as it grows among the various native lily-like plants and in the middle of small native shrubs. Some level of weed control will be necessary for the foreseeable future in both the revegetated and the natural vegetation areas if the gains made to date are not to be reversed.

Photopoint Monitoring

At Quadrat 1 in the control area of natural vegetation (**Fig. 2**) there are two main changes visible over the sixteen years of this study, the hillside in the background has become much more open in its understorey, probably largely due to browsing from the large Western Grey Kangaroo population in this area. Following the drought, from 2006-2008, a number of very large Messmate Stringybark trees fell down in the area of natural vegetation. They were often trees that had re-grown from the original forest after wood-cutting and had a weak point at their base where the original tree stump was. In addition, a significant

number of the thinner stringybark trees have died and fallen over. This is probably a natural process as these regrowth forests mature and the larger trees out-compete the smaller individuals. Eventually all these dead trees fall and contribute some important habitat structural diversity to the otherwise fairly simple understorey.

Quadrat 2 in the revegetation area clearly illustrates the significant growth of the stringybark trees over the sixteen year study period. A graph of the growth in mean height of the revegetation is shown in **Fig. 5** It is clear from comparison with the remnant old trees in this photopoint picture (**Fig. 3**) that the revegetation is still many years from maturity.

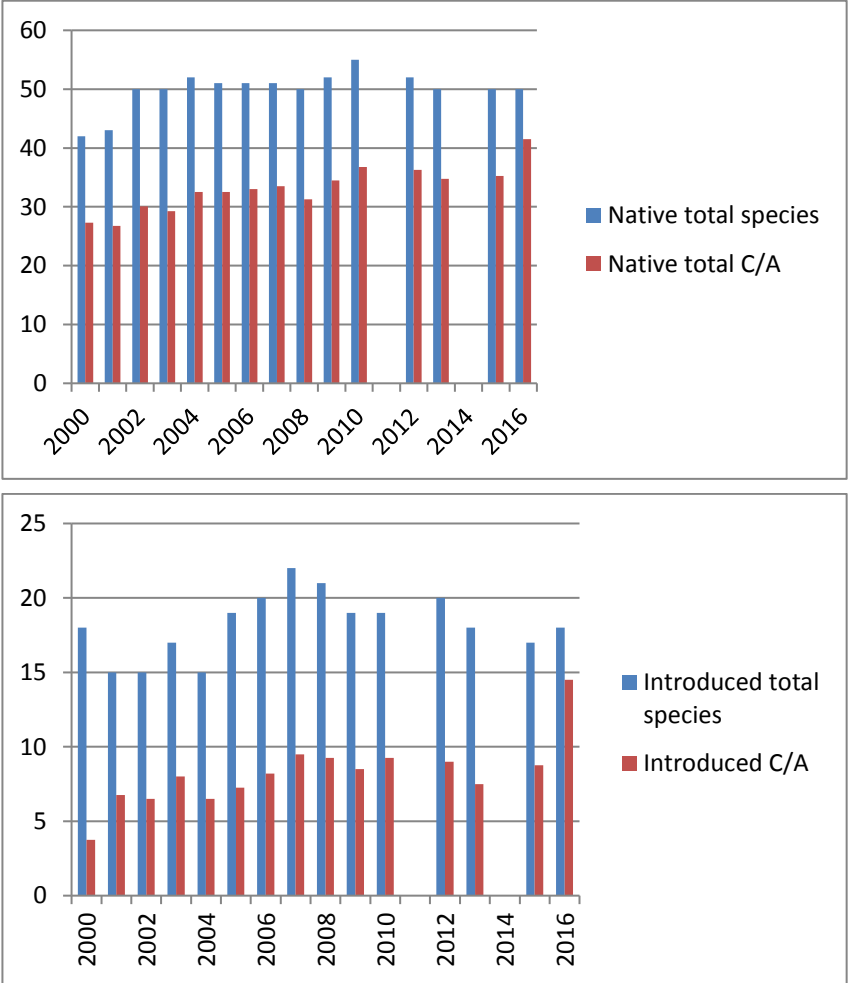


Figure 6: Natural Vegetation Quadrat NOA01001. Changes in native and introduced plant species diversity and relative cover/abundance in natural vegetation quadrat on the study area 2000-2016.

