Paruna Wildlife Sanctuary

Ecohealth Report 2020







australian wildlife conservancy

Summary

Australian Wildlife Conservancy (AWC) has implemented an Ecological Health Monitoring Program to measure changes in the status and trend of conservation assets, and threats to those assets, across Paruna Wildlife Sanctuary (Paruna). Metrics from the program are reported in annual Ecohealth Reports and Scorecards.

This is the Ecohealth Report for 2020. Metrics in this report were based on data collected during surveys carried out in 2020. The complete set of metrics and their values are summarised in the accompanying Ecohealth Scorecard.

Five surveys designed to monitor extant and reintroduced species were conducted in this reporting period. These include assemblage-level surveys of small mammals, reptiles, and birds; and targeted surveys of reintroduced species and key extant species.

The results showed that most small to medium indicator mammals have maintained low, but stable levels of occupancy. However, occupancy levels of Chuditch (Western Quoll) and Koomal (Brushtail Possum) have declined over recent years. Of the reintroduced species, the results show that Tammar Wallabies have successfully established at Paruna, likely benefitting from ongoing cat and fox control. However, the reintroduced population of Black-flanked Rock-wallaby abundance remains small and may require enhanced protection from cats and foxes.

The three threatened species of Black Cockatoo in the region were detected on 45% to 65% of survey sites. Diurnal Bird Surveys detected a total of 46 species, averaging ~15 species per site.

The survey results also found an ongoing decline in the occurrence of feral predators and herbivores on the property, reflecting the extensive control efforts directed at these species by AWC's Paruna operations staff.

Contents

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Cover photographs: (clockwise from left): Fringed lily, Queen Triggerplant, Pink Enamel Orchid, Slender Coral Fungus (C Moir/AWC), Black Cockatoo (M Smith/AWC), Honey Possum and Dwarf Bearded Dragon (N Palmer/AWC).

Introduction

Australian Wildlife Conservancy (AWC) owns, manages, or works in partnerships across 30 properties in Australia, covering almost 6.5 million hectares, to implement our mission: *the effective conservation of Australian wildlife and their habitats*. AWC relies on information provided by an integrated program of monitoring and research to measure progress in meeting its mission and to improve conservation management.

AWC's Ecohealth Monitoring Program has been designed to measure and report on the status and trends of species, ecological processes and threats on each of these properties (Kanowski et al. 2018). The program focuses on selected 'indicator' species, guilds, processes and threats, using metrics derived from data collected through a series of purpose-designed surveys. The structure of the Ecohealth Program on each AWC property is as follows. Based on the guidance provided by AWC's over-arching program framework, Ecohealth Monitoring Plans (under development) are developed, describing the conservation values or assets of each property, and threats to these assets. In addition, the Ecohealth Monitoring Plans set out the monitoring program that will be used to track the status and trend of selected indicators of these conservation assets and threats. Annual survey plans and schedules are developed to implement these plans. The outcomes of these surveys are presented in annual Ecohealth Reports and summary Ecohealth Scorecards.

This document, the Paruna Wildlife Sanctuary Ecohealth Report 2020, draws on surveys conducted during 2020 to calculate values for metrics that track the status and trend of the Ecohealth indicators. The companion Paruna Ecohealth Scorecard 2020 presents these metrics in a summary format.

Paruna Wildlife Sanctuary

Paruna Wildlife Sanctuary is a 1,952 ha property in the Avon Valley approximately 60 km north east of Perth. Paruna is within the traditional lands of the Noongar people. It is bordered by two regionally significant national parks – Walyunga National Park to the west, and Avon Valley National Park to the east. The Avon-Swan River forms much of the property's northern border (Figure 1).

