Pilliga

Annual Ecohealth Monitoring Report 2020-2021

australian wildlife conservancy

Summary

Australian Wildlife Conservancy (AWC) has implemented an Ecological Health Monitoring Framework (EHMF) to measure the changes in ecological health across the Pilliga project area (Pilliga State Conservation Area and Pilliga National Park, Gilgai Section). The EHMF provides the rationale for selecting indicators of biodiversity and ecological threats and provides detail on the design of surveys to quantify the measurement of metrics for these indicators.

Metrics detailed in this report are based on data collected during surveys conducted from June 2020 to May 2021. The complete set of metrics and their values are summarised in the accompanying scorecard.

During the 2020-21 reporting period, monitoring was conducted of two previously reintroduced species: Greater Bilby (*Macrotis lagotis*) and Bridled Nailtail Wallaby (*Onychogalea fraenata*). Monitoring of extant species included surveys for:

- Small ground-dwelling mammals, including targeted survey for the threatened Pilliga Mouse (*Pseudomys pilligaensis*)
- Medium-large mammals (both native and feral species)
- Eastern Pygmy-possum (*Cercartetus nanus*)
- Koala (*Phascolarctos cinereus*)
- Diurnal birds (woodland-dependent and ground-active guilds)
- Emu (*Dromaius novaehollandiae*)
- Pale-headed Snake (*Hoplocephalus bitorquatus*)
- Threatened orchid species: Cobar Greenhood (*Pterostylis cobarensis*) and Pine Donkey Orchid (*Diurus tricolor*)

Survey effort for the reporting period equated to:

- 633 Thomas trap nights
- 772 cage trap nights
- 1,599 Elliott trap nights
- 2,739 radio-tracking days
- 10,218 camera trap nights (7,502 in the breeding area, 2,716 across whole project area)
- 350 acoustic trap nights
- 48 nest box checks
- 150 bird surveys
- 6 ha searched for Pale-headed snake
- 16 area searches for threatened orchids (>6,800 m^2 searched)

In December 2020 (~24 months post-release) the trappable Greater Bilby population in the Pilliga breeding area was estimated at 60 (95% CI: 44 – 83) individuals. This is considered a conservative estimate of the Bilby population, due to difficulty trapping Bilbies owing to favourable conditions associated with above average rainfall. Other medium-term indicators of reintroduction success have been met for this species: (1) recruitment of new animals into the population is high; and (2) body weight and condition has been maintained.

Survival of reintroduced Bridled Nailtail Wallabies in the first 12 months post-release was in the range 81 – 88%; the short-term success criteria of >50% survival in the first 12 months post-release has been met. The success criteria of weight gain/maintenance also was met, with male and female founders having average weight gains of 91% and 33%, respectively. These results indicate that the reintroduction of Bridled Nailtail Wallabies to the Pilliga is on track to be successful.

Small mammal trapping (targeted survey for the threatened Pilliga Mouse) resulted in the capture of three native species. The Yellow-footed Antechinus (*Antechinus flavipes*) was the most abundant native species encountered and drove results for the native mammal guild. This species had markedly higher occupancy and relative abundance at sites inside the fenced area compared to sites outside the fence. This indicates that the Yellow-footed Antechinus may be starting to benefit from lower predator numbers inside the fence. Only a single Pilliga Mouse was captured. Despite higher rainfall across 2020, this species remains difficult to detect.

Macropod occupancy remains relatively stable within the Pilliga fenced area, although slight increases were observed in 2020 for Black-striped Wallaby (*Macropus dorsalis*), Red-necked Wallaby (*Macropus rufogriseus*) and Eastern Grey Kangaroo (*Macropus giganteus*). Increases in activity were also observed for Red-necked Wallaby and Eastern Grey Kangaroo. Outside the fence, Eastern Grey Kangaroo was the only macropod to display any change in 2020, with marked increases in both occupancy and activity.

More intensive monitoring of macropods in the Pilliga breeding area revealed that, with the exception of peaks in spring, macropod activity has remained relatively low and stable. There is no evidence at this stage to suggest that macropods are increasing markedly inside the fenced area.

Seven indicator bird species from the woodland-dependent and ground-active guilds were detected in 2020. Occupancy and relative abundance for most species was generally lower than in previous years.

Favourable conditions meant that surveys for two threatened orchid species, Cobar Greenhood and Pine Donkey Orchid, were conducted for the first time in 2020. Colonies of both species were located and surveyed at sites inside and outside the fence. Future surveys will reveal if actions associated with the reintroduction program result in changes to orchid density.

Contents

Document citation: Carter S, Keem J, Banikos Z, Potts C, Holland G, Kanowski J (2021) *Annual Ecohealth Monitoring Report: Pilliga 2020-21*. Australian Wildlife Conservancy, Perth.

Cover photographs, clockwise from top left: Pilliga Mouse *Pseudomys pilligaensis* (Sabrina Carter/AWC), Greater Bilby *Macrotis lagotis* (Sabrina Carter/AWC), Bridled Nailtail Wallaby *Onychogalea fraenata* (AWC), Pine Donkey Orchid *Diuris tricolor* (Jessica Skewes/AWC).

1 Introduction

Australian Wildlife Conservancy (AWC) and the NSW Government are under contract (*A Project to Reintroduce Locally Extinct Mammals*) to deliver scientific and land management services across ~36,000 ha of the Pilliga forest (Pilliga State Conservation Area and Pilliga National Park, Gilgai Section). This agreement includes the reintroduction of six locally extinct threatened mammals into a 5,800-ha feral predator-free fenced area. The Pilliga is within the traditional lands of the Gamilaroi people.

As part of the agreement, AWC has developed an Ecological Health Monitoring Framework (EHMF) to measure changes in ecological health associated with delivery of the project. The EHMF provides the rationale for selecting indicators of, and threats to, biodiversity and provides detail on the design of surveys to quantify metrics relevant to selected indicators.

This report details the results of EHMF surveys conducted at the Pilliga project site from June 2020 to May 2021. Metrics from these surveys are summarised in the accompanying scorecard.

2 Methods and effort

During the 2020-21 reporting period, monitoring was conducted of two previously reintroduced species: Greater Bilby (*Macrotis lagotis*) and Bridled Nailtail Wallaby (*Onychogalea fraenata*). Monitoring of extant species included surveys for:

- Small ground-dwelling mammals, including a targeted survey for the threatened Pilliga Mouse (*Pseudomys pilligaensis*)
- Medium-large mammals (both native and feral species)
- Eastern Pygmy-possum (*Cercartetus nanus*)
- Koala (*Phascolarctos cinereus*)
- Diurnal birds (woodland-dependent and ground-active guilds)
- Emu (*Dromaius novaehollandiae*)
- Pale-headed Snake (*Hoplocephalus bitorquatus*)
- Threatened orchid species: Cobar Greenhood (*Pterostylis cobarensis*) and Pine Donkey Orchid (*Diurus tricolor*)

A summary of survey methods implemented, and associated monitoring effort is presented in Table 1. Detailed descriptions of standard methods can be found in the Pilliga EHMF (Kavanagh et al. 2020). Methods not currently described in the EHMF are detailed in Appendix 1.

Table 1. Survey methods (and associated effort) implemented during the 2020-21 reporting period in the Pilliga project area.

Indicator	Method	Standard sites (maximum effort)	2020-21 Effort
Reintroduced mammals			
Bridled Nailtail Wallaby	2 Thomas traps per site for 4 nights—survival, condition, population estimate, recruitment	50 (400 trap nights per survey)	633 traps nights (Jul 2020, Nov 2020)*
	Unbaited camera traps (on-road & off-road)—habitat selection	21 (7686 camera nights per leap year)	7502 camera nights[##]
	Coded VHF telemetry—survival	23 animals monitored until collar removed/dropped	2739 collared animal days^
Greater Bilby	2 cage traps per site for 4 nights—population estimate, recruitment, condition	50 (400 trap nights per survey)	772 trap nights (May 2020, Dec 2020)*
	Unbaited camera traps (on-road & off-road)—habitat use	21 (7686 camera nights per leap year)	7502 camera nights[##]
Small- to medium-sized terrestrial mammals			
Pilliga Mouse (& other small mammals)	20 Elliott traps per site for 4 nights—abundance, occupancy, mean abundance and richness	20 (1600 trap nights); 10 inside (800), 10 outside (800)	1599 (800 inside, 799 outside)*
Short-beaked Echidna	2 baited cameras for 14 nights (1 on-road, 1 off-road)—activity, occupancy	50 (1400 camera nights per survey); 10 inside (280), 40 outside (1120)	2702 camera nights (546 inside, 2156 outside)[#]
Large native herbivores			
Macropods	2 baited camera traps for 14 nights (1 on-road, 1 off-road)—abundance, activity, occupancy	50 (1400 camera nights per survey); 10 inside (280), 40 outside (1120)	2702 camera nights (546 inside, 2156 outside)[#]
	Unbaited camera traps (on-road & off-road) in breeding area—abundance, activity, occupancy	21 (7686 camera nights per leap year)	7502 camera nights[##]
Arboreal mammals			
Koala	Acoustic recorders for 7 nights—activity, occupancy	50 (350 recording nights); 10 inside (70), 40 outside (280)	350 recording nights
Eastern Pygmy-possum	2 nest boxes—occupancy	24 (48 nest boxes); 12 inside (24), 12 outside (24)	48 nest boxes checked
Reptiles			
Pale-headed Snake	Spotlight area search, 250 x 40 m transect for 1-person hour—activity, occupancy	6 (6 ha searched, 6 hours total search time)	6 ha searched for 6 hours total search time
Birds			
Emu	2 baited camera traps for 14 nights (1 on-road, 1 off-road)—activity, occupancy	50 (1400 camera nights per survey); 10 inside (280), 40 outside (1120)	2702 camera nights (546 inside, 2156 outside)[#]
Woodland-dependent birds	2 ha plot, 10-min count, 10-min search, 3 replicates—abundance, occupancy, richness	50 (150 bird surveys); 10 inside (30); 40 outside (120)	150 bird surveys
Ground-active birds	2 ha plot, 10-min count, 10-min search, 3 replicates—abundance, occupancy, richness	50 (150 bird surveys); 10 inside (30); 40 outside (120)	150 bird surveys

Indicator	Method	Standard sites (maximum effort)	2020-21 Effort
Threatened plant species			
Diuris tricolor	Area search, circular plot 6 m radius—abundance/density	6 (1810 m^2 searched); 3 inside fence (905), 3 outside (905)	1810 m^2 searched (905 inside fence, 905 outside)
Pterostylis cobarensis	area search, 100 x 5 m plot—abundance/density	10 (5000 m^2 searched); 5 inside fence (2500), 5 outside (2500)	5000 m^2 searched (2500 inside fence, 2500 outside)
Threat indicators			
Fire	Remote-sensed and on-ground fire severity assessments—extent, severity	Pending burn area/characteristics	Remote-sensed assessment of 2 burn areas; 30 sites ground-truthed in 1 burn area
Feral predators	2 baited camera traps for 14 nights (1 on-road, 1 off-road)—activity, occupancy	50 (1400 camera nights per survey); 10 inside (280), 40 outside (1120)	2702 camera nights (546 inside, 2156 outside) [#]
Feral herbivores	2 baited camera traps for 14 nights (1 on-road, 1 off-road)—activity, occupancy	50 (1400 camera nights per survey); 10 inside (280), 40 outside (1120)	2702 camera nights (546 inside, 2156 outside) [#]

*Some sites/traps were opened for <4 nights
^Collars were collected as they became detached from animals (via weak link); animals were targeted for collar removal during July and November trapping surveys
[#]A total of seven cameras malfunctioned during the 2020 camera surveys (4 in autumn, 3 in spring)
[##] An aggregated total of 180 camera nights had malfunctioning/inactive cameras.

3 Climate Summary

The climate in the Pilliga region is classified as subtropical, with hot summers and cool, moderately dry winters (BOM 2021a). Mean maximum temperatures range from 34 C in summer to 18 C in winter (BOM 2021b). Most rainfall occurs in the summer months although heavy rainfall events may occur at any time of the year (BOM 2021b).

The mean annual maximum temperature in 2020, 26.7 C, was lower than that of the previous three years (2019 = 28.9 C, 2018 = 28.2 C, 2017 = 27.6 C). 2020 was also a year of significant rainfall with a total of 771.2 mm falling, the highest annual rainfall total since the start of the Pilliga project (Figure 1). The beginning of 2021 has also had higher than average rainfall. Multiple flood events occurred throughout the project area in 2020-21 (Figure 2).

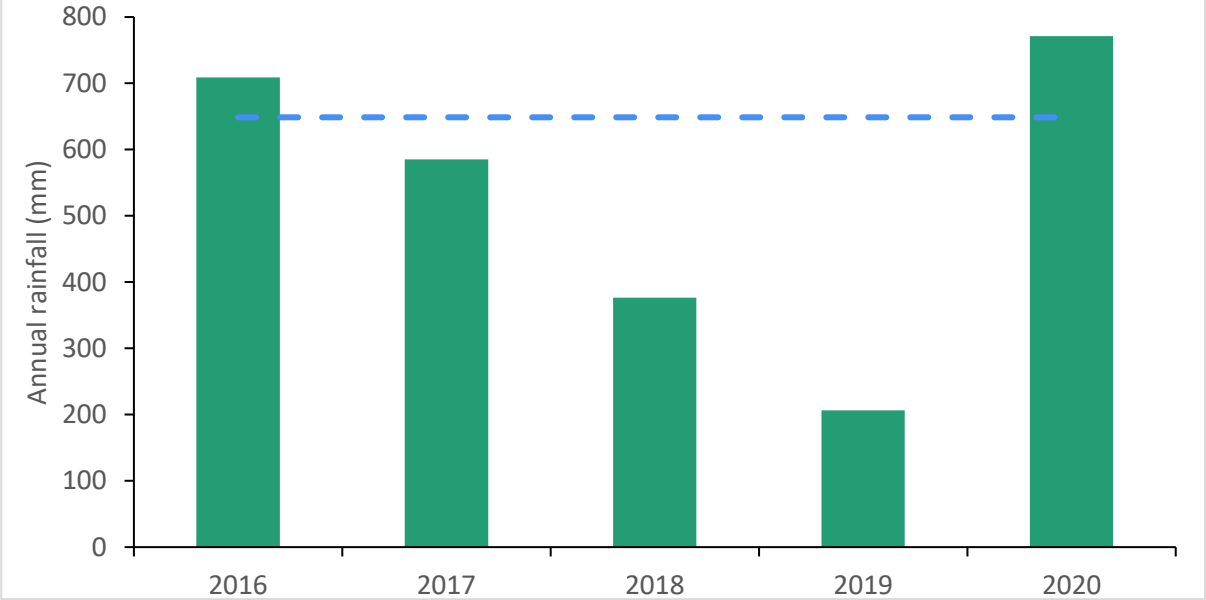

Figure 1. Annual rainfall in the Pilliga region, 2016-20. Data from Narrabri West Post Office (1962–2001) and Narrabri Airport AWS (2002–June 2020) (BOM 2021b). Dashed line = average annual rainfall.

Figure 2. Flooded Rocky Creek flowing through the Pilliga fence following significant rain in March 2021.

4 Results

4.1 Reintroduced mammals

4.1.1 Greater Bilby

Trapping of the Greater Bilby population in December 2020 marked ~24 months since this species was reintroduced to the Pilliga breeding area. The trappable population was estimated at 60 (95% CI: 44–83). This population estimate is considered to be conservative, due to environmental conditions (see Discussion).

In total, 46 individual Greater Bilbies were captured in December 2020. This includes 11 founders and 35 (76%) Pilliga-born animals. Thirteen (28%) Bilbies were captured for the first time in December 2020. In the earlier trapping survey conducted in May 2020, 32 (71%) of the 45 animals captured were Pilliga-born, and 31 (69%) were captured for the first time in that survey. Across the two surveys conducted during the reporting period, 80% of individuals captured were new recruits. This rate of recruitment is sufficiently high to maintain or increase the population, thus the medium-term target of sufficient recruitment has been met.

Of the 14 females captured in December 2020, eight (57%) were carrying pouch young. Five had two pouch young, while three had a single pouch young. Of the six females without pouch young, four were adult females with extended lactating teats and two were sub-adults (non-reproductive) weighing 240 g and 280 g, respectively. Thus, all sexually mature females displayed signs of breeding during the December 2020 survey.

In December 2020, the body weight of male Bilbies ranged from 195 to 1790 g. Excluding juvenile animals (i.e., body weight <300 g), the average weight of independent males and females was 1266 g and 887 g, respectively (Figure 3). Mean body weights for males and females remain relatively stable and within the range expected for the species; the medium-term success criteria of maintenance of body weight/condition has been met.