Plant, Vertebrate & Invertebrate Monitoring

Plants

Changes in plant species diversity and relative cover abundance are shown for Quadrat 1 in the natural vegetation (**Fig. 6**) and Quadrat 2 in the revegetation (**Fig. 7**). The natural vegetation quadrat supported a total plant diversity of 55 native species (39% of the total of 144 for the study area) and only 22 introduced species (21% of the total of 105 for the study area). The revegetated area in 2016 however still only supported 18 native species and, in the early years of the study, up to 39 introduced species. By 2016, as the

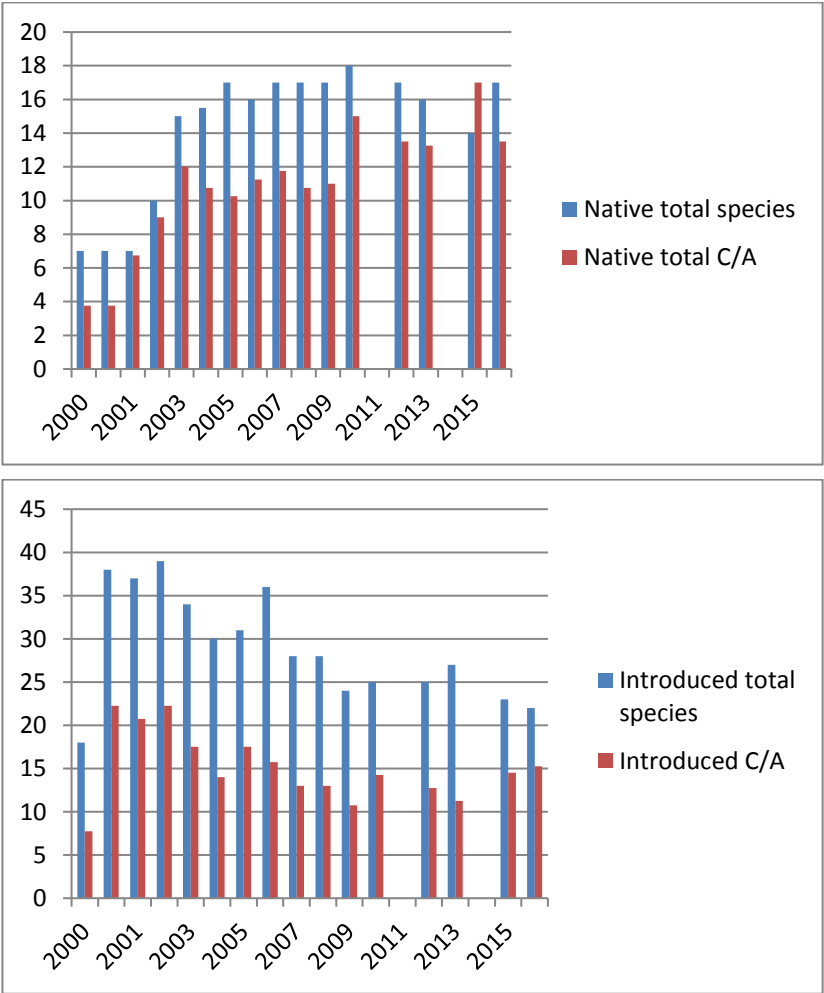


Figure 7: Revegetated area Quadrat NOA01002. Changes in native and introduced plant species diversity and relative cover/abundance in revegetation quadrat 2000-2016.

trees in the revegetation grew quite thickly, the number of introduced species has been reduced to 22.

The changes in relative cover/abundance shown in **Fig. 6** show the opposite pattern. In the natural vegetation, the native species cover/abundance remained at around 35 from 2000 to 2016 while introduced species went from 6 to 14 showing perhaps that weed control has not been as good as it could have been over this 16 year period.

In the revegetation there have been more striking changes over this 16 year period, with native species (mostly those planted, but with some colonization from nearby natural vegetation) going from 7 to 18 and introduced species on the decline from 38 in 2000 to 22 in 2016 (**Fig. 7**). The cover/abundance for native species has increased from 3 to 17 showing the planted species growing significantly. Introduced species cover/abundance has declined over this period from 22 to as low as 11.

Mammals

Changes in the mammal species diversity and relative abundance is shown for Quadrat 1 in the natural vegetation and Quadrat 2 in the revegetation (**Fig. 8**). The natural vegetation quadrat supported a total diversity of 6 native species (85% of the total of 7, excluding bats, for the study area) and 4 introduced species (57% of the total of 7 for the study area). The revegetated area in 2016 however still only supports 4 native species (57% of the total of 7 for the study area) and 3 introduced species (43% of the total of 7 for the study area). Two of these, the house mouse and black rat have not been trapped since 2012, but black rats are known to still be present. Native species not yet found in the revegetated area include: Southern Brown Bandicoot (*Isoodon obesulus*), Yellow-footed Antechinus (*Antechinus flavipes*) and Bush Rat (*Rattus fuscipes*); all of which require much denser understorey than has yet developed in the fifteen years of revegetation to date. Relative abundance of mammals recorded (**Fig. 8**) is very variable through the study period in both the natural vegetation and revegetated area ranging between 1 and 18. In general however, throughout the study period, mammals are consistently more abundant in the natural vegetation than in the revegetation (**Fig. 8**).