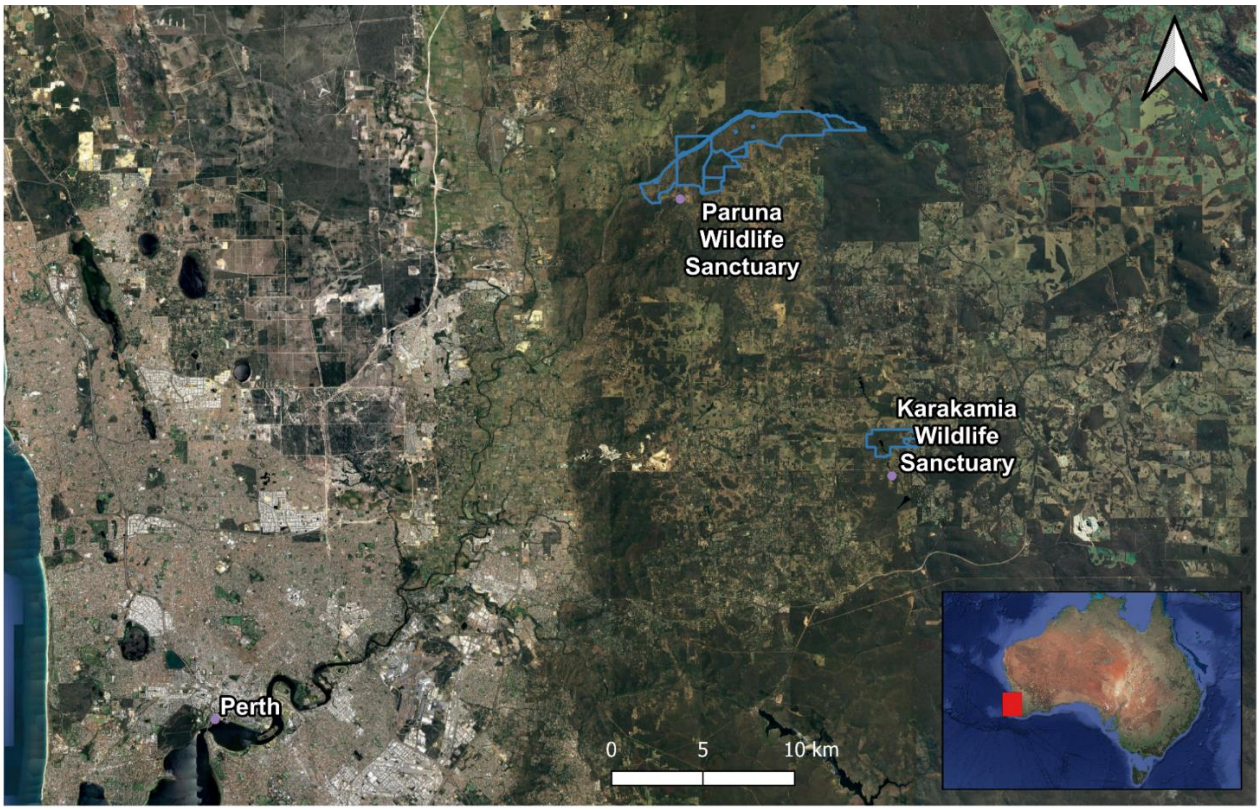

Figure 1. Location and regional context of Paruna Wildlife Sanctuary and Karakamia Wildlife Sanctuary. Inset indicates location within Australia.

Paruna features nine broad vegetation types (Figure 2) with the property dominated by woodlands of Wandoo (*Eucalyptus wandoo*), Jarrah (*Eucalyptus marginata*), Marri (*Corymbia callophylla*) and Powderbark Wandoo (*Eucalyptus accendens*) interspersed with large areas of shrublands.