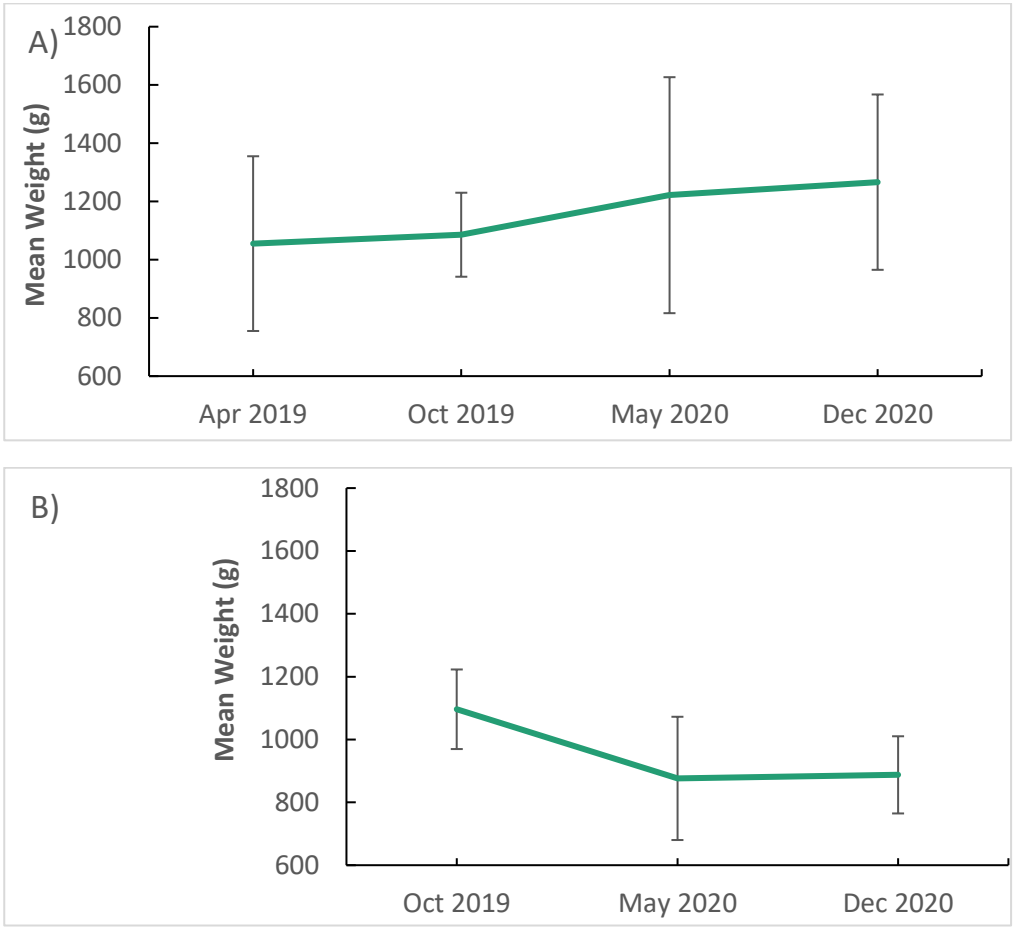

Figure 3. Mean body weight for independent (A) male and (B) female Greater Bilbies captured in the Pilliga.

Cameras permanently deployed in the breeding area provide information on monthly Greater Bilby activity (trigger events per 100 camera nights), including in relation to broad vegetation types. Bilby activity was generally higher in 2020 compared to 2019 (Figure 4). Activity patterns for the two broad vegetation types in which cameras are deployed (Shrubland (veg. type 141): Broombush; Forest (veg. type 398): Narrow-leaved Ironbark – White Cypress Pine – Buloke) were similar across 2020 with marked increases in the first half of the year. Cameras positioned on roads/tracks recorded lower activity for much of the survey period, but increased to levels similar to off-track cameras from September 2020 onwards (Figure 4).

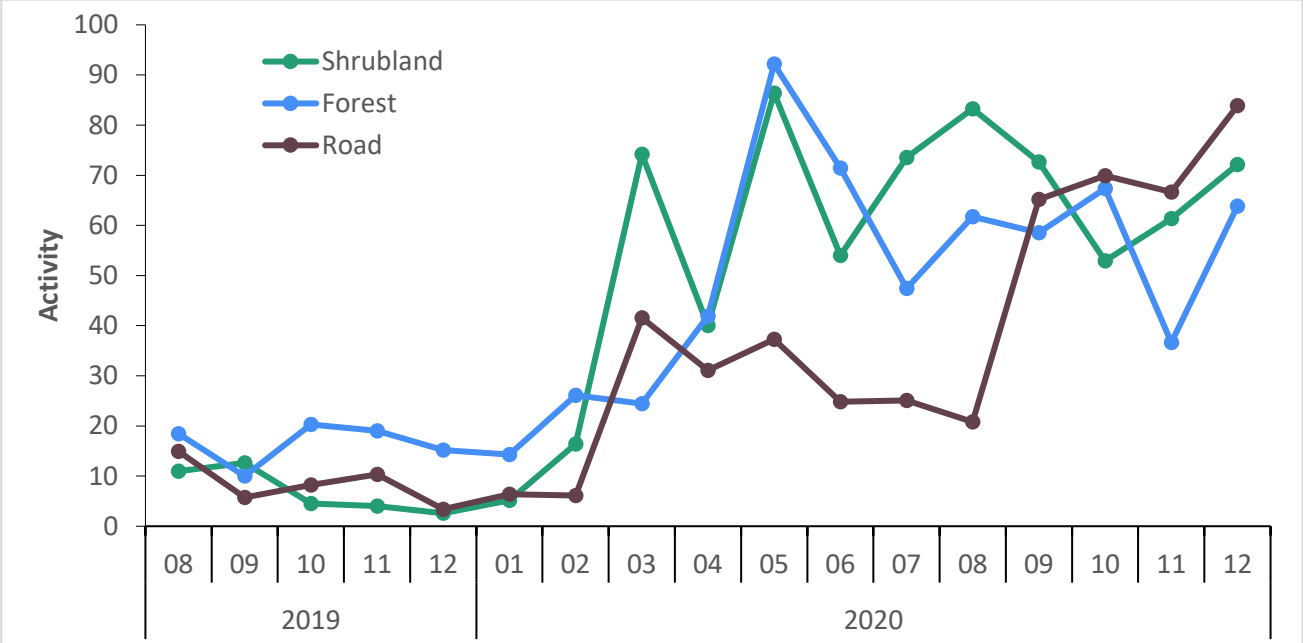

Figure 4. Monthly Greater Bilby activity (trigger events per 100 camera nights) by broad vegetation type in the Pilliga breeding area, August 2019 to December 2020. Vegetation type: see text.

4.1.2 Bridled Nailtail Wallaby

Radio-tracking of Bridled Nailtail Wallabies was conducted for 12 months post-release. Some collars became detached from animals (via built-in weak links) inside 12 months; where possible these were re-deployed in the subsequent trapping session. Radio-tracking combined with live trapping demonstrated that survival of Bridled Nailtail Wallabies was in the range 81 – 88% at 12 months post-release. Thus, the short-term success criteria of >50% survival in the first 12 months post-release was met.

In November 2020 (~14 months post-release) 19 founder animals were captured. All had gained weight since their release in the Pilliga. Average weight gain (as a percentage of body weight at release) was 91% (51 – 151%) for males and 33% (13 – 45%) for females. This means that the short-term success criteria of weight gain/maintenance in the first 12 months post-release was met.

Cameras permanently deployed in the breeding area revealed a steady increase in Bridled Nailtail Wallaby activity for much of 2020 (Figure 5). After peaking in October, activity declined in November 2020. Activity was consistently higher at cameras deployed in Forest and on roads/tracks compared to Shrubland. However, by December 2020 differences in vegetation type were less pronounced (Figure 5).

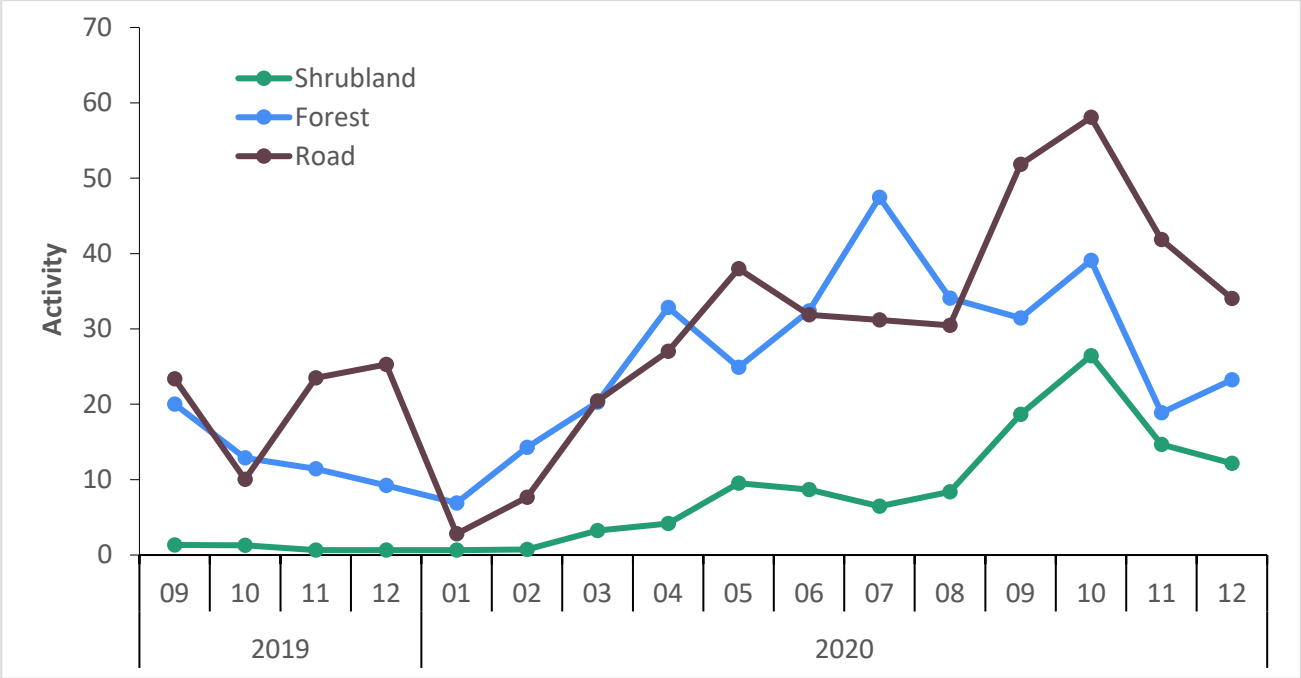

Figure 5. Monthly Bridled Nailtail Wallaby activity (trigger events per 100 camera nights) by broad vegetation type in the Pilliga breeding area, September 2019 to December 2020. Veg type: see text.

4.2 Small- to medium-sized terrestrial mammals

4.2.1 Pilliga Mouse (and other small mammals)

In March 2021, targeted surveys for the threatened Pilliga Mouse were conducted. A subset of 20 sites (10 inside the fence, 10 outside) was selected, with a focus on sites where the Pilliga Mouse had been detected in previous surveys. While Pilliga Mouse was the primary target species, this survey also effectively sampled other small ground-dwelling mammals. To enable comparison with previous years (where both Elliott and pitfall traps were deployed), data is presented for Elliott trapping results only.

Three native mammal species were detected: Pilliga Mouse, Yellow-footed Antechinus and Common Dunnart. Both the Pilliga Mouse and Common Dunnart were represented by a single capture (Pilliga Mouse was detected inside the fence, Common Dunnart outside; Table 2). These two species have been encountered infrequently in all surveys to date (Table 2). The Yellow-footed Antechinus was encountered more readily, with 50 individuals trapped at 13 different sites (occupancy = 65%; Table 2). Occupancy of the Yellow-footed Antechinus was higher inside the fence (90%) compared to outside (40%), as was observed in the previous survey in 2020 (Table 2). Relative abundance (individuals captured per 100 trap nights) was also higher inside the fence (Figure 6).

Occupancy and abundance for the native small mammal guild mirror results for the Yellow-footed Antechinus, owing to the dominance of this species within the guild (Appendix 2). In addition to native species, the introduced house mouse was also readily encountered (see Section 4.8.4 Other feral species).

Table 2. Occupancy of small native mammal indicator species, 2017 to 2021.
2017–2019: n = 60 (20 inside, 40 outside); 2020: n = 44 (18 inside, 26 outside); 2021: n = 20 (10 inside, 10 outside). Note: data reflects Elliott trapping results only.

Indicator	Year	Occupancy (%)		
		Inside	Outside	Total
Yellow-footed Antechinus	2017	75.0	35.0	48.3
Antechinus flavipes	2018	70.0	47.5	55.0
	2019	65.0	45.0	51.7
	2020	83.3	15.4	43.2
	2021	90.0	40.0	65.0
Pilliga Mouse	2017	0.0	7.5	5.0
Pseudomys pilligaensis	2018	15.0	10.0	11.7
	2019	0.0	5.0	3.3
	2020	0.0	0.0	0.0
	2021	10.0	0.0	5.0
Common Dunnart	2017	0.0	2.5	1.7
Sminthopsis murina	2018	5.0	2.5	3.3
	2019	10.0	2.5	5.0
	2020	0.0	0.0	0.0
	2021	0.0	10.0	5.0
Small-medium mammal guild	2017	75.0	47.5	56.7
	2018	75.0	52.5	60.0
	2019	65.0	47.5	53.3
	2020	83.3	15.4	43.2
	2021	100.0	40.0	70.0

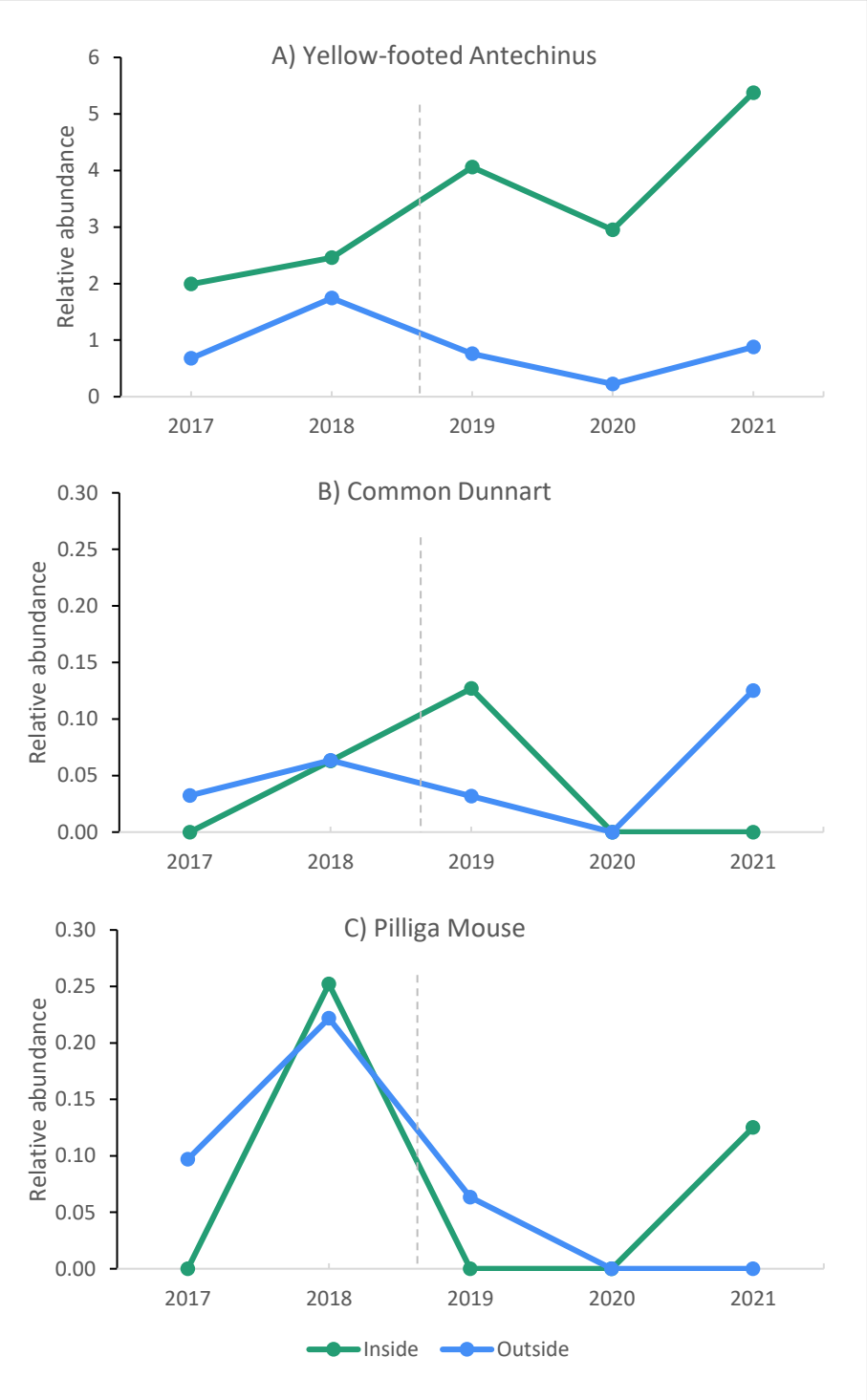

Figure 6. Relative abundance (total individuals per 100 trap nights) of small mammal indicator species inside and outside the fenced area, 2017 to 2021. Dashed line denotes fence completion. 2017–2019: n = 60 (20 inside, 40 outside); 2020: n = 44 (18 inside, 26 outside); 2021: n = 20 (10 inside, 10 outside). Note: data for Elliott trapping results only.