Birds

Changes in the bird species diversity and relative abundance is shown for Quadrat 1 in the natural vegetation and Quadrat 2 in the revegetation (**Fig. 9**). The natural vegetation quadrat supported a total diversity of 35 native species (56% of the total of 63 for the study area) and both of the 2 introduced species known from the study area. The revegetated area in 2016 however still only supports 29 native species (46% of the total of 63 for the study area) and the same two introduced species. Native species recorded from the natural vegetation quadrat but not yet found in the revegetated area include: the Mistletoebird, Spotted Pardalote and Sacred Kingfisher. Relative abundance of birds recorded (**Fig. 9**) is very variable through the study period in both the natural vegetation (between 16 and 100) and the revegetated area (between 14 and 90). Throughout the study period, however, birds are consistently more abundant in the natural vegetation than in the revegetation (**Fig. 9**).

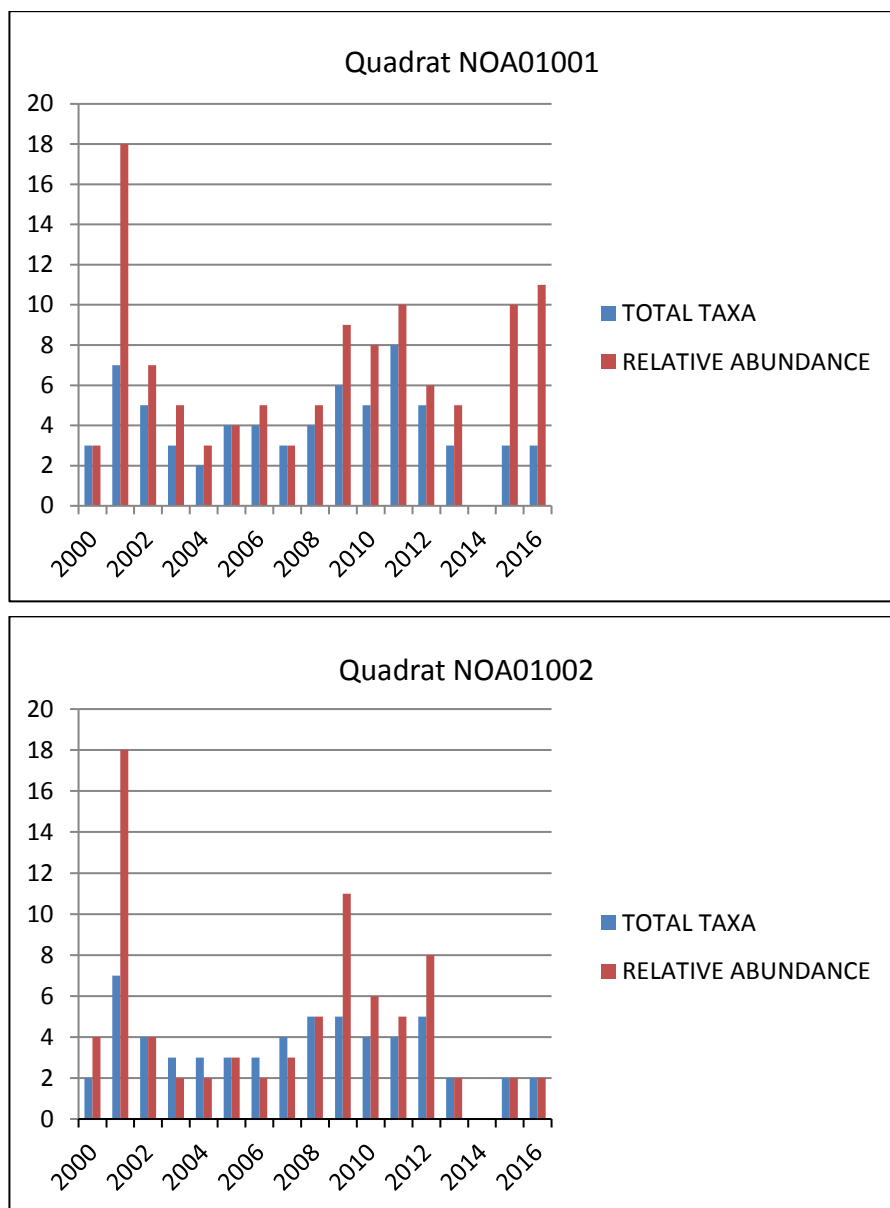


Figure 8: Changes in native and introduced mammal species diversity and relative abundance on the study area from 2000-2016; at Quadrat NOA01001 in the natural vegetation and at Quadrat NOA01002 in the revegetation area.