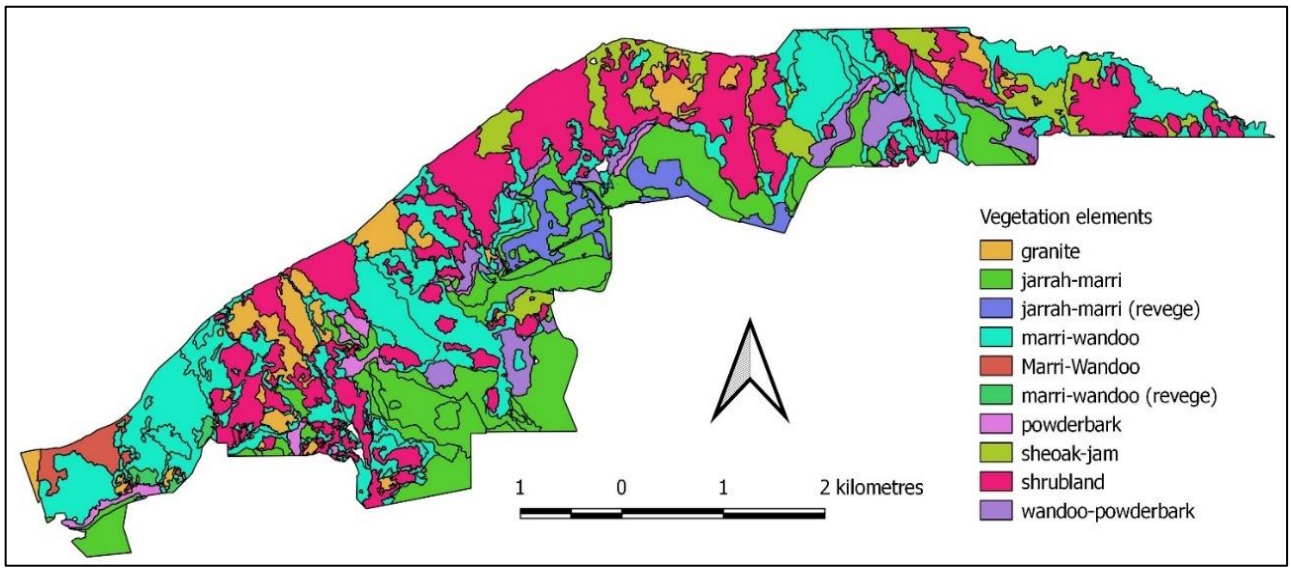

Figure 2. Broad vegetation types at Paruna Sanctuary.

Around 140 bird species, 12 frog species, 24 native mammal species and 47 reptile species are confirmed or considered likely to occur at Paruna. Extensive control efforts for feral cats (*Felis catus*), red foxes (*Vulpes vulpes*), pigs (*Sus scrofa*), goats (*Capra hircus*) and rabbits (*Oryctolagus cuniculus*) have allowed for the reintroduction of the nationally endangered Black-flanked Rock-wallaby (*Petrogale lateralis*), as well as populations of the Tammar Wallaby (*Macropus eugenii*), Southern Brown Bandicoot (Quenda; *Isoodon obesulus*) and Brushtail Possum (Koomal; *Trichosurus vulpecula*). The sanctuary also supports extant populations of other threatened species including the Western Quoll (Chuditch; *Dasyurus geoffroii*), Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*; nationally vulnerable), Baudin's Black Cockatoo (*Zanda baudinii*; nationally vulnerable) and Carnaby's Black Cockatoo (*Z. latirostris*; nationally endangered) as well as iconic small mammals such as the Honey Possum (*Tarsipes rostratus*) and Western Pygmy Possum (*Cercartetus concinnus*).

Climate and weather summary

Paruna experiences a Mediterranean climate with warm, dry summers and cool, wet winters (Figure 3). Annual average maximum temperatures have been steadily increasing over the past 120 years (Figure 4), with the 2020 average maximum temperature 1.0°C warmer than the preceding long-term (1900-2019) average.

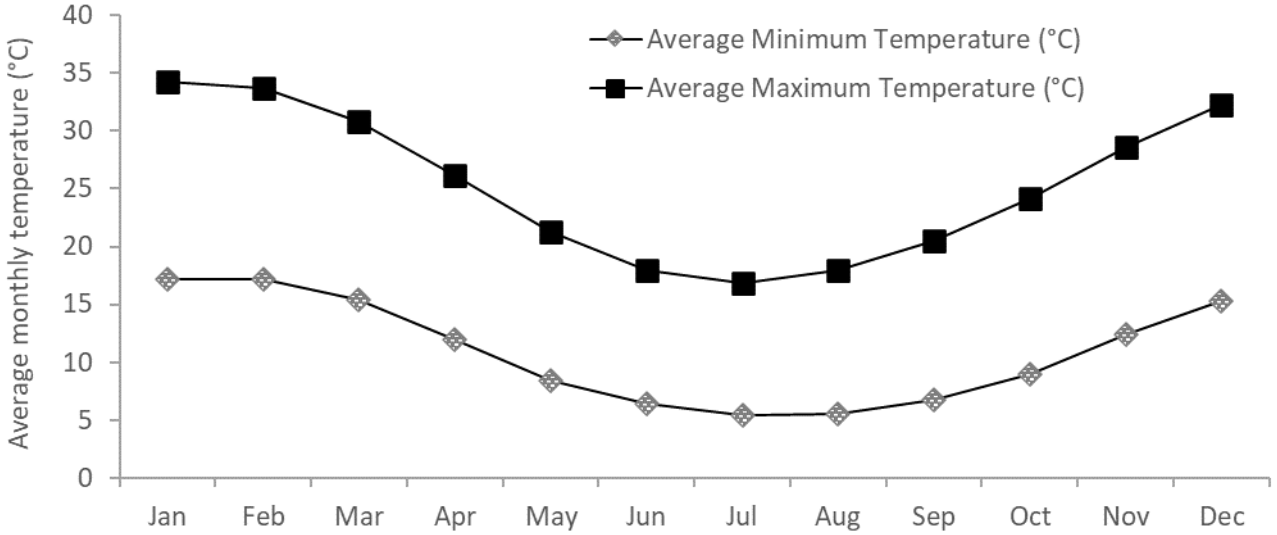

Figure 3. Mean minimum and mean maximum monthly temperature at Northam Monitoring Station, 1902-2020 (BOM Station No. 010111). Source: BOM Climate Data Online.