4.2.2 Echidna

Both occupancy and activity for the Echidna (*Tachyglossus aculeatus*) inside the fence were low in autumn 2020 but displayed marked increases in spring (Figure 7). A similar pattern was observed in spring 2018. Outside the fence, Echidna occupancy and activity increased gradually in 2020 (Figure 7).

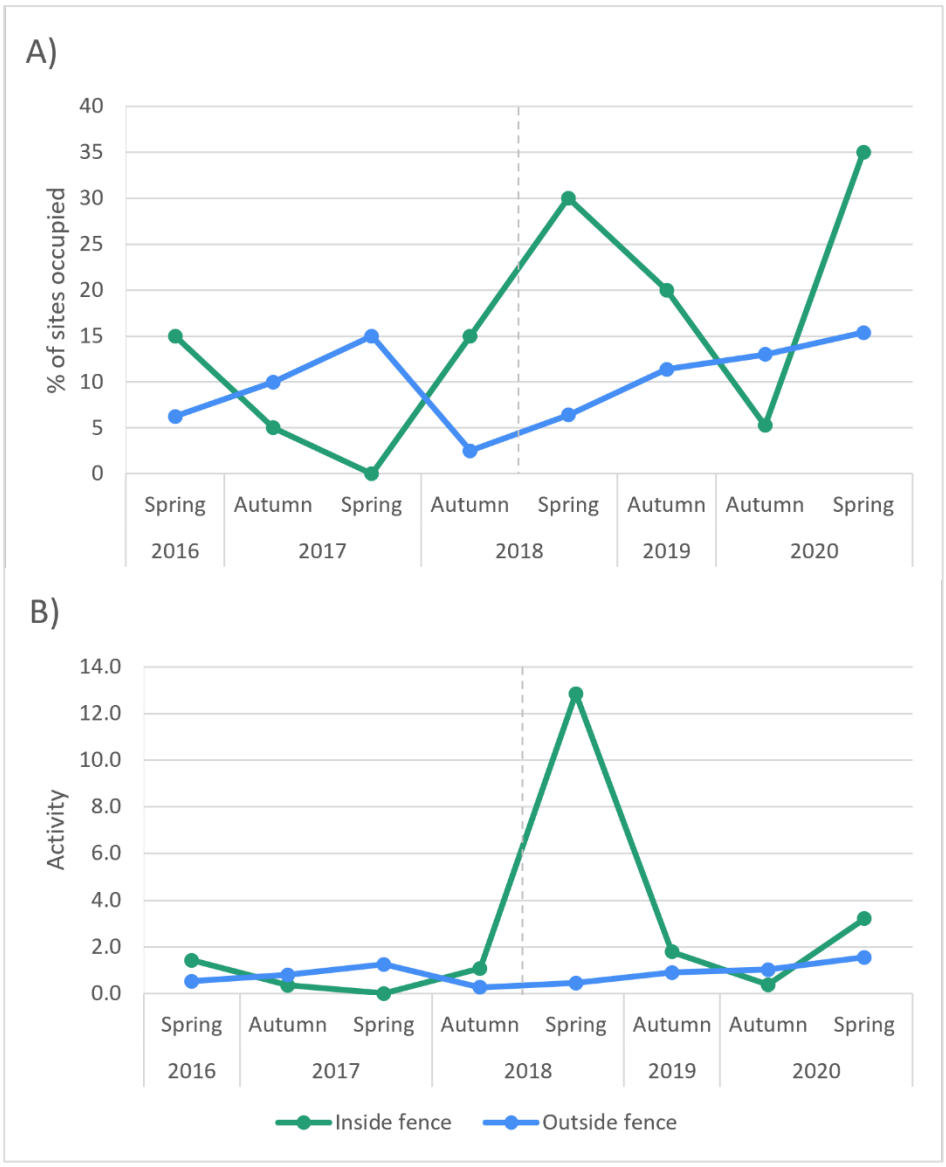

Figure 7. A) Occupancy (percentage of sites detected), and B) activity (number of trigger events per 100 camera trap nights) for Echidna inside and outside the fenced area, 2016-2020. Dashed line denotes fence completion.

4.3 Large native herbivores

4.3.1 Macropods

4.3.1.1 Entire Pilliga project area; 50 sites

Cameras deployed at all monitoring sites (n = 50; 40 outside fence, 10 inside) provide a useful comparison either side of the conservation fence. Within the Pilliga fenced area, occupancy rates for both Eastern Grey Kangaroo and Black-striped Wallaby remained within the range observed previously (Figure 8a). Swamp Wallabies (*Wallabia bicolor*) were not detected inside the fence in 2020 but are known to still be present (see Section 4.3.1.2 below). Red-necked Wallabies were detected inside the fence for the first time in 2020 (but were previously known to be present, see Section 4.3.1.2 below). Activity (number of trigger events per 100 camera trap nights) inside the fence increased for both Eastern Grey Kangaroo and Red-necked Wallaby in 2020 (Figure 8c). Outside the fence, there was little change in occupancy or activity for the three smaller macropod species (Figure 8b&d). However, marked increases in both metrics were observed for the Eastern Grey Kangaroo.

Figure 8. Occupancy (percentage of sites detected) inside (A) and outside (B) the fence, and activity (trigger events per 100 camera trap nights) inside (C) and outside (D) the fence for macropod indicator species, 2016-2020. Dashed line denotes fence completion.

4.3.1.2 Breeding area; 21 cameras

All four macropod indicator species remain within the Pilliga breeding area (Figure 9). For most of 2020 macropod activity in the breeding area remained stable. Spikes in activity for all species were observed in September 2020 but were particularly marked for the three smaller species. However, activity for all species declined in December 2020 (Figure 9). Occupancy of all macropods increased in the first half of 2020 before declining in spring (Figure 10). The Black-striped Wallaby has had consistently higher occupancy than other species since cameras were permanently deployed in the breeding area.

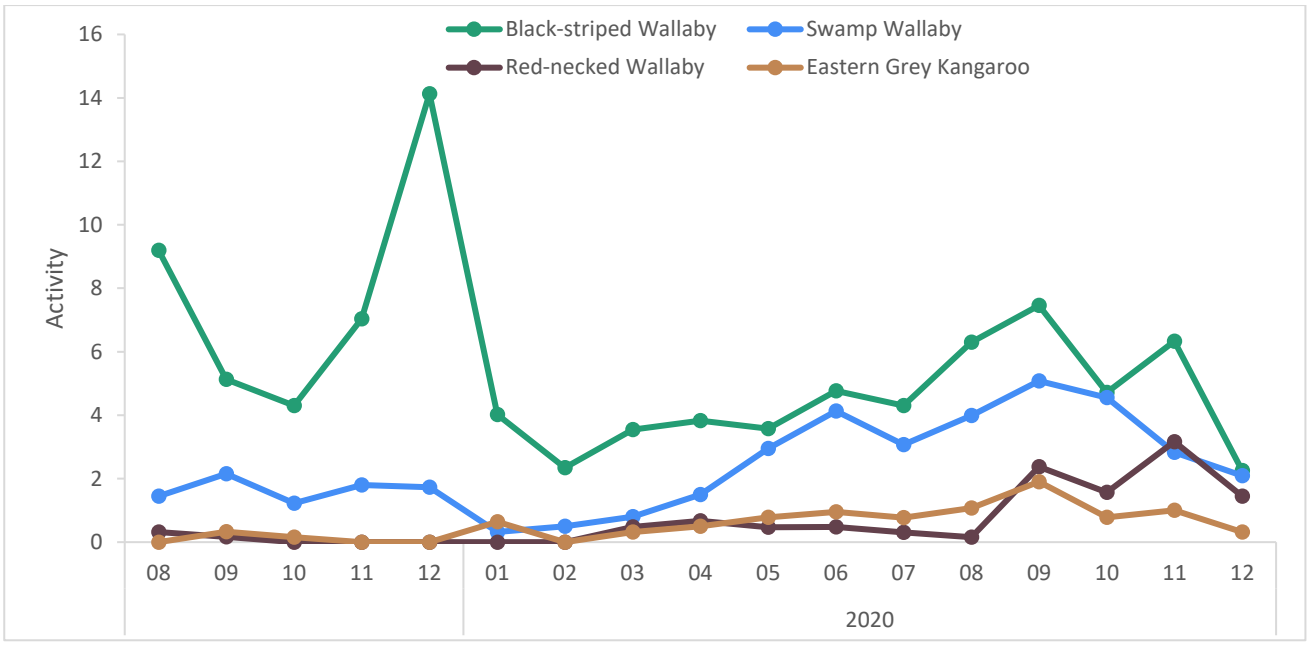

Figure 9. Activity (trigger events per 100 camera trap nights) for macropod indicator species in the Pilliga breeding area, 2019 - 2020.

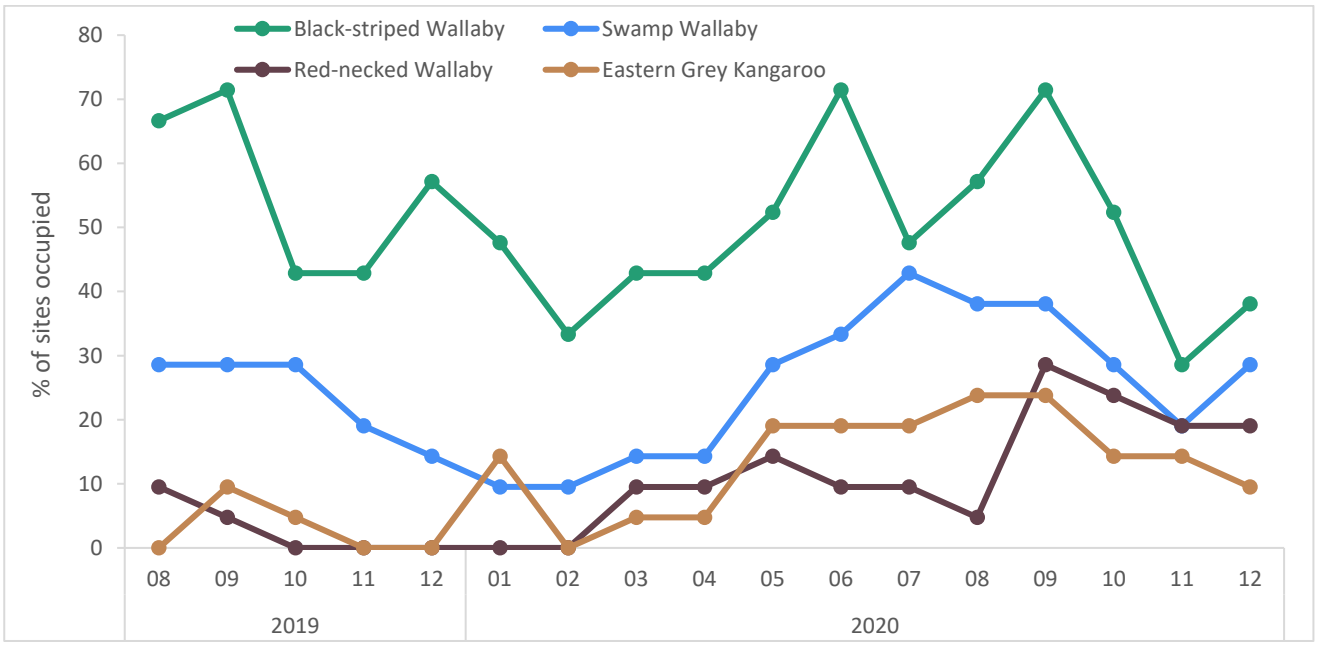

Figure 10. Occupancy (percentage of sites detected) for macropod indicator species inside the Pilliga breeding area, 2019 - 2020.

4.4 Arboreal mammals

4.4.1 Koala

The use of AudioMoth acoustic recorders to detect Koalas was trialled in 2020 (Appendix 1). AWC is currently working with NSW DPIE (Brad Law) to have recordings analysed using specialised sound recognition software.

4.4.2 Eastern Pygmy-possum

All nest boxes were inspected in March 2021. No Eastern Pygmy-possums were detected. To date there have been no records of arboreal mammals obtained from nest boxes.

4.5 Reptiles

4.5.1 Pale-headed Snake

Targeted surveys for the threatened Pale-headed Snake (*Hoplocephalus bitorquatus*) were conducted for the first time in February 2021 (Appendix 1). No Pale-headed Snakes were recorded.

4.6 Birds

4.6.1 Emu

Emus have not been detected inside the Pilliga fenced area since spring 2018. Outside the fence, both occupancy and activity increased in 2020 (Figure 11).

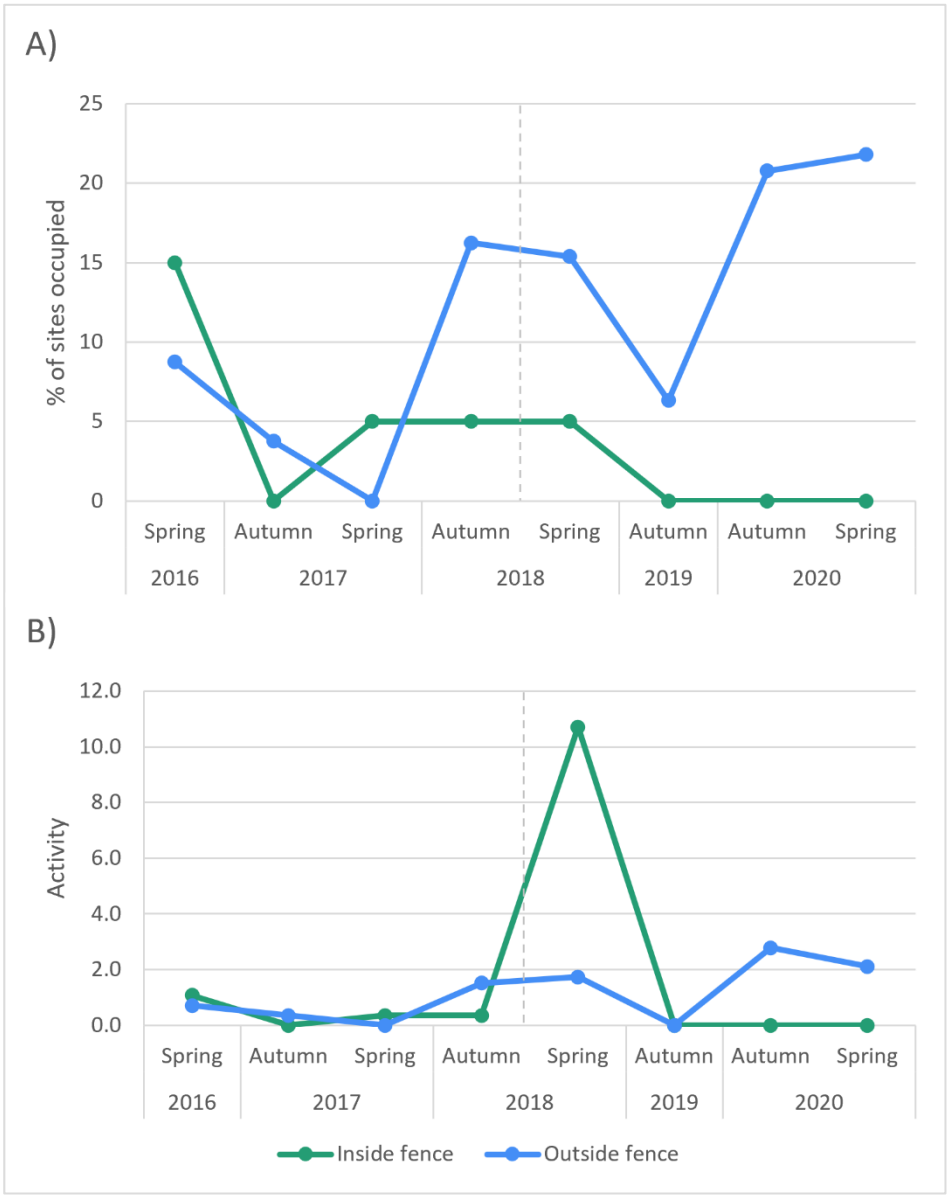

Figure 11. A) Occupancy (percentage of sites detected), and B) activity (trigger events per 100 camera trap nights) for Emus inside and outside the fence, 2016-2020. Dashed line denotes fence completion.