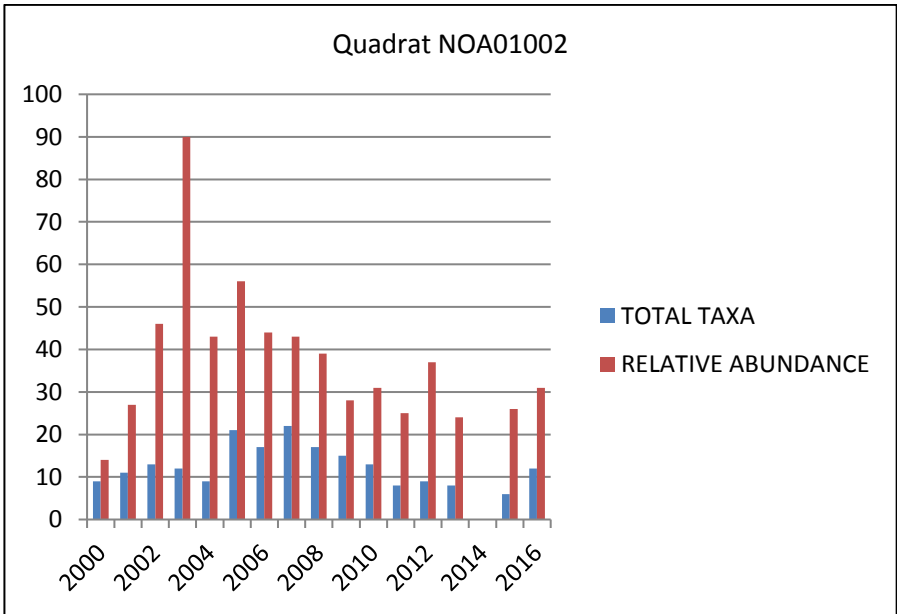
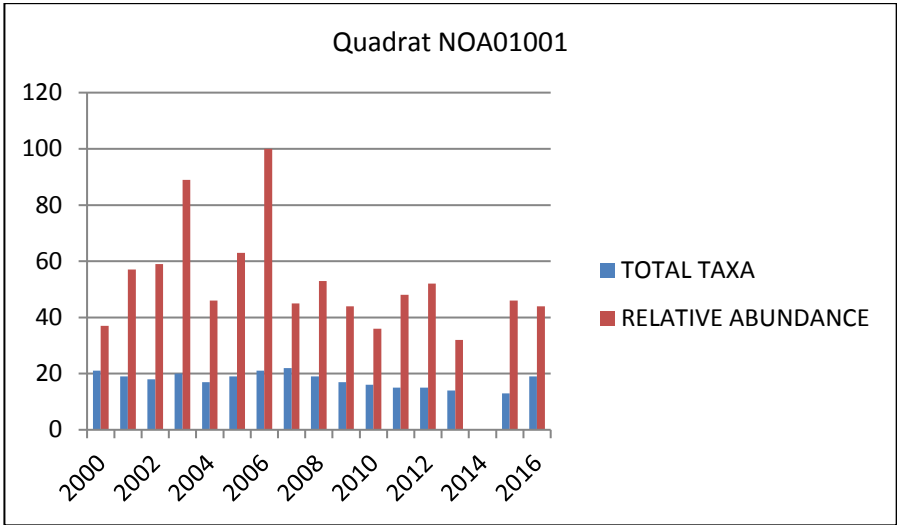


Figure 9: Changes in native and introduced bird species diversity and relative abundance on the study area from 2000-2016; at Quadrat NOA01001 in the natural vegetation and at Quadrat NOA01002 in the revegetation area.