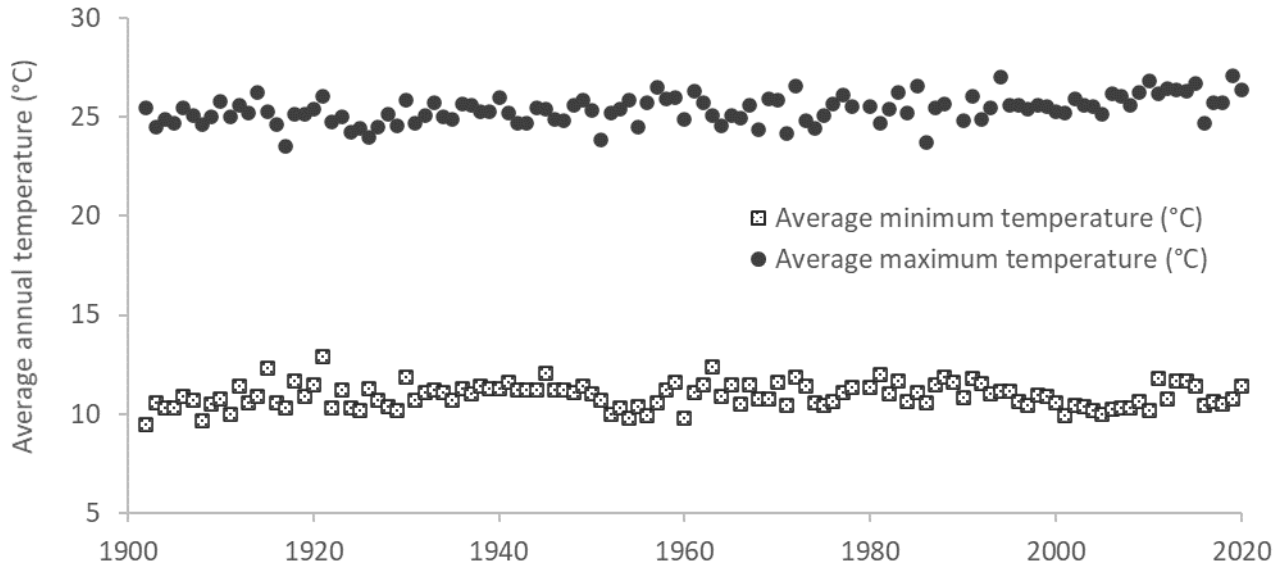

Figure 4. Mean minimum and mean maximum annual temperature at Northam Monitoring Station (1902-2020; BOM Station No. 010111). Source: BOM Climate Data Online.

Total annual rainfall has steadily decreased since 1908 (Figure 5), and total monthly rainfall in 2020 was predominantly below average, particularly in winter months (Figure 6). In 2020, total annual rainfall (674 mm) was well below the long-term average (797 mm, 1908-2019).