4.6.2 Diurnal birds

In total, 1,857 individual birds from 87 species were recorded in the Pilliga project area in 2020. Both total species richness and mean species richness per site were higher than the previous survey in 2018 (Appendix 3).

4.6.2.1 Woodland-dependent birds

Three indicator species classified as woodland-dependent were identified in 2020: South-eastern Glossy Black Cockatoo (*Calyptorhynchus lathami*), Little Lorikeet (*Glossopsitta pusilla*) and Varied Sittella (*Daphoenositta chrysoptera*). Neither the Glossy Black Cockatoo nor Little Lorikeet was detected during the previous survey in 2018 (Figure 12a, b; Table 3). Varied Sittella has been detected in all surveys conducted to date, but both its abundance and occupancy were low in 2020 compared to previous years (Figure 12c; Table 3). As yet the conservation fence is not influencing the relative abundance of woodland-dependent species (Figure 12a, b, c). The relative abundance of the woodland-dependent bird guild as a whole was lower in 2020 than in any previous survey (Figure 13).

4.6.2.2 Ground-active birds

Four indicator species classified as ground-active were identified in 2020: Turquoise Parrot (*Neophema pulchella*), South-eastern Brown Treecreeper (*Climacteris picumnus victoriae*), Speckled Warbler (*Pyrrholaemus sagittatus*) and Eastern Grey-crowned Babbler (*Pomatostomus temporalis temporalis*). The Turquoise Parrot was more abundant in 2020 than any previous year, but was only detected inside the fence (Figure 12d). The other three species were more abundant outside the fence but differences were not marked and sample sizes were small (Figure 12e, f, g). Abundance of the ground-active bird guild as a whole was similar to that in 2018, but lower than 2016-17 (Figure 14). There was little difference when comparing inside and outside the fence.

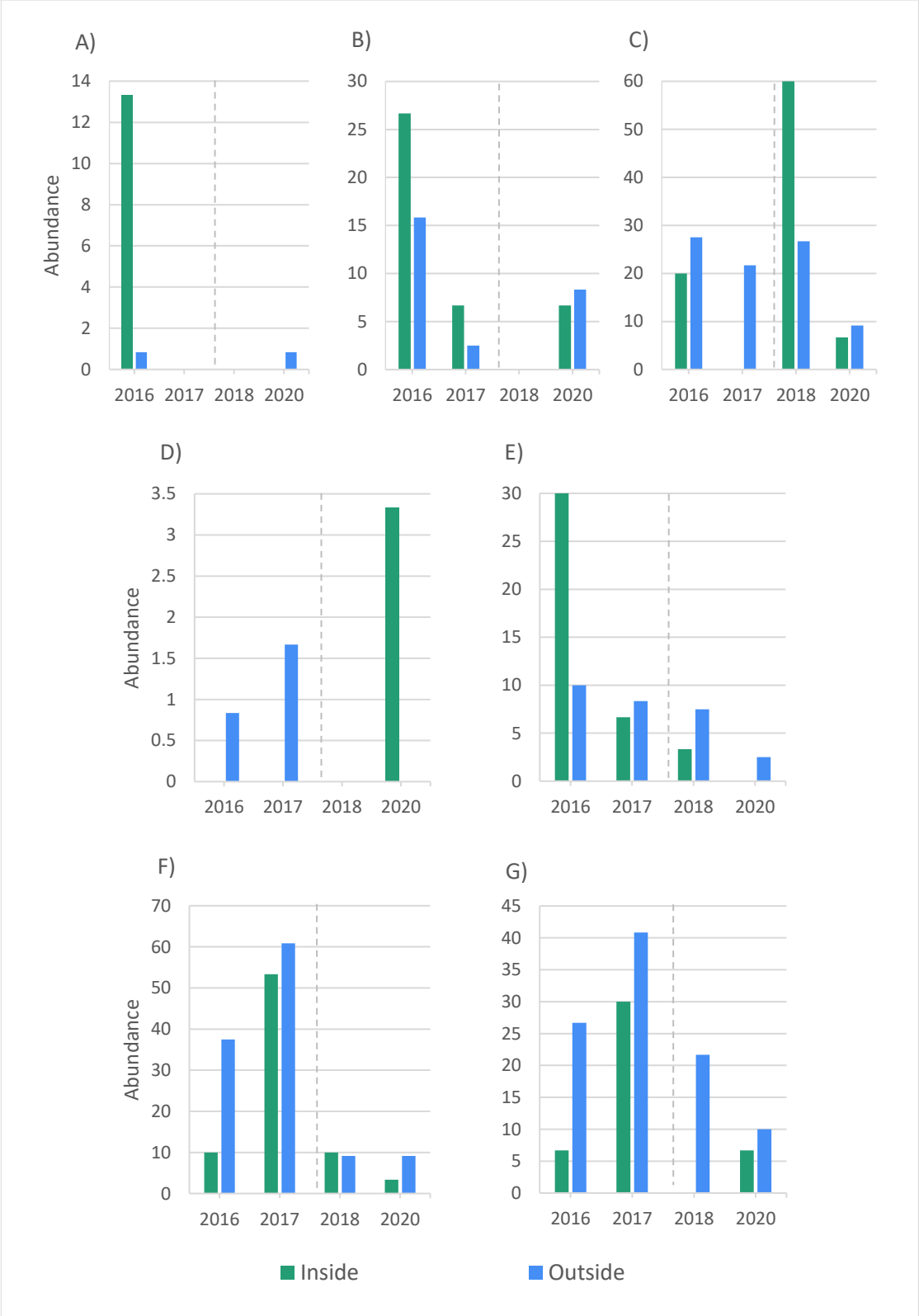

Figure 12. Relative abundance (individuals per 100 surveys) of diurnal bird indicator species. Woodland-dependent birds: A) South-eastern Glossy Black Cockatoo, B) Little Lorikeet, C) Varied Sittella. Ground-active birds: D) Turquoise Parrot, E) South-eastern Brown Treecreeper, F) Speckled Warbler, G) Eastern Grey-crowned Babbler. Data is shown for both inside and outside the fence. Dashed line denotes fence completion.

Table 3. Occupancy (percentage of sites occupied) and counts for indicator diurnal bird species, 2016-2020.

Indicator	Year	Count	Occupancy (%)
South-eastern Glossy Black Cockatoo	2017	5	4
Calyptorhynchus lathami lathami	2018	0	0
	2019	0	0
	2020	1	2
Little Lorikeet	2017	27	16
Parvipsitta pusilla	2018	5	6
	2019	0	0
	2020	12	6
Varied Sittella	2017	39	28
Daphoenositta chrysoptera	2018	26	20
	2019	50	20
	2020	13	10
Turquoise Parrot	2017	1	2
Neophema pulchella	2018	2	2
	2019	0	0
	2020	1	2
South-eastern Brown Treecreeper	2017	21	20
Climacteris picumnus victoriae	2018	12	16
	2019	10	10
	2020	3	4
Speckled Warbler	2017	48	44
Pyrrholaemus sagittatus	2018	89	72
	2019	14	14
	2020	12	12
Eastern Grey-crowned Babbler	2017	34	16
Pomatostomus temporalis temporalis	2018	58	24
	2019	26	8
	2020	14	10

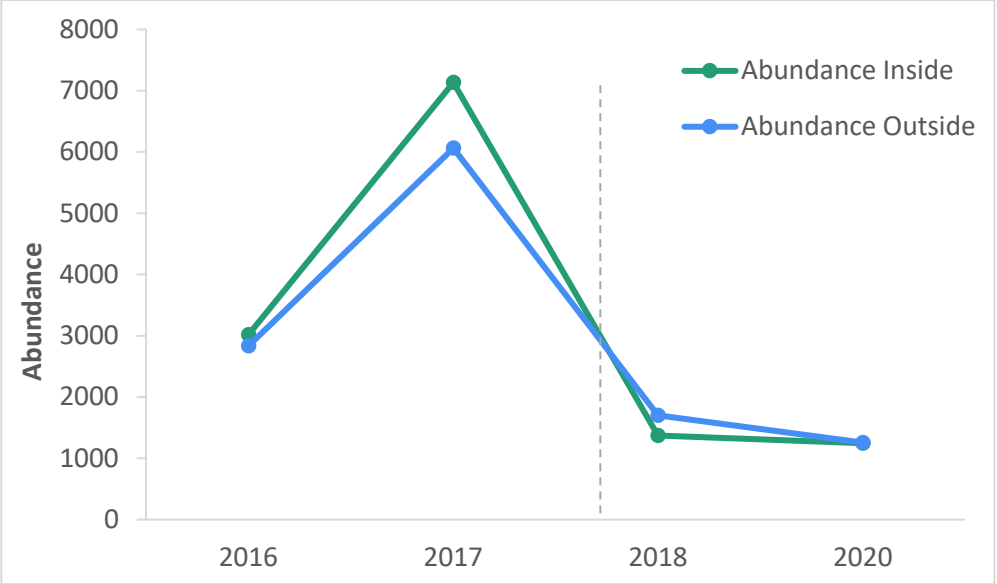

Figure 13. Relative abundance (individuals per 100 surveys) of the woodland-dependent bird guild inside and outside the fence. Dashed line denotes fence completion.

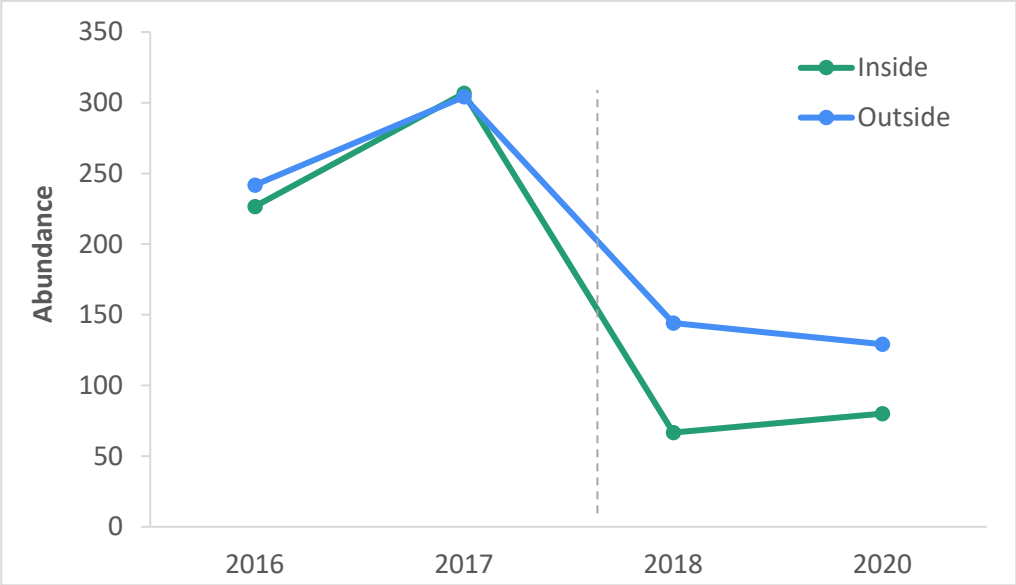

Figure 14. Relative abundance (individuals per 100 surveys) for the ground-active bird guild inside and outside the fence. Dashed line denotes fence completion.

4.7 Threatened plant species

4.7.1 Diuris tricolor

Favourable conditions allowed targeted surveys for *Diuris tricolor* to be conducted for the first time in spring 2020. Historical locations within the project area were searched, and general field inspections conducted to locate plants. Six sites (three inside the fence, three outside) were established (Appendix 1). Observed densities of *D. tricolor* were relatively high (0.31 individuals/m^2; Table 4) because all sites were centred on dense clusters of plants. No difference was observed inside compared to outside the fence.

4.7.2 Pterostylis cobarensis

Targeted surveys for *Pterostylis cobarensis* were also conducted for the first time in 2020. Counts for this species were conducted at existing monitoring sites (five inside the fence, five outside), but sites were inspected for presence of the species before being chosen (Appendix 1). *P. cobarensis* was detected at a density of 0.06 individuals/m^2 both inside and outside the fence (Table 4).

Table 4. Mean number of individuals (per site and per square metre) of *Pterostylis cobarensis* and *Diuris tricolor* encountered during surveys in 2020.

Species	Individuals/site		Individuals/m²	
	Inside	Outside	Inside	Outside
P. cobarensis	30.2	29.4	0.06	0.06
D. tricolor	98.0	96.3	0.31	0.31

4.8 Threat indicators

4.8.1 Fire

Two fuel reduction burns were undertaken in the project area in the 2020-21 reporting period. One was in the block bounded by Keelimore Road, Main Road, Butchers Road and County Line Road (Keelimore burn). The other was in the block bounded by Artree Gully Road, Harris Road and Railway Survey Road (Harris burn). Proposed burn areas were 783 ha for the Keelimore burn and 379 ha for the Harris burn (Figure 15). Aerial ignition was employed for both burns on 8 September 2020, following perimeter burning between 29 April and 3 May 2019.

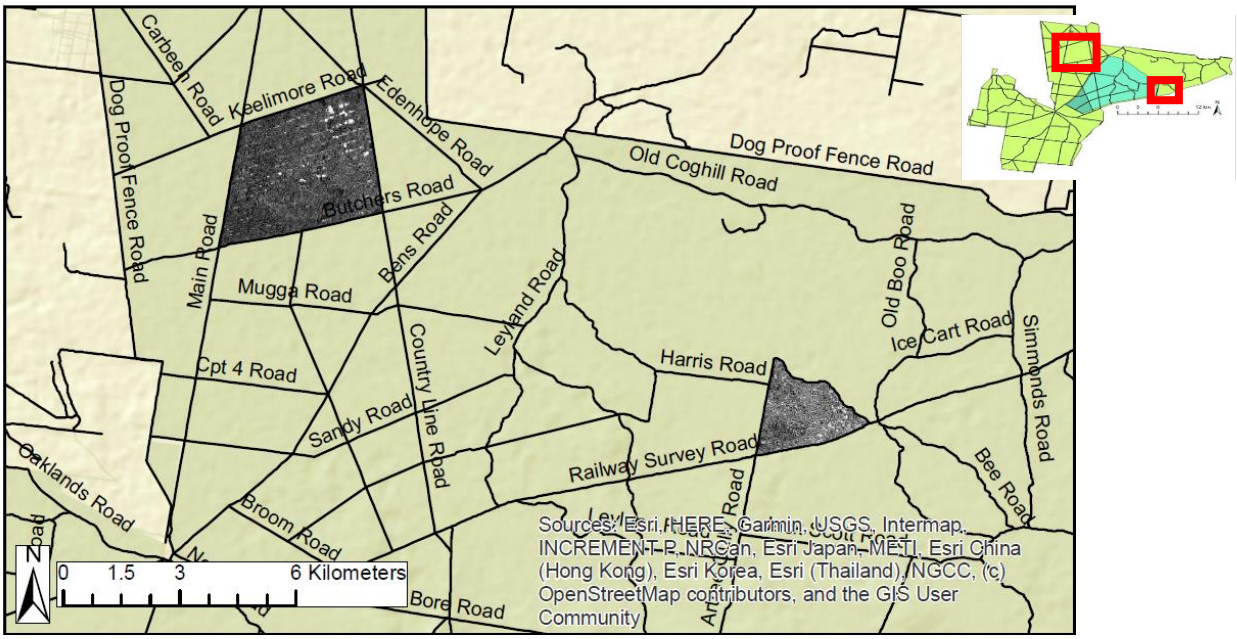

Figure 15. Location of the Keelimore and Harris burn blocks within the Pilliga project area.