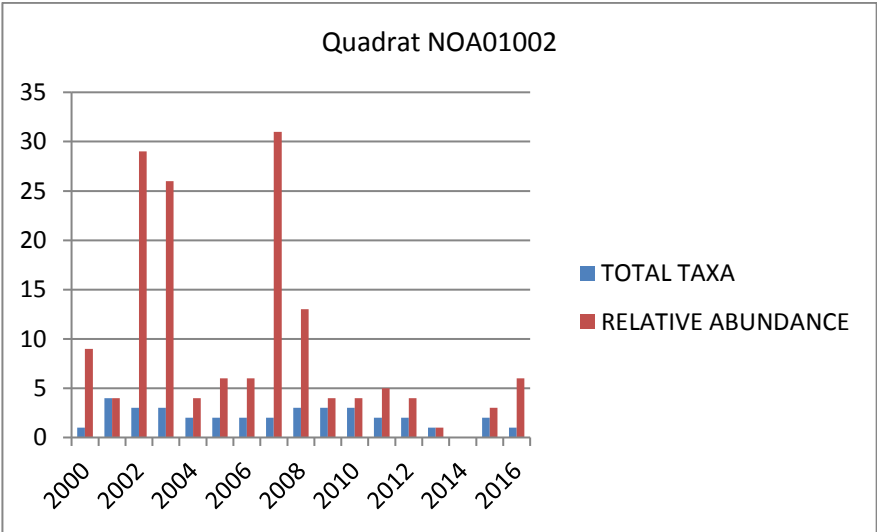
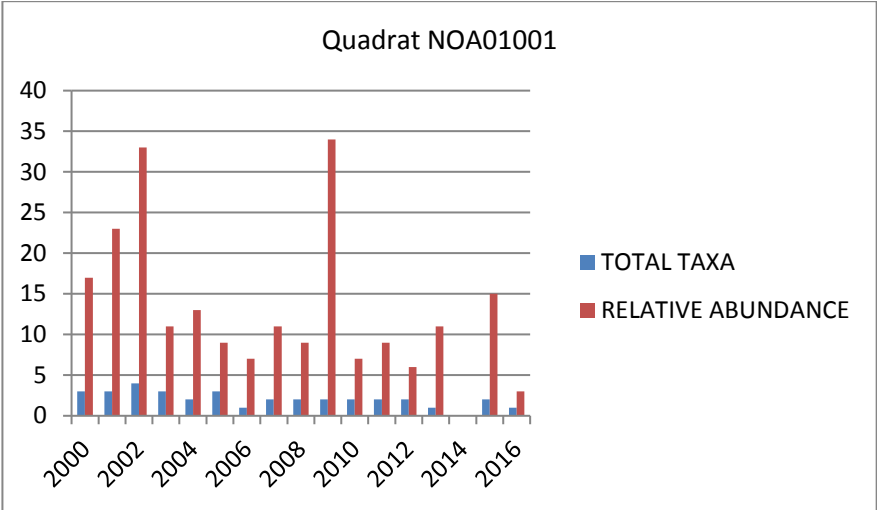


Figure 10: Changes in reptile species diversity and relative abundance on the study area from 2000-2016; at Quadrat NOA01001 in the natural vegetation and at Quadrat NOA01002 in the revegetation area.

Reptiles

Reptile activity is significantly influenced by the temperatures over the trapping period. The changes in the reptile species diversity and relative abundance shown for Quadrat 1 in the natural vegetation and Quadrat 2 in the revegetation (**Fig. 10**) reflect this variability. The natural vegetation quadrat supported a total diversity of 5 reptile species (56% of the total of 9 for the study area). The revegetated area supported 4 species. The revegetation area, even before the trees became established, consisted of dense grassland with two remnant stringybark trees (see **Fig. 3**). This provided lots of sunny basking spots and invertebrate food and was therefore almost as good as the natural vegetation in terms of reptile habitat. Relative abundance of reptiles recorded (**Fig. 10**) is again very variable through the study period in both the natural vegetation (between 1 and 34) and the revegetated area (between 1 and 31). Throughout the study period, however, reptiles were consistently more abundant in the natural vegetation than in the revegetation (**Fig. 10**).

Frogs

Like reptiles, frog captures were dependent on weather during the trapping period but even more so with rain allowing them to become active and encounter the pitfall traps. The changes in frog species diversity and relative abundance shown for Quadrat 1 in the natural vegetation and Quadrat 2 in the revegetation (**Fig. 11**) reflect this variability. The natural vegetation quadrat supported 3 frog species (56% of the total of 6 for the study area). The revegetated area also supported 3 species. The Brown Toadlet (*Psuedophryne bibroni*) was only found in the natural vegetation while the Spotted Marsh Frog (*Limnodynastes tasmaniensis*) only occurred in the revegetation. There were so few frog captures that relative abundance tells us little, but when frogs were active, more were caught in the natural vegetation than in the revegetation (**Fig. 11**).

Invertebrates

Invertebrates captured during this study are graphically presented in **Fig. 12** at the level of Order (rather than species level as for the plants and vertebrates above). The natural vegetation quadrat supported 23 Orders of invertebrates while the revegetated area supported 26 Orders. In the natural vegetation quadrat the highest number of taxa were (in order of abundance) Coleoptera (beetles), Diptera (flies), Hymenoptera (ants, bees and wasps), Hemiptera (true bugs), Araneae (spiders), Blattodea (cockroaches) and Mollusca (slugs and snails). By comparison, the revegetated area supported (in order of abundance) Coleoptera (beetles), Hymenoptera (ants, bees and wasps) Diptera (flies), Blattodea (cockroaches) and Araneae (spiders).