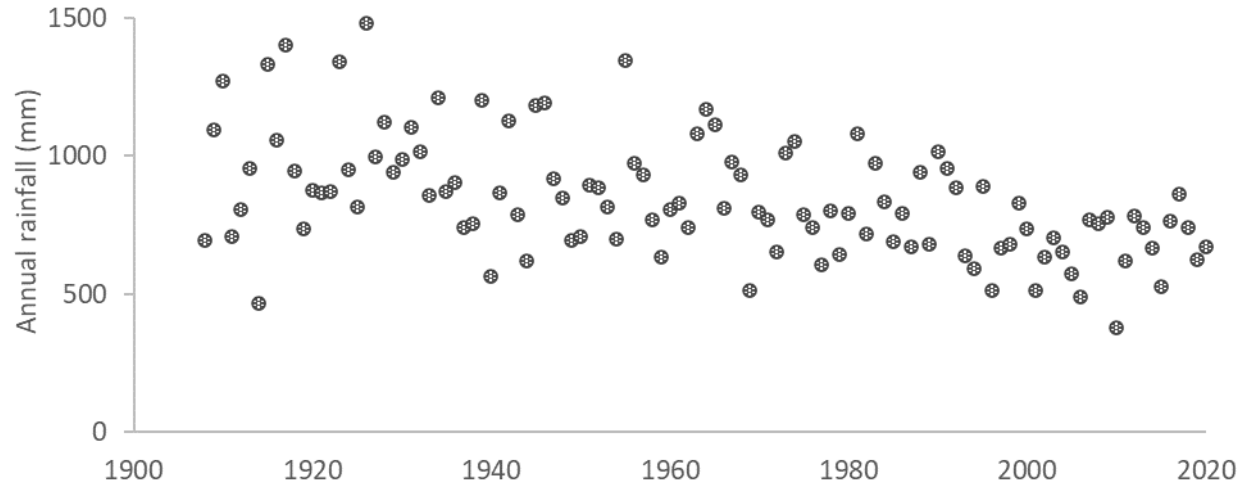

Figure 5. Annual rainfall at Chidlow, 1908-2020 (BOM Station 009007). Source: BOM Climate Data Online.

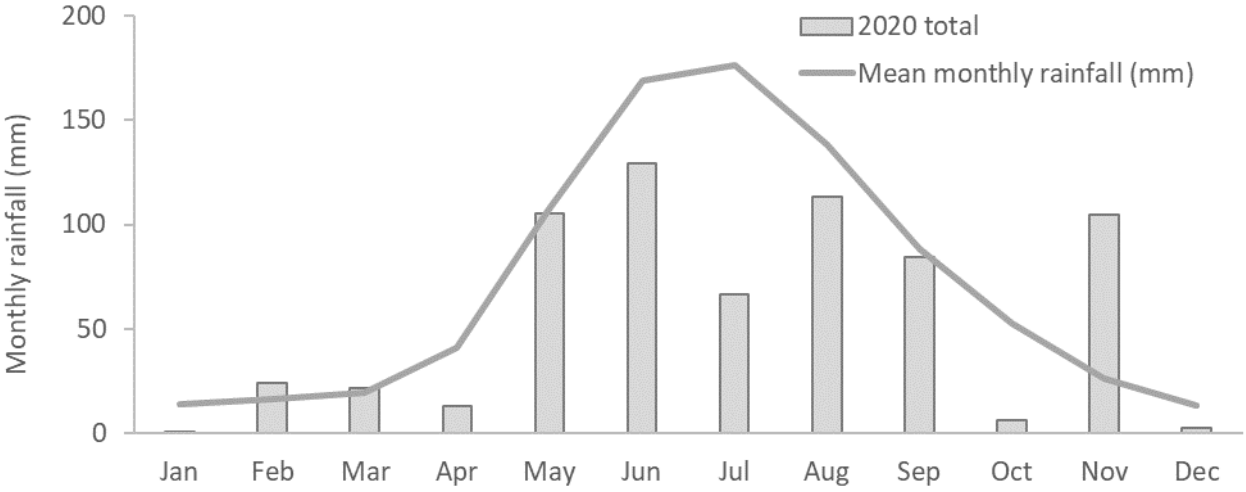

Figure 6. Rainfall in 2020 compared with mean monthly rainfall at Chidlow, 1908-2020.

Methods

Indicators and metrics

Paruna's Ecohealth Monitoring Program has been designed to measure and report on the status and trends of species and threats on the sanctuary. The program focuses on selected biodiversity and threat indicators, using metrics derived from data collected through a series of purpose-designed surveys. A selection of species or guilds were chosen as biodiversity indicators which fit into one or more of the following categories: (1) declining and/or threatened species or guilds, (2) strong drivers of ecosystem function, or (3) are a member of the full range of taxa (to enable ongoing surveillance monitoring of a range of taxonomic groups to provide early warning of any unexpected declines).

In 2020, 22 of 24 biodiversity indictors (species and guilds) are reported on; the rationale for their selection is recorded for each indicator in Table 1. Threat metrics are selected to ensure monitoring the status and trends of introduced weeds, predators and herbivores and changed fire regimes (where appropriate). In 2020, 9 of 10 threat metrics are reported on (Table 2).

Table 1. Wildlife indicators for Paruna's Ecohealth Monitoring Program. Rationale for selection: T = threatened, declining, vulnerable, or rare; D = strong driver of ecosystem function; S = surveillance monitoring. Metric definitions: Population size = estimate of number of individuals; Occupancy = proportion of sites detected; Species richness = average number of species detected at each site.