Landsat imagery was used to calculate the difference in Normalised Burn Ratio (dNBR) across the 2020 burn areas, and 20 m x 20 m pixels were classified by apparent fire severity (Table 5). These calculations did not include fire severity from the perimeter burns. Analysis showed fire severity within both burns as predominantly 'low' or 'unburnt' (Figure 16). A small cluster of moderate-high severity burn pixels were identified in the north-east of the Keelimore burn (Figure 16b).

Table 5. Fire severity classes according to dNBR classification, with examples of severity indicators. Upper and lower dNBR values taken from Parker et al. (2015). Char height values taken from Cheney (1981).

Fire severity class	Lower dNBR	Upper dNBR	Char height (m)	Leaf litter	Shrub layer	Crown scorch
Unburnt	-Inf	0.077	N/A	Unburnt	Unburnt	Unburnt
Low	0.078	0.257	<1.5	Scorched or lightly charred	Heat damage or scorched	Unburnt or mild leaf scorch
Moderate	0.258	0.427	1.5-6.0	Charred	Scorched, charred	Mild-moderate leaf scorch
High	0.428	Inf	6.0-15.0	Absent	Charred	Leaves charred/ absent

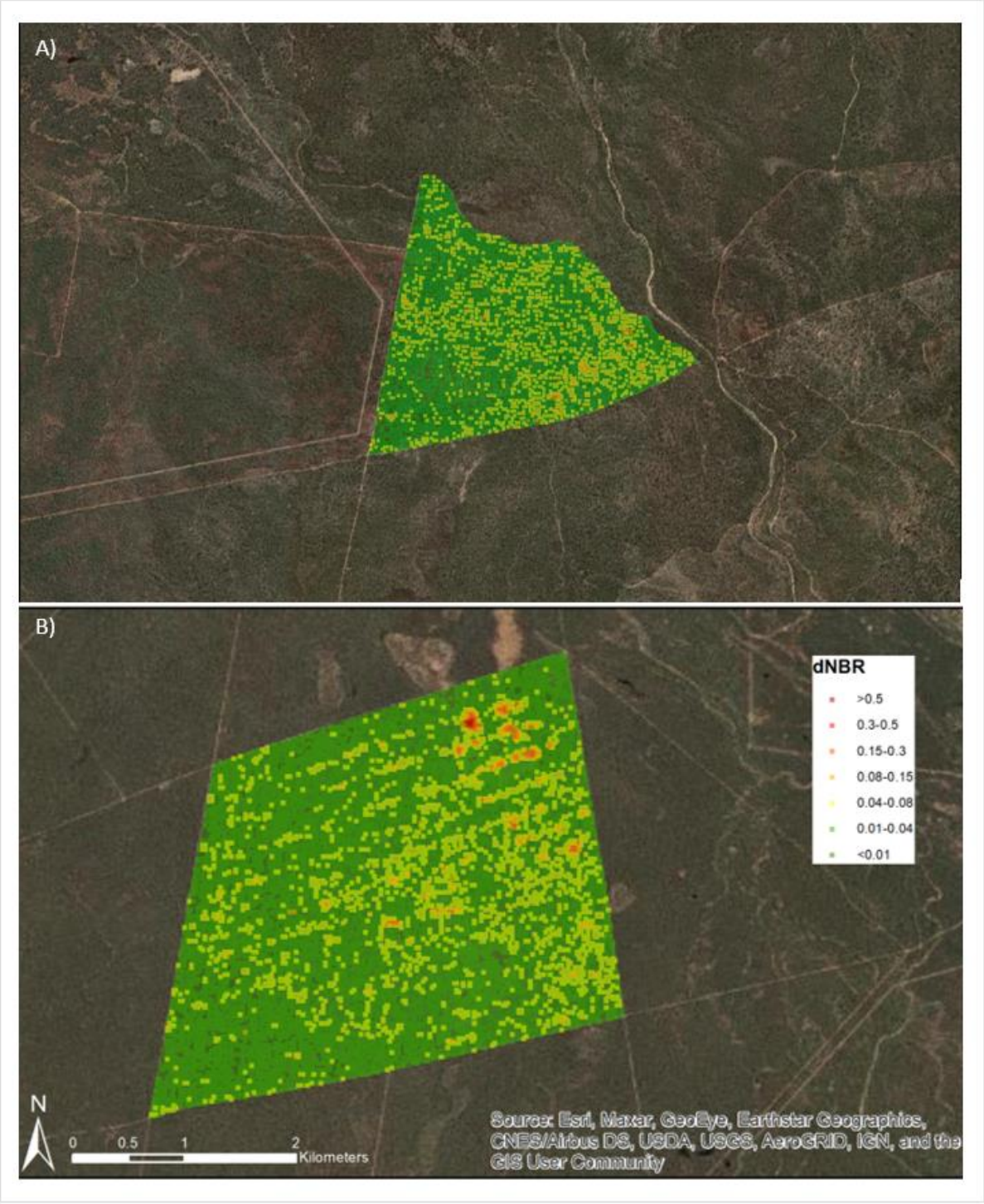

Figure 16. Fire severity classification of 20 x 20 m pixels according to difference in Normalised Burn Ratio (dNBR) for A) Harris burn block, and B) Keelimore burn block.

After stratifying for fire severity and vegetation type, a subset of 30 pixels (sites) within the Keelimore burn was randomly selected for ground-truthing in May 2021 (Figure 17). An overall assessment of fire severity (unburnt, low, moderate, high) was recorded at each site using various metrics. Metrics included fire scar height, damage to shrub layer and leaf litter, and evidence of crown scorch. Indicators of fire damage and fire-related ecosystem processes were also recorded (presence of burnt woody debris, erosion, tree mortality, tree fall, and epicormic growth). Due to almost all pixels in the Harris block being classified as unburnt or low severity burn by dNBR, ground-truthing in this block was not undertaken.

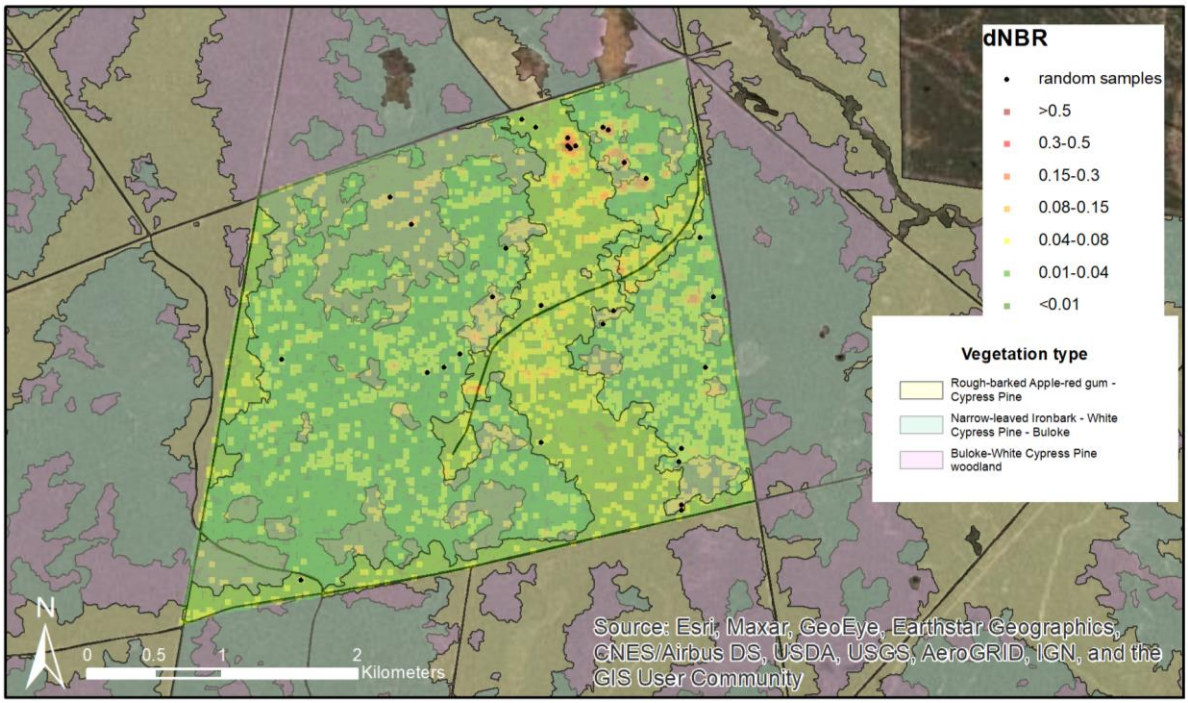

Figure 17. Random sites (20 m x 20 m pixels, n=30) selected for ground-truthing fire severity in the Keelimore burn block, stratified by dNBR fire severity classification and vegetation type.

Classification by dNBR was moderately successful at measuring fire severity (Figures 18, 19). Of the 20 pixels that had been classified as unburnt by dNBR, 7 (35%) were assessed on the ground as low severity burn and 2 were classified as moderate.The majority (62.5%) of pixels that had been classified as low severity matched on-ground assessments. The remainder of pixels in this severity class (37.5%) were assessed as moderate severity. The one moderate severity site assessed was also classified as moderate after ground-truthing. The high severity site assessed was classified as moderate on the ground.

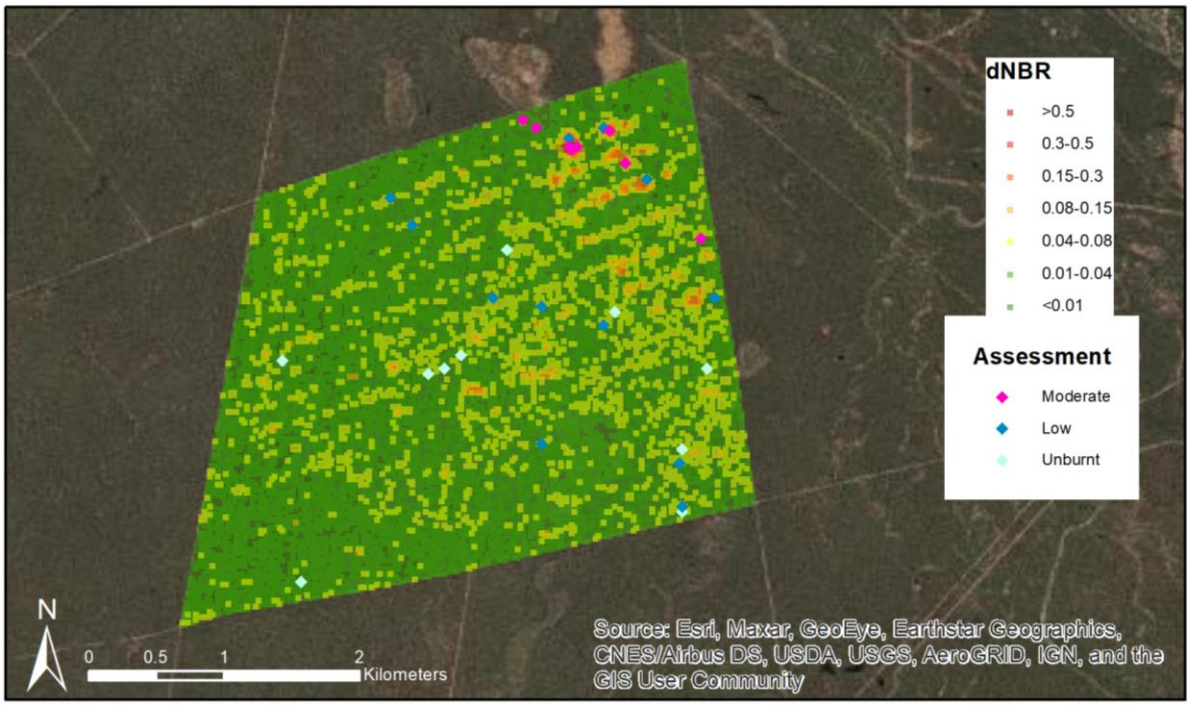

Figure 18. Results from ground-truthing difference in Normalised Burn Ratio (dNBR) fire severity classifications in the Keelimore burn block.

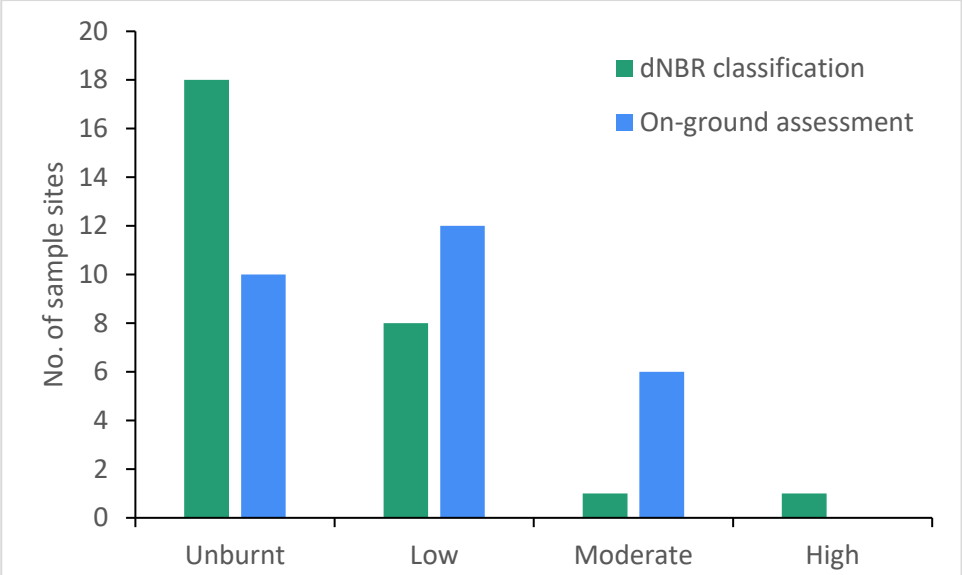

Figure 19. Comparison of difference in Normalised Burn Ratio (dNBR) fire severity classifications and ground-truthed classifications in the Keelimore burn block (n = 30 pixels/sites).

On-ground assessments of low severity fire impacts generally involved 5-100% shrub layer heat damage and/or scorch and no crown scorch (Figure 20). Fire char height was generally below 1.5 m. Moderate severity fire impacts involved 40-100% shrub layer scorch or charring and fire char heights up to 6 m (Figure 21). Sites with moderate fire impacts also contained large pieces of burnt woody debris, as well as large, burnt-out and fallen dead trees.

Burnt woody debris and epicormic shoots were present at the majority of burnt sites. Some seedling recruitment was observed at sites with moderate fire damage. A small number of moderately burnt sites had an ash layer present although repeated and heavy rainfall on the fire scar in the months following the fire renders this metric unreliable. There was no evidence of erosion.

Figure 20. Low severity fire impacts in the Keelimore burn block. Note heat damage/scorch of low shrubs.

Figure 21. Moderate severity fire impacts in the Keelimore burn block.

Approximately 10% of the intended area of the Keelimore burn was burnt at low fire severity and <1% at moderate fire severity. Less than 1% of the intended area of the Harris burn was burnt at low fire severity. Whilst the 2019 perimeter fire was not part of this assessment, moderate fire severity metrics were observed during the on-ground assessment of the Keelimore burn along County Line Road and Keelimore Road, with reduced canopy and high occurrence of grassy understorey.

4.8.2 Feral predators

No feral predators were detected inside the fence in 2020 (Figure 22a, c). While the smaller breeding area is known to be predator-free, one fox is known to remain in the wider fenced area, but this animal was not detected during standard ecological monitoring. Outside the fence, detections of wild dogs remain rare (Figure 22b, d). Activity and occupancy of foxes initially increased slightly in autumn 2020, but then declined markedly in spring. Both metrics for this species were lower in spring 2020 than in any previous survey. Activity and occupancy for cats increased in 2020, reaching their highest levels in surveys to date by the end of the year (Figure 22b, d).