In terms of relative biomass, the natural vegetation quadrat supported, in order of relative abundance, Hymenoptera (ants, bees and wasps), Coleoptera (beetles), Diplopoda (millipedes) and Araneae (spiders), while the revegetated area supported, in order of relative abundance, Diplopoda (millipedes), Hymenoptera (ants, bees and wasps), Coleoptera (beetles) and Araneae (spiders). The relative abundance of taxa (**Fig. 13**) declined through the 15 years of the study in both the natural vegetation and in the revegetation, but invertebrates were consistently more abundant in the former.

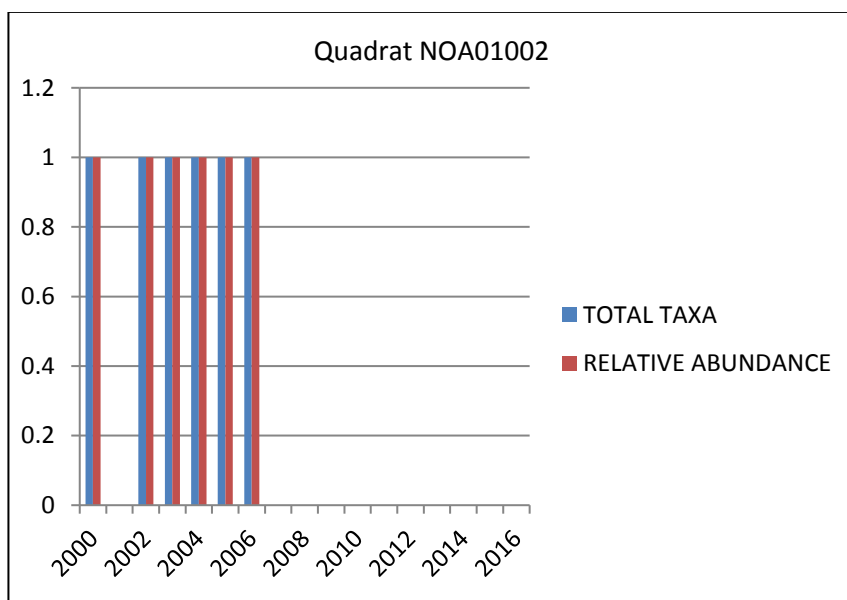
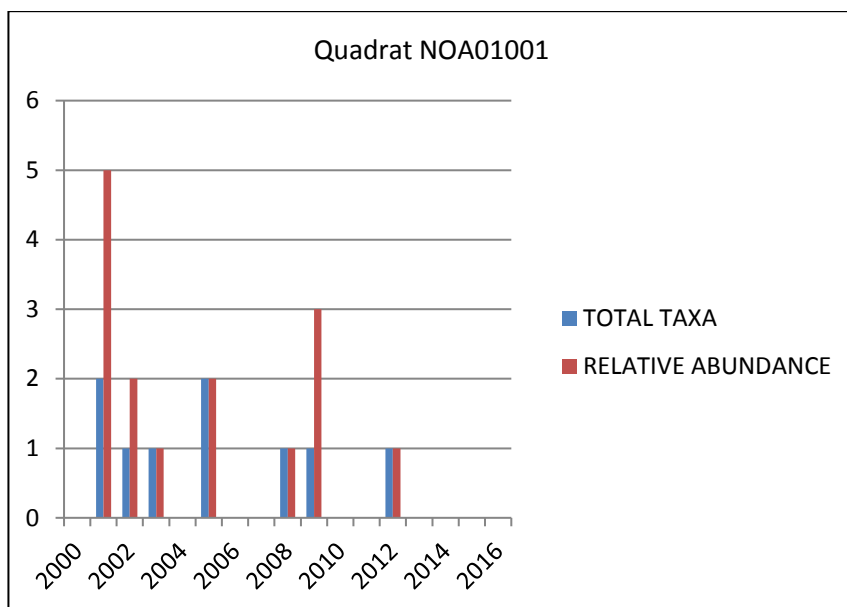


Figure 11: Changes in frog species diversity and relative abundance on the study area from 2000-2016; at Quadrat NOA01001 in the natural vegetation and at Quadrat NOA01002 in the revegetation area.