Indicator	Rationale			Survey method	Metric/s
	T	D	S		
Mammals					
Small-medium mammals					
Southern Brown Bandicoot (Quenda*; Isoodon obesulus*)		*	*	Sanctuary-wide Camera Survey	Occupancy
Grey-bellied Dunnart (*Sminthopsis griseoventor*)		*	*	Standard Trapping Survey	Occupancy
Western Quoll (Chuditch; *Dasyurus geoffroii*)	*	*	*	Sanctuary-wide Camera Survey	Occupancy
Short-beaked Echidna *(Tachyglossus aculeatus)*		*	*	Sanctuary-wide Camera Survey	Occupancy
Medium sized mammals					
Black-flanked Rock-wallaby (*Petrogale lateralis*)	*	*	*	Targeted Survey	Population size
Tammar Wallaby (*Macropus eugenii*)		*	*	Sanctuary-wide Camera Survey	Occupancy
Black-gloved Wallaby (*Macropus irma*)		*	*	Sanctuary-wide Camera Survey	Occupancy
Western Grey Kangaroo (*Macropus fuliginosus*)			*	Sanctuary-wide Camera Survey	Occupancy
Arboreal mammals					
Common Brushtail Possum (Koomal; *Trichosurus vulpecula*)		*	*	Sanctuary-wide Camera Survey	Occupancy

Indicator	Rationale			Survey method	Metric/s
	T	D	S		
Western Pygmy Possum (*Cercartetus concinnus*)		*	*	Standard Trapping Survey	Occupancy
Honey Possum (*Tarsipes rostratus*)		*	*	Standard Trapping Survey	Occupancy
Bats					
White-striped free-tailed bat (*Austronomus australis*)		*	*	Acoustic Recording	Occupancy. Data under analysis.
Reptiles					
Small reptiles					
Buchanan's Snake-eyed Skink (C*ryptoblepharus buchananii*)		*	*	Standard Trapping Survey	Occupancy
South-western Orange-tailed Slider (*Lerista distinguenda*)		*	*	Standard Trapping Survey	Occupancy
Common Dwarf Skink (*Menetia greyii*)		*	*	Standard Trapping Survey	Occupancy
Marbled Gecko (*Christinus marmoratus*)		*	*	Standard Trapping Survey	Occupancy
Barking Gecko (*Underwoodisaurus milii*)		*	*	Standard Trapping Survey	Occupancy
Small reptile guild				Standard Trapping Survey	Richness
Medium reptiles					
Bobtail (*Tiliqua rugosa*)		*	*	Standard Trapping Survey (camera trapping)	Occupancy
Birds					
Black-cockatoos					
Red-tailed Black-cockatoo (*Calyptorhynchus banksia*)	*	*		Targeted Survey	Occupancy
Carnaby's Black-cockatoo (*Zanda latirostris)*	*	*		Targeted Survey	Occupancy
Baudin's Black-cockatoo (*Zanda baudinii)*	*	*		Targeted Survey	Occupancy
Other					
Diurnal birds		*	*	Diurnal Bird Survey	Richness
Amphibians					
Frogs		*	*	Acoustic Recording	Occupancy. Data under analysis.

Table 2. Threat indicators for Paruna's Ecohealth Monitoring Program

Indicator	Rationale	Survey method	Metric/s
Introduced predators			
Feral cat (*Felis catus*)	Predation by cats is a major threatening process for wildlife.	Sanctuary-wide Camera Survey	Occupancy
Red fox (*Vulpes vulpes*)	Predation by foxes is a major threatening process for wildlife.	Sanctuary-wide Camera Survey	Occupancy
Introduced herbivores			
Rabbit (*Oryctolagus cuniculus*)	Threat to wildlife, vegetation	Sanctuary-wide Camera Survey	Count
Goat (*Capra hircus*)	Threat to wildlife, vegetation	Sanctuary-wide Camera Survey	Count
Pig (*Sus scrofa*)	Threat to wildlife, vegetation	Sanctuary-wide Camera Survey	Count
Sheep (*Ovis aries*)	Threat to wildlife, vegetation	Sanctuary-wide Camera Survey	Count
Fallow Deer (*Dama dama*)	Threat to wildlife, vegetation	Sanctuary-wide Camera Survey	Count
House mouse (*Mus musculus*)	Threat to wildlife, vegetation	Standard Trapping Survey	Occupancy
Weeds			
Weeds	Threat to wildlife, vegetation	Mapping	TBD. Not surveyed 2020
Fire			
Fire	Inappropriate fire regimes are a threat to vegetation and wildlife.	Mapping	Extent of planned and unplanned burns (ha)

Survey types and history

Five surveys were conducted on Paruna in 2020, to enable the reporting on the status and trends of 22 biodiversity and 9 threat indicators (Table 3). Surveys consisted of a Standard Trapping Survey (for small-medium mammals and reptiles), a Sanctuary-wide Camera Survey (for medium to large mammals and feral species), a targeted live-trapping survey for Black-flanked Rock-wallabies, a Diurnal Bird Survey (for terrestrial birds), and a Black Cockatoo Survey. In addition to ground-based ecological surveys, analysis of sanctuary-wide satellite data are conducted for the Fire Scar Analysis.