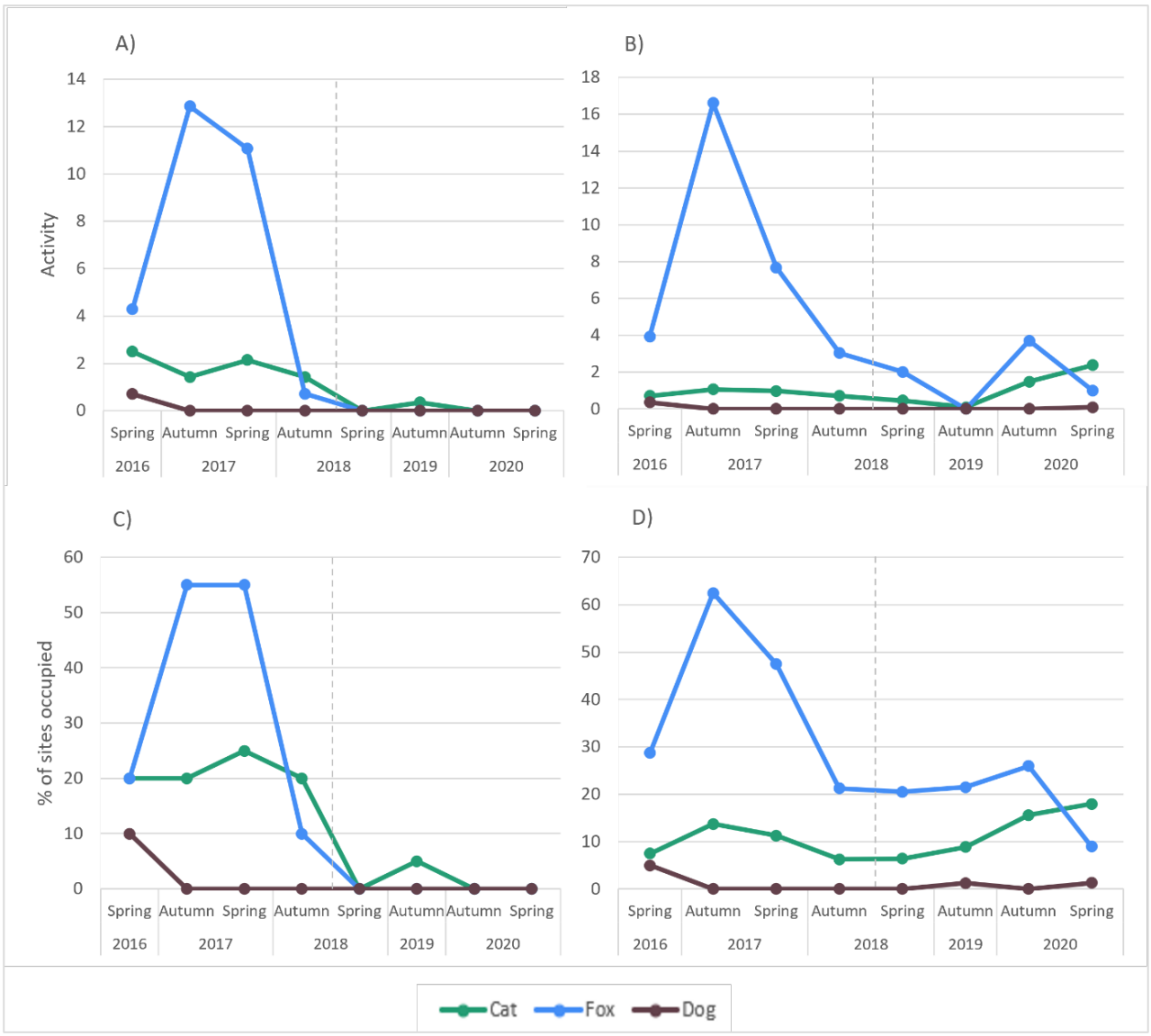

Figure 22. Results from monitoring feral predator activity (trigger events per 100 camera trap nights) and occupancy (percentage of sites detected): A) activity inside the fence; B) activity outside the fence; C) occupancy inside the fence; and D) occupancy outside the fence. Dashed line denotes fence completion.

4.8.3 Feral herbivores

Activity and occupancy of feral herbivores inside the fence was low in 2020, particularly in spring (Figure 23a, c). Pigs, deer and horses were not detected. Goats were detected in autumn but not in spring. Rabbits/hares were detected in autumn and spring, but infrequently; in spring 2020 both activity and occupancy were lower than in 2018-19 (Figure 23a, c).

Outside the fence, rabbits/hares, goats and pigs increased in both activity and occupancy in 2020 (Figure 23b, d). In spring 2020, activity and occupancy for rabbits/hares was higher than in previous years. Goats had been declining in both activity and occupancy since autumn 2018 but displayed a small increase in both metrics in spring 2020 (Figure 23b, d).

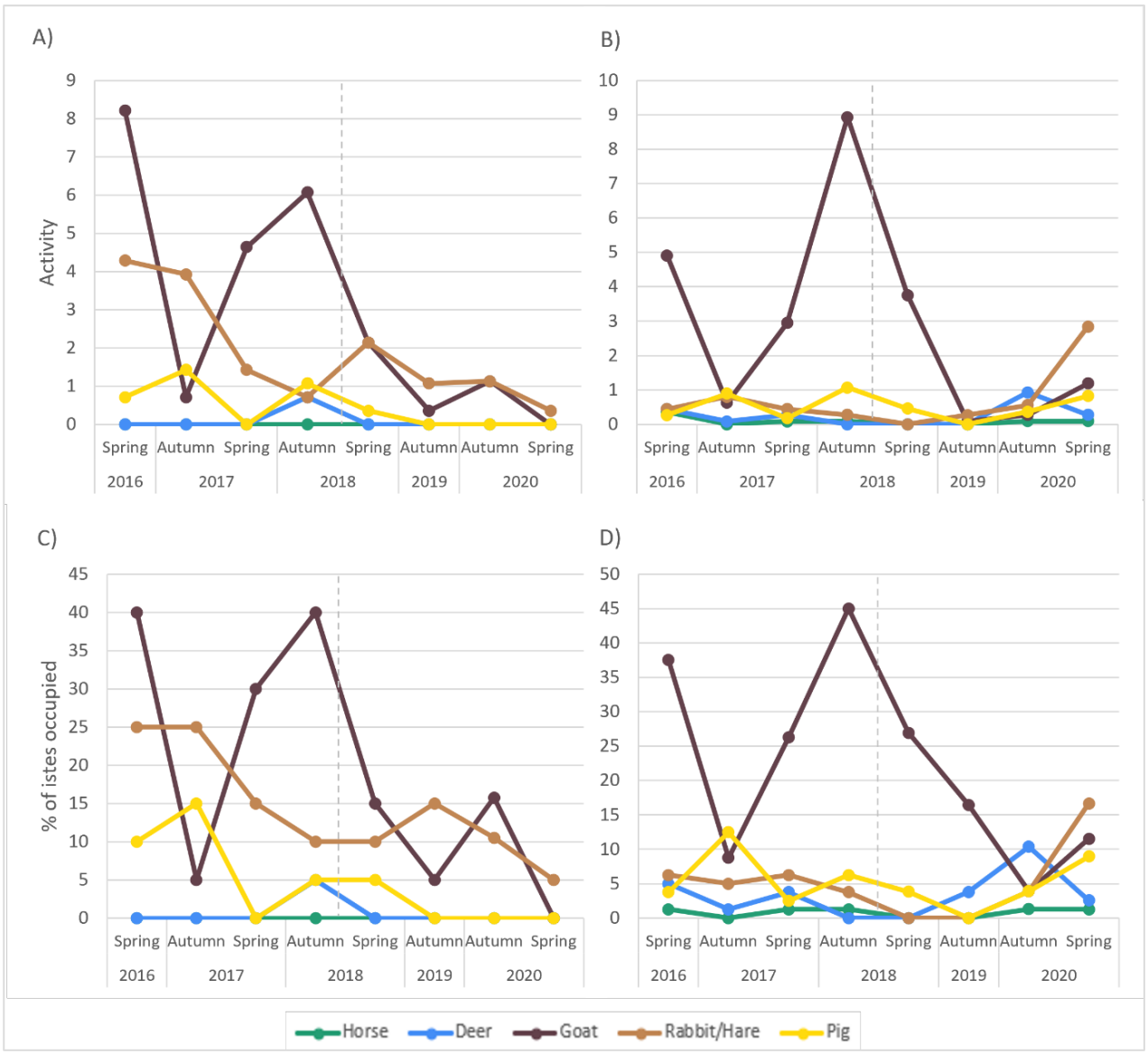

Figure 23. Results from monitoring feral herbivore activity (trigger events per 100 camera trap nights) and occupancy (percentage of sites detected): A) activity inside the fence; B) activity outside the fence; C) occupancy inside the fence; and D) occupancy outside the fence. Dashed line denotes fence completion.

4.8.4 Other feral species

The introduced house mouse (*Mus domesticus*) was detected at 100% of sites (n = 20) during targeted surveys for the threatened Pilliga Mouse (see Section 4.2.1 Pilliga Mouse (and other small mammals)). A total of 222 individuals were caught: 74 inside the conservation fence and 148 outside. High capture rates for house mouse corresponds to a plague of this species occurring in the broader region.

Discussion

Reintroduced mammals

Greater Bilbies were reintroduced to the Pilliga breeding area over two years ago. Most indicators show that Bilbies are successfully establishing in the Pilliga. Recruitment is high (80% of all individuals captured in 2020 were new recruits) and animals have attained and maintained body weight within the acceptable range for the species. Bilby activity (as determined from camera traps and observations of foraging pits/burrows) is increasing and widespread across the breeding area.

Since all other indicators suggest the Bilby population is establishing, the most recent population estimate (60; 95% CI: 44 – 83) is considered conservative. High rainfall in the Pilliga throughout 2020 has resulted in substantial vegetation growth and a likely increase in resource availability for Bilbies (e.g., greater invertebrate abundance/activity). Such conditions may reduce the propensity of Bilbies to enter traps. Typical capture rates for Bilbies in the Pilliga are not yet clear. Trap success may be lower than for other locations where the species is found owing to vegetation type and higher overall productivity.

Bridled Nailtail Wallabies have now been in the Pilliga breeding area for more than one year. Both short-term success criteria were met for this species: survival of founders was high (81 – 88%), and animals gained weight following release. Importantly, survival was monitored for a full 12-month period, with collars retrieved from the field (i.e., collars that detached from animals via weak links) redeployed on suitable animals in subsequent trapping surveys (Bridled Nailtail Wallabies were trapped quarterly during the first year post-release). Thus, most founders are known to have survived not just the initial reintroduction period, but long enough to contribute to the first Pilliga-born generation.

Pilliga Mouse (and other small mammals)

Just one Pilliga Mouse was captured during targeted surveys for this species. Despite drought conditions abating in 2020, the Pilliga Mouse remains scarce in the project area. At the time that surveys were undertaken, much of northern and central NSW was experiencing a house mouse plague. More than 200 house mice were captured during the survey, with this feral species encountered at all survey sites. It is likely that high trap closure rates resulting from house mouse captures negatively affected capture of native species.

The Pilliga Mouse is a site-managed species under the NSW Government's *Saving our Species* program. Consequently, annual surveys for this species will continue to be conducted with a view to better understanding vegetation/habitat preferences, response to climate (e.g., rainfall), and change in relation to the conservation fence. However, records obtained for this species to date (2017 – 2021) are insufficient to support formal data analyses.

In 2020 small mammal surveys were conducted via Elliott trapping only at a subset of monitoring sites (n = 20) for the first time. To allow comparison with data collected in previous years, only records obtained from Elliott traps were considered in this report. This resulted in the exclusion of a small number of records from pitfall traps. Metrics reported (proportion of sites occupied and individuals captured per 100 trap nights) are largely insensitive to differences in sample size.

The Yellow-footed Antechinus has always been the most widespread and abundant small native mammal in the Pilliga project area. Since the construction of the conservation fence, occupancy and relative abundance of this species has increased inside the fence, relative to outside. This provides a strong indication that this species is benefiting from the reduction/removal of feral predators inside the fenced area. This finding is expected to become more apparent in the future.

Macropods

Four macropod species continue to be encountered inside the fenced area (including the smaller breeding area). Data was presented for cameras permanently deployed in the breeding area (as well as standard

surveys of sites inside/outside the fence) as the higher survey effort associated with these cameras provides greater insight into the status of macropods inside the fence. At this stage there is no strong suggestion of a sustained increase in macropod occupancy or activity inside the fence/breeding area. However, patterns for individual species were variable (e.g., Red-necked Wallaby activity and occupancy may have increased inside the fence, as well as Eastern Grey Kangaroo activity). Management of macropods inside the fence will be guided by the Pilliga Macropod and Emu Management Plan.

Other mammal surveys

Acoustic surveys are being widely deployed in NSW to detect Koalas. Spotlighting and call-playback surveys have failed to detect Koalas in the Pilliga project area in recent years. Consequently, acoustic surveys were trialled for the first time in 2020. This survey method has the promise to be more efficient and effective at detecting Koalas in the Pilliga, should they still occur. Call recognition software is required to efficiently detect Koala calls on audio recordings. AWC is working with NSW DPIE (Brad Law) to have data obtained in late 2020 analysed. It was not possible for analysis to occur prior to preparation of this report. All findings will be shared once analysis is complete.

Nest box inspections again failed to detect any arboreal mammal species, including Eastern Pygmy-possum. No arboreal mammal has ever been encountered in nest boxes erected for this project. This likely reflects low abundance of arboreal mammals (as indicated by previous spotlighting surveys) and availability of natural hollows. There is likely little value in continuing to employ nest boxes as a survey technique.

Birds

In total, seven indicator species from the woodland-dependent and ground-active bird guilds were recorded. Abundance and occupancy were generally low for both guilds, and there is currently no suggestion of a response to the conservation fence, although (outside the breeding area), the fenced area it is yet to become feral predator-free. It is expected that woodland-dependent and ground-active bird species will increase in abundance and occupancy inside the fence in response to feral predator removal and other land management actions (including herbivore removal/suppression). More time is likely required for any response to become apparent.

Feral predators and herbivores

Feral predators were not detected inside the fence (despite the ongoing presence of a single fox in the wider fenced area), and activity of feral herbivores inside the fence was consistently low throughout 2020. This reflects the ongoing focus to control and remove all feral species inside the fence. Outside the fence, fox activity declined in spring 2020 while cat activity increased. Activity of most feral herbivores also increased outside the fence. There will be a greater focus on feral animal control outside the fence once the wider fenced area is declared feral predator-free.

Acknowledgements

AWC acknowledges the Gamilaroi people as the Traditional Custodians of the country on which the Pilliga resides. We also acknowledge their continuing connection to land, culture and community. We pay our respects to Gamilaroi Elders past present and emerging.

References

BOM (2021a) Climate classification maps. Australian Government Bureau of Meteorology, Canberra. Available at: http://www.bom.gov.au/jsp/ncc/climate_averages/climate-classifications/index.jsp?maptype=kpn#maps

BOM (2021b) Climate Data Online. Australian Government Bureau of Meteorology, Canberra. Available at: http://www.bom.gov.au/climate/data/index.shtml?bookmark=200

Cheney NP (1981) Fire behaviour. In: *Fire and the Australian Biota* (AM Gill, RH Groves, IR Noble, eds), p. 582. Australian Academy of Science, Canberra.

Department of Planning, Industry and Environment (2020) Koala monitoring procedures - Factsheet: Acoustic monitoring with AudioMoth, Version 7.

Kavanagh R, Holland G, Belder D, Berry L, Leo V, Joseph L, Kanowski J (2020) Ecological Health Monitoring Plan: Pilliga Forests. Australian Wildlife Conservancy, Perth.

Parker BM, Lewis T, Srivastava SK (2015) Estimation and evaluation of multi-decadal fire severity patterns using Landsat sensors. *Remote Sensing of Environment* 170, 340–349

Appendix 1

Targeted Survey Methodologies

During the reporting period, surveys were conducted that are not described in the Pilliga EHMF (Kavanagh et al. 2020). This included the trial of a new survey technique for a previously monitored species, and targeted surveys for threatened species conducted for the first time in 2020-21. Brief details of these surveys are provided below. Relevant details will be included in the Pilliga EHMF in the next revision/update.

Acoustic monitoring surveys

In Spring 2020, passive acoustic monitoring devices, AudioMoths, were trialled as an alternative method to monitor for Koala (*Phascolarctos cinereus*) presence at Ecohealth monitoring sites. Methods detailed by Department of Planning, Industry and Environment (2020) were followed. AudioMoths were deployed at each 2.5 km grid site for seven nights at the end of October. The devices were set to continuously record between sunset and sunrise.

Pale-headed snake surveys

In February 2021, area searches targeting Pale-headed Snakes (*Hoplocephalus bitorquatus*) were trialled as a possible method for detecting this cryptic species. A literature review highlighted that red gum forests and riverine floodplains with mature hollow bearing trees may be core habitat for *H. bitorquatus* (Fitzgerald et al 2010; Shelton et al 2018; Shelton et al 2020). Potential sites were selected based on historic records (n = 2), plant community type, and proximity to watercourses (ephemeral creek or gilgai). Fourteen sites were ground-truthed and four sites were selected based predominantly on presence of large hollow bearing trees (Figure 1).