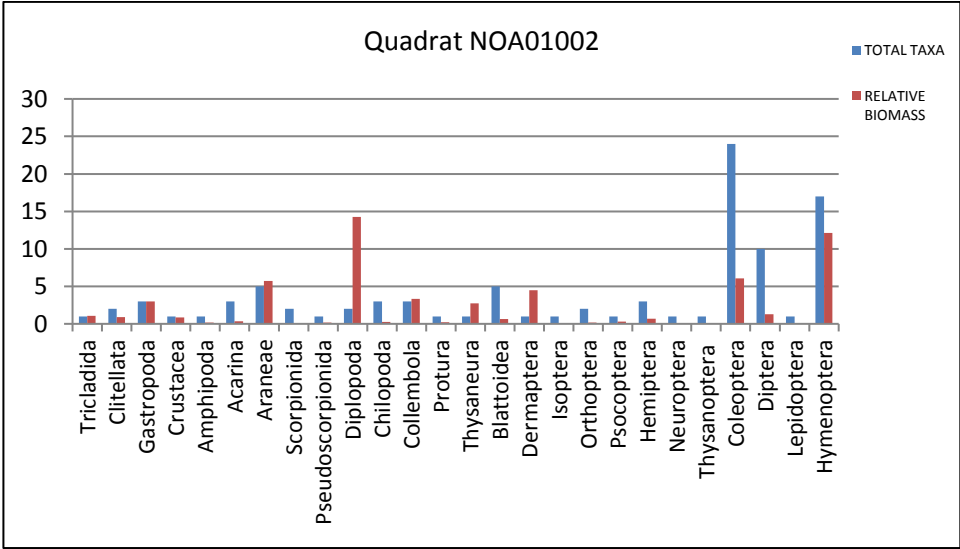
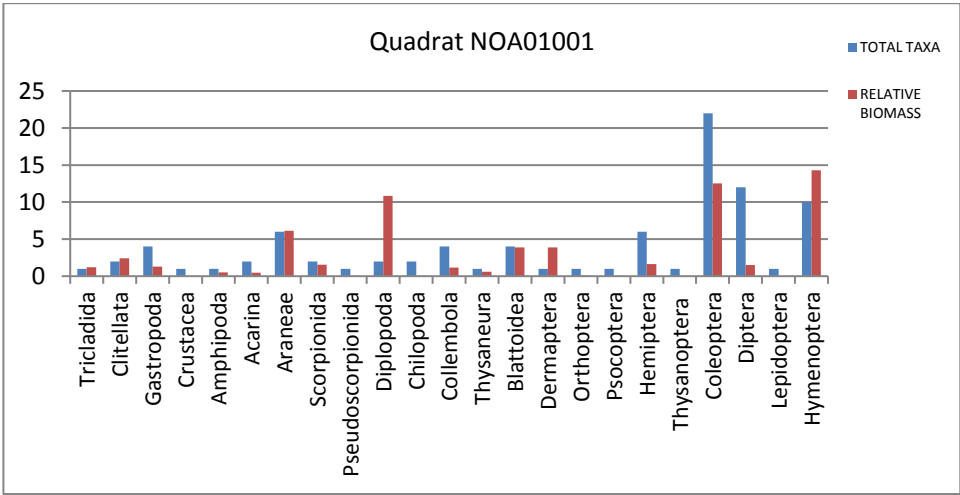


Figure 12: Total taxa and relative biomass of each Order of invertebrates across the whole 16 year study period combined; at Quadrat NOA01001 in the natural vegetation area and at Quadrat NOA01002 in the revegetation area.

DISCUSSION

Over the 16 year study period, the revegetated area showed an obvious increase in the cover/abundance of native species as the planted trees and shrubs grew, but in terms of native plant species diversity, it was still less than half that of the control area of natural vegetation. There was however a significant decline in the number of weed species over the period even though there was an actual increase in the ‘weediness’ of the natural