Table 3: Survey effort for Ecohealth Monitoring Program surveys on Paruna in 2020

Survey name	Description/comment	Survey history	Effort in 2020
Standard Trapping Survey	20 sites surveyed over 3 days. Each site contained 8 pitfall traps, 12 funnel traps, 20 Elliott traps, and 2 cage traps. 40 camera traps deployed across 20 sites over 28 consecutive days (2 cameras per site).	2019 – 18 sites 2020 – 20 sites	3,246 live trap nights 702 camera trap nights
Black-flanked Rock-wallaby Survey	4 nights trapping at 3 outcrop locations with a total of 40 Thomas traps.	2010 – 2014 – 20 traps 2015 – 2018 – 40 traps 2019 – 2020 – 40 traps	160 trap nights
Sanctuary-wide Camera Survey	175 sites surveyed with lured camera traps (1 camera per site, 2 bait cannisters per site)	2016 – 72 sites 2017 – 172 sites 2018 – 164 sites 2019 – 176 sites 2020 – 175 sites	2,381 trap nights
Diurnal Bird Survey	20 sites surveyed over 4 days, 2 ha 20 minute	2020 – 20 sites	80 surveys
Black Cockatoo Survey	20 sites surveyed seasonally	2020 – 20 sites 8 sites (winter) 12 sites (autumn) 20 sites (winter) 14 sites (spring)	54 surveys

Survey design and methods

Standard Trapping Survey

The Paruna Standard Trapping Survey occurs biennially and consists of a live-trapping survey for small mammals and reptiles, and camera monitoring. Vegetation type was used to stratify the 20 Standard Trapping Survey sites at Paruna (Figure 7). The 20 sites are situated across four major vegetation types: Jarrah-Marri (n = 5), Wandoo-Marri (n = 5), cleared-revegetated (n = 5) and shrubland (n = 5). Sites are separated by a minimum of 400 m and all sites are at least 100 m from roads or tracks.

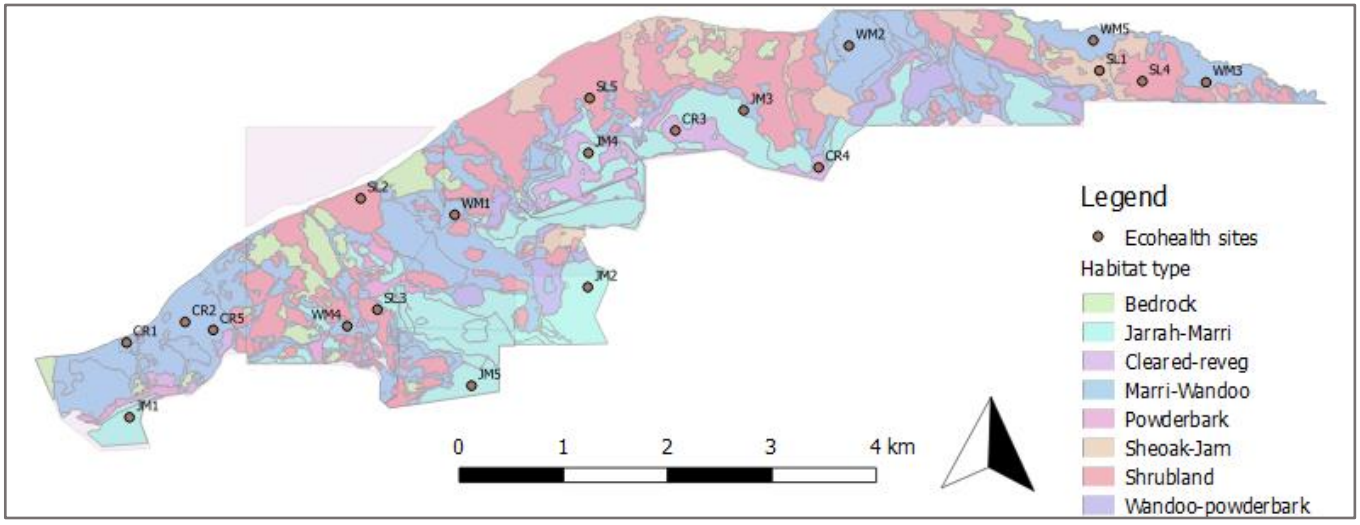

Figure 7. Map of Standard Trapping Survey sites at Paruna.