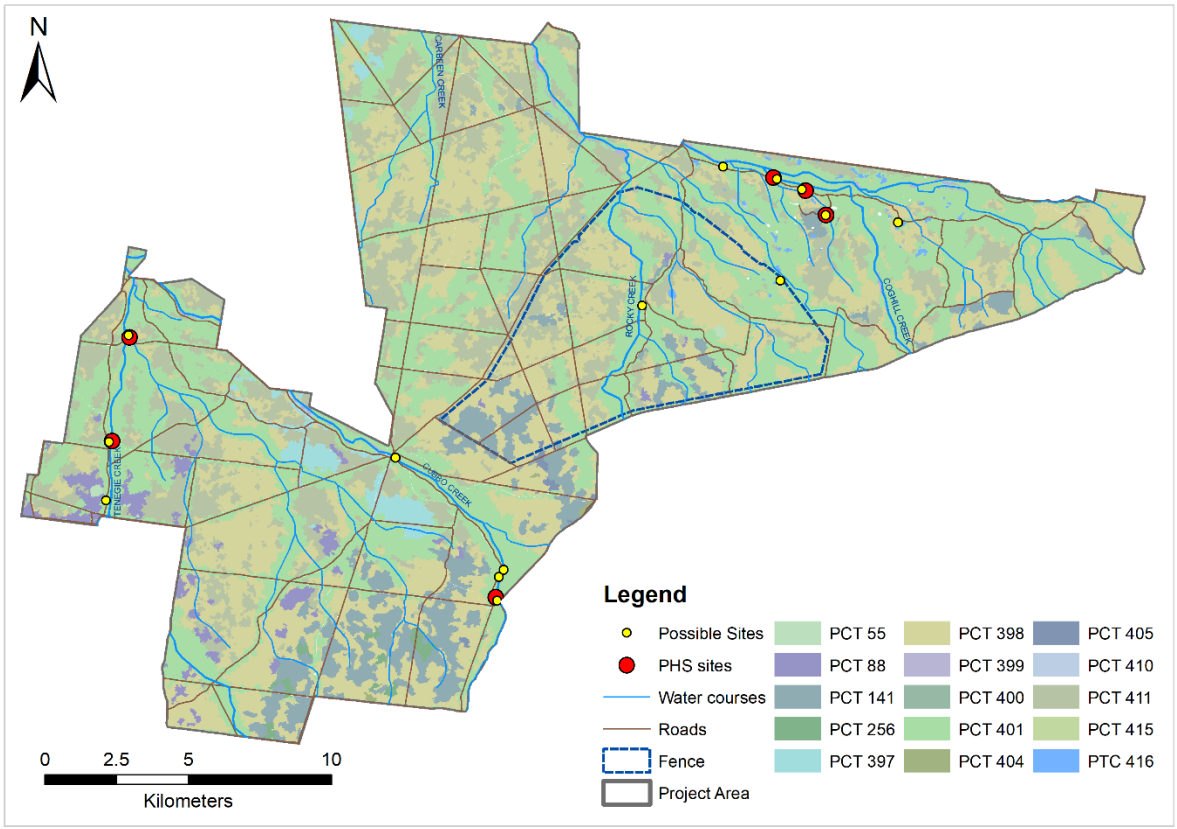

Figure 1. Sites selected for Pale-headed Snake surveys.

At each site, a 10000 square meter area (250 by 40 meter transect) was searched for the equivalent of one person-hour. The first survey of each night begun 30 minutes post sunset. Methods were based on Shelton et al. (2018).

References

Fitzgerald M, Brian L, Shine R (2010) Ecology and conservation of the Pale-headed Snake (*Hoplocephalus bitorquatus*, Elapidae). *Australian Zoologist* 35, 283–290.

Shelton MB, Phillips SS, Goldingay RL (2020) Habitat requirements of an arboreal Australian snake (*Hoplocephalus bitorquatus*) are influenced by hollow abundance in living trees. *Forest Ecology and Management* 455.

Shelton MB, Goldingay RL, Phillips SS (2018) Population ecology of a cryptic arboreal snake (*Hoplocephalus bitorquatus*). *Australian Journal of Zoology* 65, 383–390.

Threatened orchid surveys

Targeted orchid surveys aim to detect new populations of threatened orchid species. Permanent survey sites (Figure 2) can be monitored over time to detect changes in orchid abundance in response to seasonal variation, land management practices, and the reintroduction of locally extinct omnivorous mammals, namely the Brush-tailed Bettong (*Bettongia penicillata*). In particular, surveys will target NSW Threatened Orchid species *Diuris tricolor* (Pine Donkey Orchid, Vulnerable) and *Pterostylis cobarensis* (Rusty/Cobar Greenhood, Vulnerable).

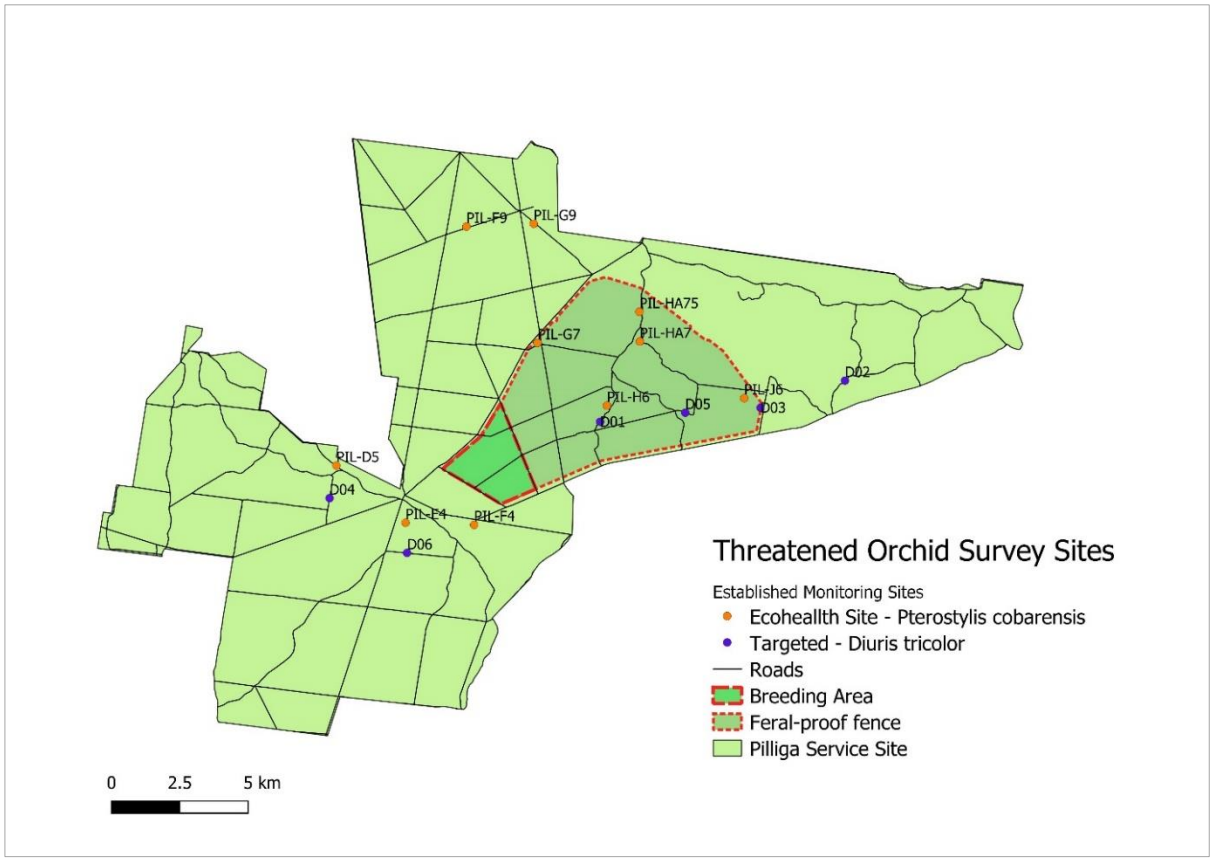

Figure 2. Location of established threatened orchid survey sites for *P. cobarensis* and *D. tricolor*

Targeted surveys will be conducted during Spring of flowering year. Consecutive years of flowering may be surveyed less frequently to reduce the chance of negatively impacting threatened orchids through trampling. Considerations will be given to climatic and seasonal conditions, as well as availability of resources.

Pterostylis cobarensis

Ten Ecohealth monitoring sites were selected to monitored for *P. cobarensis*, five inside the fence and five outside. Selection was based on the presence of *P. cobarensis* during preliminary walk-throughs in Spring 2020.

A 500 m^2 area (100 x 5 metre transect, see Figure 3) is searched and all individual plants with mature flowers are recorded. Plants with only immature flowers are recorded as *Pterostylis sp*. as accurate identification is not always possible.

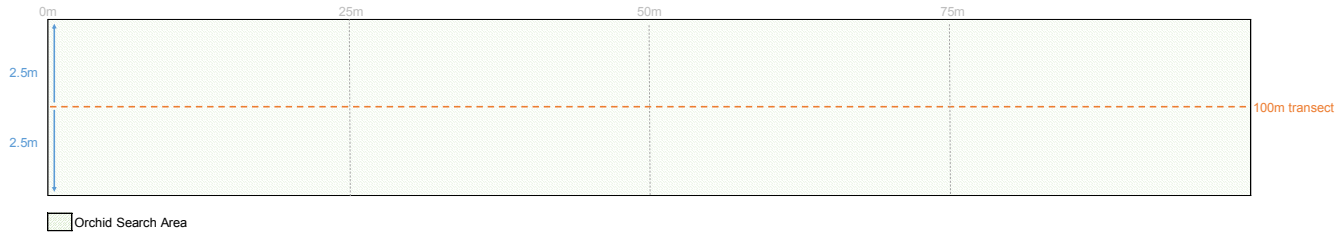

Figure 3. Diagram of survey transect search area for *P. cobarensis*

Diuris tricolor

Six permanent monitoring sites have been established for *D. tricolor,* three inside the fenced area and three outside. At each site, 2-3 higher density 'clusters' were identified. Site selection was based on the presence and relative abundance of *D. tricolor* during preliminary walk-throughs in Spring 2020.

Each 113 m^2 area (six-metre radius plot, see Figure 4) is searched and all individual plants with mature flowers are recorded. Plants with only spent or immature flowers are recorded as *Diuris sp*. as accurate identification is not always possible.

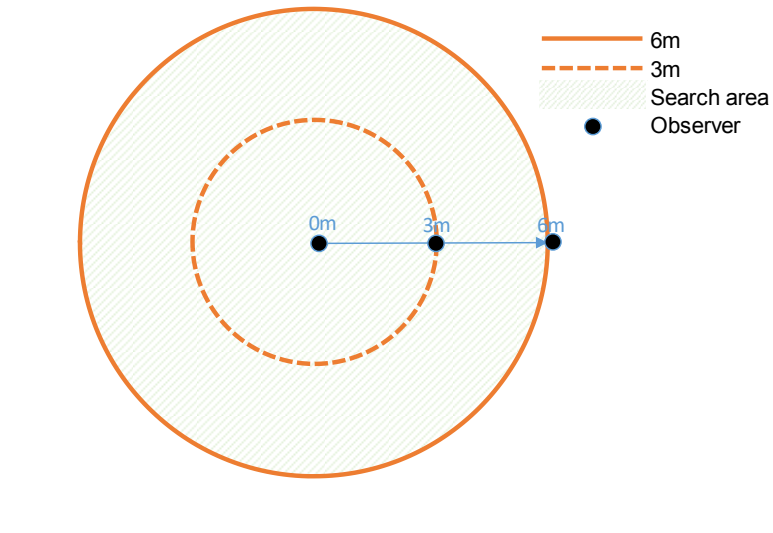

Figure 4. *Diuris tricolor* cluster survey plot diagram

Appendix 2

Small- to medium-sized terrestrial mammals

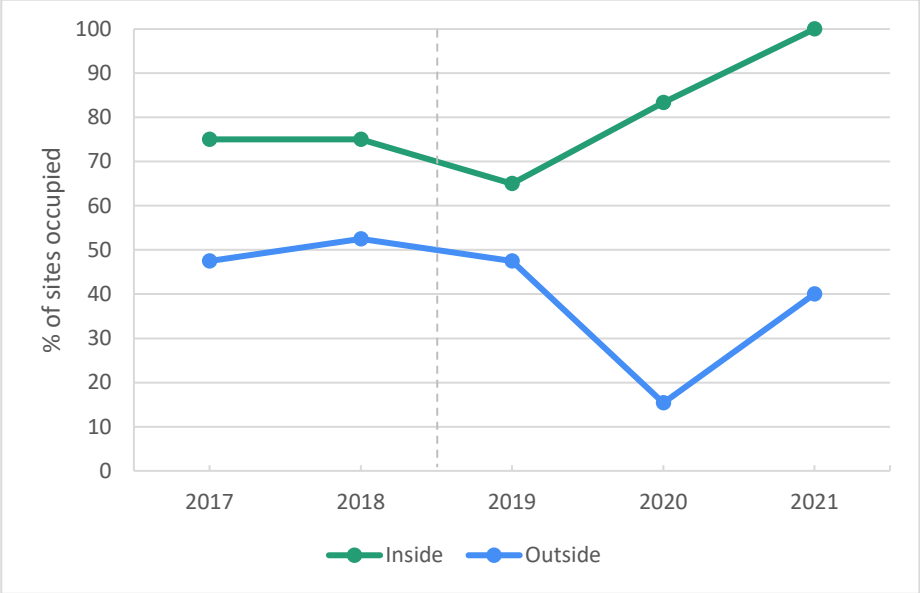

Figure 5. Occupancy of the small mammal guild, 2017 to 2021.
Dashed line denotes fence completion. 2017–2019: n = 60 (20 inside, 40 outside); 2020: n = 44 (18 inside, 26 outside); 2021, n = 20 (10 inside, 10 outside).

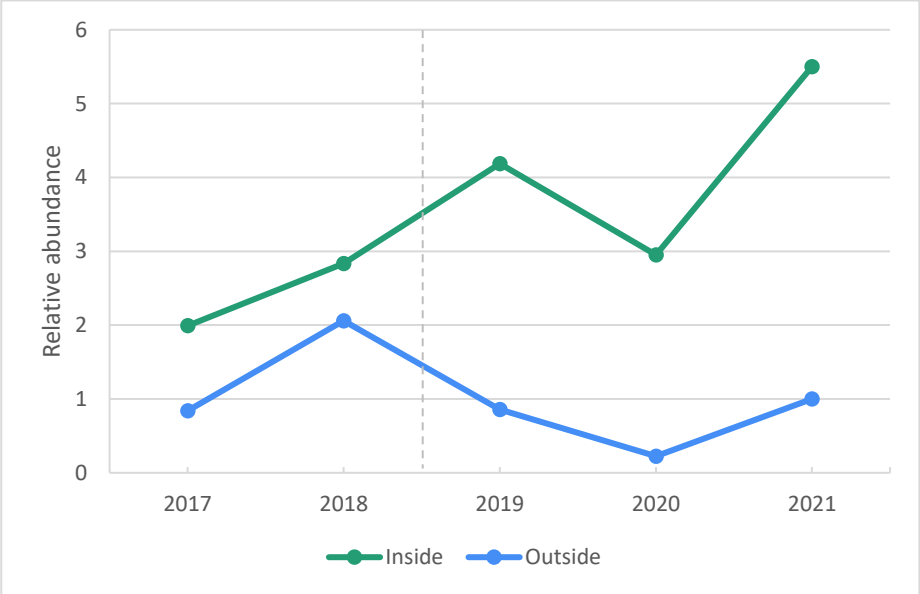

Figure 6. Relative abundance (total individuals per 100 trap nights) of the small mammal guild inside and outside the fenced area, 2017 to 2021. Dashed line denotes fence completion. 2017–2019: n = 60 (20 inside, 40 outside); 2020: n = 44 (18 inside, 26 outside); 2021, n = 20 (10 inside, 10 outside).