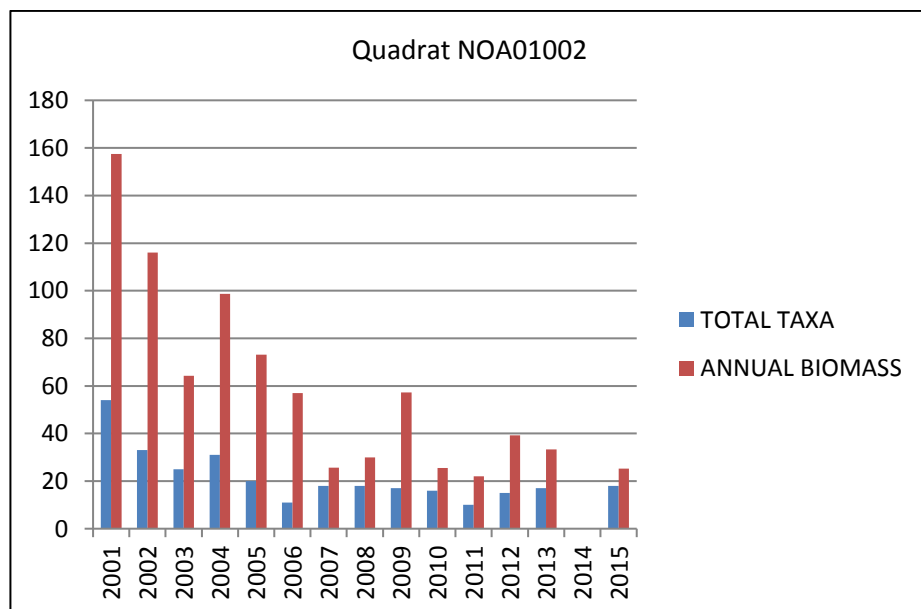
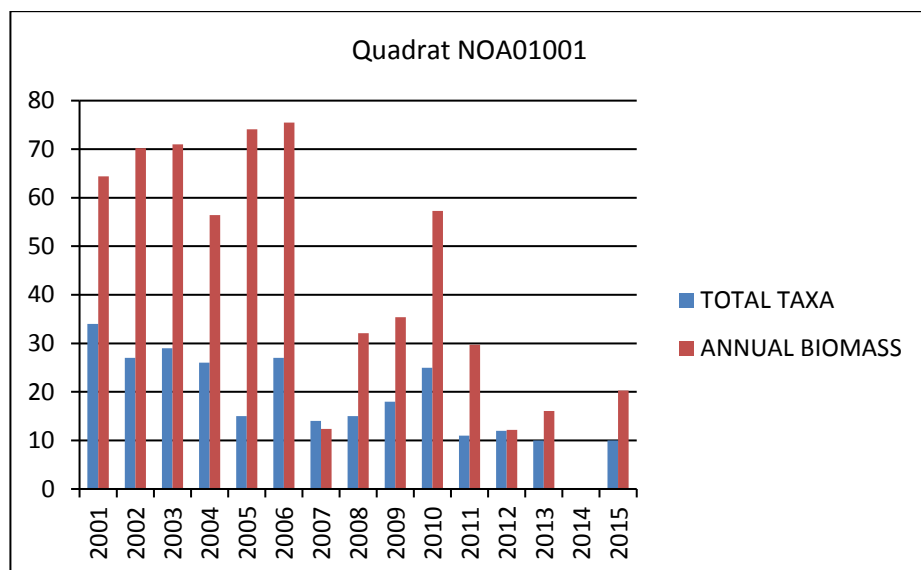


Figure 13: Changes in native and introduced invertebrate species diversity and relative biomass from 2001-2015 at Quadrat NOAA01001 in the natural vegetation on the study area; Quadrat NOAA01002 in the revegetation area.

vegetation over the same period. These results are similar to a study of revegetation attempts in the Braidwood area in NSW (Wilkins *et al.* 2003). They found that the restoration works proved somewhat ineffectual at providing a successional pathway towards reaching the floristic goal of restoring the ecosystem to the remnant condition. When the planted species were removed from the statistical analysis, the revegetated sites showed no difference in the number of exotics and natives than the untreated pasture and, as with the present study, also had significantly more exotic species and less than half of the native species of the remnant sites.

In a review of 27 studies in Gippsland, Victoria (22 of which looked at bird populations only) Ryan (1999) examined revegetation plantings that had been established to ameliorate the negative effects of clearing remnant vegetation and to provide new habitat for fauna. In relation to the vegetation, he concluded that structural complexity increased with age of planting, toward that of remnants, even when very few species were planted at establishment. Richness of all plants and native plants, however, did not increase with age. Native ground cover plants were not included at establishment in either planting type, and their richness also did not increase with age of planting which suggests that, unlike in our study, colonization did not occur through time.

Ryan (1999) concluded that ecological plantings can achieve similar overall structural complexity as remnant vegetation within 30–40 years but will not gain a native ground layer and will not necessarily contain some important structural features by this age. This review also concluded that while revegetation provides habitat for many species of birds and some arboreal marsupials, it is far from being a substitute for remnant vegetation, at least in the medium term (several decades). Species richness of birds was greater in revegetated areas that were large, wide, structurally complex, old and near remnant vegetation. Bats, small terrestrial mammals, reptiles and amphibians did not appear to benefit significantly from revegetation in the short term. In addition, these studies suggested that revegetated sites provide habitat for a wide range of bird species, however, the majority are common generalist or edge species capable of exploiting a range of natural and disturbed habitats. Few species with specialized habitat requirements were recorded utilizing revegetated areas.

It will be interesting to see if the relatively small area of revegetation in the Upper Sturt study area, surrounded as it is by a much larger area of relatively natural vegetation, will follow this trend or whether in another 16 years it will be successfully colonised by native understorey species from the surrounding vegetation making it more closely similar to the remnant native vegetation as a habitat for the more specialised animals and plants of the local stringybark forests.

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All photographs taken by Tony Robinson unless credited.

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