Appendix 3

Bird species richness

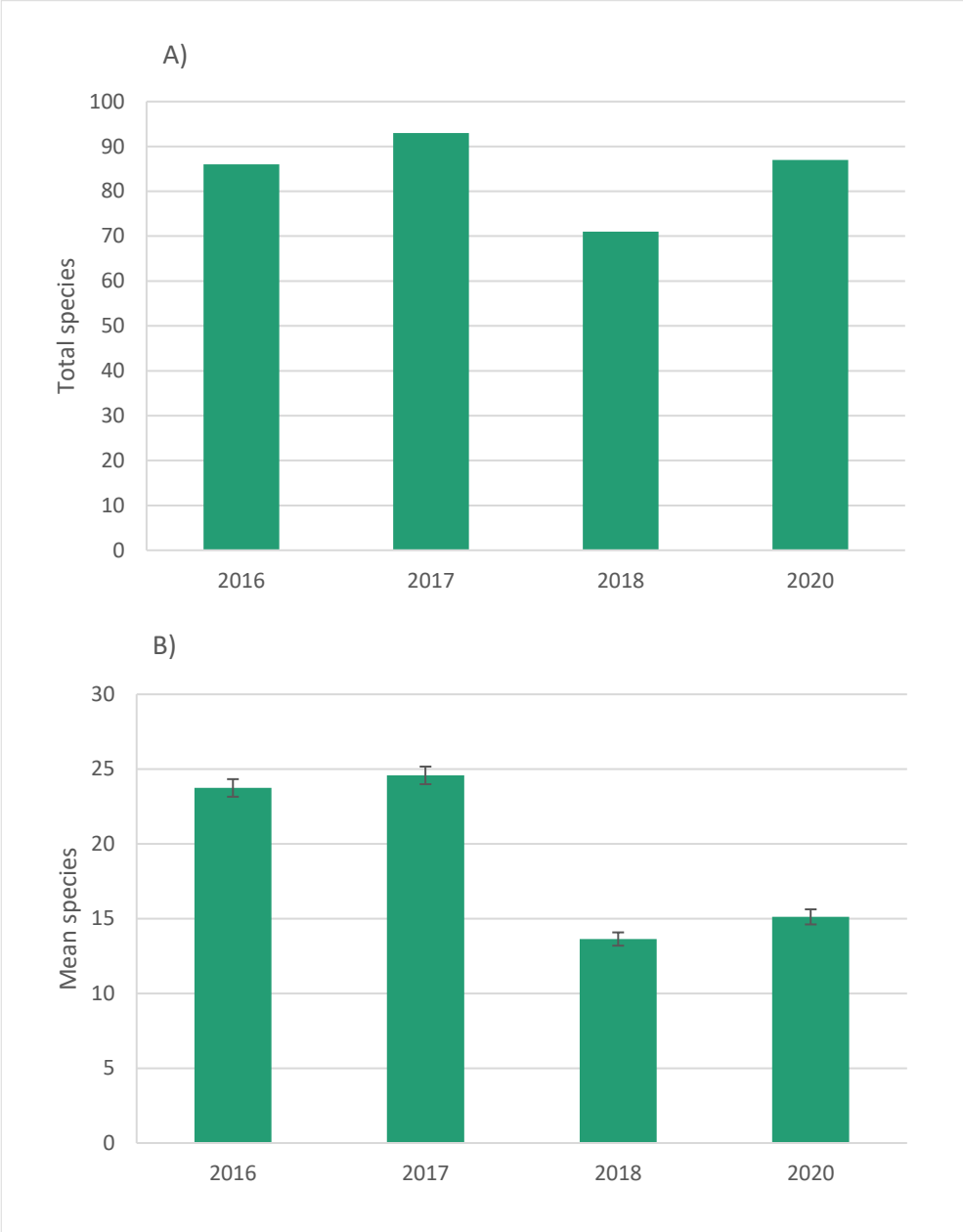

Figure 7. A) Total species richness of diurnal birds, and B) mean (± s.e.) diurnal bird richness per site, 2016 to 2020.

Ecohealth Scorecard

Pilliga Service Site 2020-2021

australian wildlife conservancy

Size: 35,632 hectares

Bioregion: Brigalow Belt South

Biodiversity Metrics

Indicator	Metric (*definitions below table)	Value		Year	Comments
		Inside	Outside		
Mammals					
Reintroduced mammals					
Greater Bilby *Macrotis lagotis*	Population estimate Recruitment Condition	60 80% 887 – 1266 g	- - -	2020-21	Population estimate is considered conservative. High rainfall & associated resource availability in 2020 likely to be reducing trap success. 80% of all animals captured in 2020-21 were new recruits. Medium-term target of sufficient recruitment is being met. Female mean body weight: 887 g; male mean body weight: 1266 g. Medium-term target of weight maintenance within acceptable range is being met.
Bridled Nailtail Wallaby *Onychogalea fraenata*	Survival rate Condition	81 – 88% +33 – 91%	- -	2020-21	Short-term target of survival >50% was met. All founders gained weight following release. Average weight gain (as a percentage of body weight at release) was 90.6% (50.7 – 151.0%) for males and 32.9% (12.9 – 44.8%) for females. Short-term target of maintenance of body weight within 20% of release weight was met.
Small-medium mammals					
Short-beaked Echidna *Tachyglossus aculeatus*	Activity	0.4 3.2	1.0 1.6	Autumn 2020 Spring 2020	Increase in activity inside the fence in spring 2020. No clear trend in activity through time.
	Occupancy (%)	5.3 35	13 15.4	Autumn 2020 Spring 2020	Increase in occupancy inside the fence in spring 2020. No clear trend in occupancy through time.
Yellow-footed Antechinus *Antechinus flavipes*	Abundance Occupancy (%)	5.4 90	0.9 40	2020-21†	Abundance higher & increasing through time inside the fence. Occupancy higher & increasing through time inside the fence.
Common Dunnart *Sminthopsis murina*	Abundance Occupancy (%)	0.0 0	0.1 10	2020-21†	A single individual was recorded in 2020-21. No clear trend in abundance through time (small sample size). A single individual was recorded in 2020-21. No clear trend in occupancy through time (small sample size).w

Indicator	Metric (*definitions below table)	Value		Year	Comments
		Inside	Outside		
Rufous Bettong *Aepyprymnus rufescens*	Abundance Occupancy (%)	0.0 0	0.0 0	2020	Not detected in any survey year.
Pilliga Mouse *Pseudomys pilligaensis*	Abundance Occupancy (%)	0.1 10	0.0 0	2020-21†	A single individual was recorded in 2020-21. No clear trend in abundance through time (small sample size). A single individual was recorded in 2020-21. No clear trend in occupancy through time (small sample size).
Small-medium mammals guild	Abundance Richness	5.5 1.0	1.0 0.5	2020-21†	Metrics driven by results for Yellow-footed Antechinus.
Arboreal mammals					
Eastern Pygmy-possum *Cercartetus nanus*	Occupancy (%) (nest boxes)	0	0	2020-21†	Not detected in nest boxes in 2020-21 or any other survey year. Spotlight surveys not conducted in 2020-21.
Koala *Phascolarctos cinereus*	Data from audio monitoring trials currently being processed externally. Spotlight surveys not conducted in 2020-21.				
All other arboreal mammals	Spotlight surveys not conducted in 2020-21.				
Large native herbivores					
Black-striped Wallaby *Macropus dorsalis*	Occupancy (%)	5 15	3 13	Autumn 2020 Spring 2020	Similar pattern inside/outside fence for both occupancy and activity. No clear trend through time.
	Activity	0.4 1.4	0.2 1.6	Autumn 2020 Spring 2020	
Eastern Grey Kangaroo *Macropus giganteus*	Occupancy (%)	5 10	69 71	Autumn 2020 Spring 2020	Consistently low occupancy inside the fence through time. Large increase in occupancy outside the fence in 2020.
	Activity	0.8 5.4	14.6 17.2	Autumn 2020 Spring 2020	Increase in activity inside the fence in spring 2020. Overall, much higher activity outside the fence in 2020.
Red-necked Wallaby *Macropus rufogriseus*	Occupancy (%)	10.5 10	1.3 1.3	Autumn 2020 Spring 2020	Increase in occupancy inside the fence in 2020. Consistently low occupancy through time outside the fence.
	Activity	3 5.4	0.1 0.2	Autumn 2020 Spring 2020	Increase in activity inside the fence in 2020. Consistently low activity through time outside the fence.
Swamp Wallaby *Wallabia bicolor*	Occupancy (%)	0 0	6.5 7.7	Autumn 2020 Spring 2020	Decline in occupancy inside the fence in 2020 (species not detected). Consistent occupancy through time outside the fence.
	Activity	0 0	0.5 1.2	Autumn 2020 Spring 2020	Decline in activity inside the fence in 2020 (species not detected). Consistent activity through time outside the fence.

Ecohealth Scorecard

Indicator	Metric (*definitions below table)	Value		Year	Comments
		Inside	Outside		
Bats					
Bat surveys not conducted in 2020-21.					
Reptiles					
Small-medium reptiles					
Pale-headed Snake *Hoplocephalus bitorquatus*	Occupancy (%)	0	0	2020-21	Targeted surveys were conducted for the first time in February 2021. Species not detected.
Small-medium reptile guild	Surveys not conducted in 2020-21.				
Birds					
Emu *Dromaeus novaehollandiae*	Occupancy (%)	0 0	21 22	Autumn 2020 Spring 2020	Not detected inside the fence since spring 2018. Increase in occupancy outside the fence in 2020.
	Activity	0.0 0.0	2.8 2.1	Autumn 2020 Spring 2020	Not detected inside the fence since spring 2018. Slight increase in activity outside the fence in 2020.
Woodland birds					
Glossy Black Cockatoo *Calyptorhynchus lathami*	Count Occupancy (%) Abundance	0 0 0.0	1 3 0.8	2020-21	Only one individual observed in 2020-21. No clear trend through time (small sample size).
Little Lorikeet *Glossopsitta pusilla*	Occupancy (%) Abundance	20 6.7	3 8.3	2020-21	Higher occupancy inside the fence in 2020. No clear trend through time. Similar abundance inside/outside fence. No clear trend through time.
Varied Sittella *Daphoenositta chrysoptera*	Occupancy (%) Abundance	10 6.7	10 9.2	2020-21	Similar occupancy & abundance inside/outside fence. No clear trend through time.
Woodland birds guild	Richness Abundance	15.9 1246.7	14.9 1257.5	2020-21	Similar values inside/outside fence. Decline in abundance since 2017.
Barking Owl *Ninox connivens*	Surveys not conducted in 2020-21. Surveys will resume in 2021-2022.				
Ground-active woodland birds					
Malleefowl *Leipoa ocellata*	Occupancy (%)	0	0	2020	Not detected in any survey year. No known active mounds within the project area.
Brown Treecreeper *Climacteris picumnus*	Occupancy (%) Abundance	0 0	5 2.5	2020-21	Not detected inside the fence. Pattern of decline through time for both occupancy and abundance.
Speckled Warbler *Pyrrholaemus sagittatus*	Occupancy (%) Abundance	10.0 3.3	12.5 9.2	2020-21	Occupancy similar inside/outside fence. Higher abundance outside fence.

Ecohealth Scorecard

Indicator	Metric (*definitions below table)	Value		Year	Comments
		Inside	Outside		
Turquoise Parrot *Neophema pulchella*	Occupancy (%) Abundance	10.0 3.3	0 0	2020-21	Only detected inside the fence in 2020-21. No clear trends through time.
Grey-crowned Babbler *Pomatostomus temporalis*	Occupancy (%) Abundance	20.0 6.7	7.5 10	2020-21	Higher occupancy inside the fence, but more abundant outside the fence. General decline in abundance since 2017.
Ground-active birds – guild	Richness Abundance	1.8 80.0	2.0 129.2	2020-21	Similar richness inside/outside fence. Higher abundance outside fence since 2018.
Bush Stone-curlew *Burhinus grallarius*	Surveys not conducted in 2020-21. Only detected during spotlight surveys to date.				
Frogs					
Amphibian surveys not conducted in 2020-21.					
Vegetation and habitat features					
Vegetation					
General vegetation surveys not conducted in 2020-21.					
Habitat features					
Habitat feature surveys not conducted in 2020-21.					
Threatened vegetation					
Diuris tricolor	Abundance Count	0.3 294	0.3 289	2020-21	Surveyed for first time in 2020-21. No difference inside/outside fence.
Pterostylis cobarensis	Abundance Count	0.1 151	0.1 147	2020-21	Surveyed for first time in 2020-21. No difference inside/outside fence.
Tylophora linearis	*T. linearis* surveys not conducted in 2020-21. Targeted surveys will be conducted when conditions suit.				
Commersonia procumbens	*C. procumbens* surveys not conducted in 2020-21. Targeted surveys will be conducted when conditions suit.				
Ecological processes					
Ecological process surveys not undertaken in 2020-21.					

* Definitions:

- Population estimate – number of individuals
- Abundance (mammals, reptiles, frogs) – total individuals recorded per 100 trap nights (mammals, reptiles, frogs)
- Abundance (birds) – individuals per 100 surveys
- Abundance (threatened vegetation) – total individuals per square metre searched. Sites selected based on target species presence.
- Total Richness – total number of species at Pilliga project area
- Richness – average number of species per site
- Occupancy – percentage of sites at which the species was detected

- Frequency – mean number of records per site (point intercepts/quadrats)

† Abundance survey effort 2020-21 (mammals) – 33% of sites were surveyed (n=20: 10 inside, 10 outside) using Elliott traps only to target Pilliga Mouse. No pitfall or funnel traps were deployed.

Threats/threat management metrics

Indicator	Metric (*definitions below table)	Value		Year	Comments on status and trend
		Inside	Outside		
Feral predators					
Cat	Activity	0.0 0.0	1.5 2.4	Autumn 2020 Spring 2020	Cats not detected inside fence (known to be eradicated). Small increase in both activity and occupancy outside the fence in 2020.
	Occupancy (%)	0 0	16 18	Autumn 2020 Spring 2020	
Fox	Activity	0.0 0.0	3.8 1.0	Autumn 2020 Spring 2020	Fox not detected inside the fence (despite one known to be present). Decline in both activity and occupancy outside the fence in spring 2020.
	Occupancy (%)	0 0	26 9	Autumn 2020 Spring 2020	
Feral herbivores					
Goat	Activity	1.1 0.0	0.3 1.1	Autumn 2020 Spring 2020	Declining activity & occupancy inside the fence – not detected in spring 2020. General decline in activity & occupancy outside the fence since autumn 2018; slight increase in both metrics between autumn and spring 2020.
	Occupancy (%)	16 0	4 12	Autumn 2020 Spring 2020	
Deer	Activity	0.0 0.0	0.9 0.3	Autumn 2020 Spring 2020	Not detected inside the fence in 2020. Consistently low activity & occupancy outside the fence.
	Occupancy (%)	0 0	10 3	Autumn 2020 Spring 2020	
Pig	Activity	0 0	0.4 0.8	Autumn 2020 Spring 2020	Not detected inside the fence in 2020. Consistently low activity & occupancy outside the fence; small increase in both metrics in spring 2020.
	Occupancy (%)	0 0	4 9	Autumn 2020 Spring 2020	
Rabbit	Activity	1.1 0.4	0.6 2.8	Autumn 2020 Spring 2020	Decline through time in activity and occupancy inside the fence. Consistently low activity & occupancy outside the fence but notable increase in both metrics in spring 2020.
	Occupancy (%)	11 5	4 17	Autumn 2020 Spring 2020	

Ecohealth Scorecard

Indicator	Metric (*definitions below table)	Value		Year	Comments on status and trend
		Inside	Outside		
Weeds					
Weed surveys not conducted in 2020-21.					
Fire					
Fuel reduction burn	Extent (ha) % of project area	1162 ha 3.2%		2020	Two fuel reduction burns of approximately 783 ha and 379 ha respectively were undertaken in spring 2020. The vegetation within both burn areas was predominantly unburnt.
	Severity	Low to moderate†			
	Seasonality	September (spring)			

* Definitions:

- Occupancy – percentage of sites at which the species was detected
- Activity – mean number of photo sequences per site in which the species was detected

† Fire severity was estimated using difference in normalised burn ratio (dNBR). 30 sites (stratified by mapped severity and vegetation type) within the burn footprints were then ground-truthed to determine the accuracy of the Landsat imagery used for the dNBR.

Ecohealth Scorecard

Operations Metrics: Activity

Activity	Value		Comments
	Inside	Outside	
Number of ignitions	0	0	
Planned fires (ha)	0	2	Two planned burns conducted in spring 2020
Goats removed	47	0	
Rabbits killed	0	0	
Pigs killed	0	0	
Cats killed	0	4	
Foxes killed	0	15	
Meat baits laid	0	0	
Meat baits taken	0	0	
CPE nights	300	0	
CPEs triggered	0	0	
Area of weeds treated (ha)	73	38	
Camera trap nights	34,405	0	
Tracks dragged (km)	1,586	0	
Cage trap nights	0	0	
Soft jaw trap nights	846	836	