The live-trapping component of the Standard Trapping Survey comprised pitfall, funnel, box (Elliott) and cage trapping for small mammals and reptiles. At each site (n = 20), two trapping arrays were constructed (Figure 8). Each array consisted of 30 m of drift fencing (20 m long edge, 10 m short edge) in a T-shape, six funnel traps, and four pitfall bucket traps. 20 Elliott traps were placed around the perimeter of the site (five traps on each side, spaced 10 m apart). Two cage traps were placed at opposite corners of the site. Cage and Elliott traps were baited with universal bait (peanut butter, oats, and sardines).

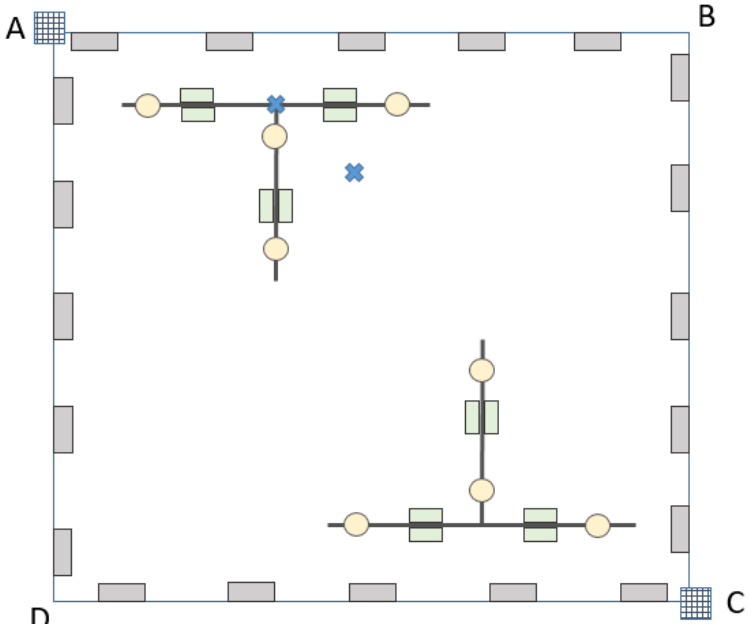

Figure 8. Paruna standard trapping survey live, and camera trapping set up. Black lines depict drift fences, yellow circles pitfall traps, green rectangles funnel traps, blue crosses camera traps, grey rectangles box traps and hatched square cage traps.

Funnel and pitfall traps were open for the duration of the trapping and were cleared twice daily (early morning and late afternoon). Cage and Elliott traps were opened in the late afternoon and cleared and closed in the morning.

Following the completion of four nights of live trapping, the camera trap array was constructed. A small gap was created in the drift fence at the centre of one 'T' array. A cork tile was placed into the gap and a camera was placed 'horizontally' above the cork tile at 1 m height. A second 'vertical' camera was placed ~2 m from the from the cork tile, facing toward the cork tile and baited cannister, at a height of 20 cm.

Cameras were programmed to take three images per trigger with no quiet period between triggers and remained in-situ for 17-18 days, depending on the site.

Black-flanked Rock-wallaby Survey

The Black-flanked Rock-wallaby trapping survey monitors the species' population size. The survey has been conducted annually. Trapping sites (n = 40 traps) are restricted to three granite outcrops in which the species has been detected (Figure 9): the original translocation release site, an outcrop 1.5 km to the west and a more recently (2019) established site within a gorge between the other sites.

A total of 40 Thomas traps were deployed at three outcrops for three nights where Black-flanked Rock-wallaby are known or likely to occur (Figure 10). One outcrop (the main outcrop) contained 20 traps, whilst the second outcrop and gorge site contained 10 traps each. Traps were wired open and pre-baited with chaff, apple and dairy crave for two weeks prior to trapping. During the three nights of trapping, traps were opened in the late afternoon and cleared at first light the following morning. Captured individuals were processed and the following data were recorded: microchip, weight, sex, age, pouch condition and pes length.

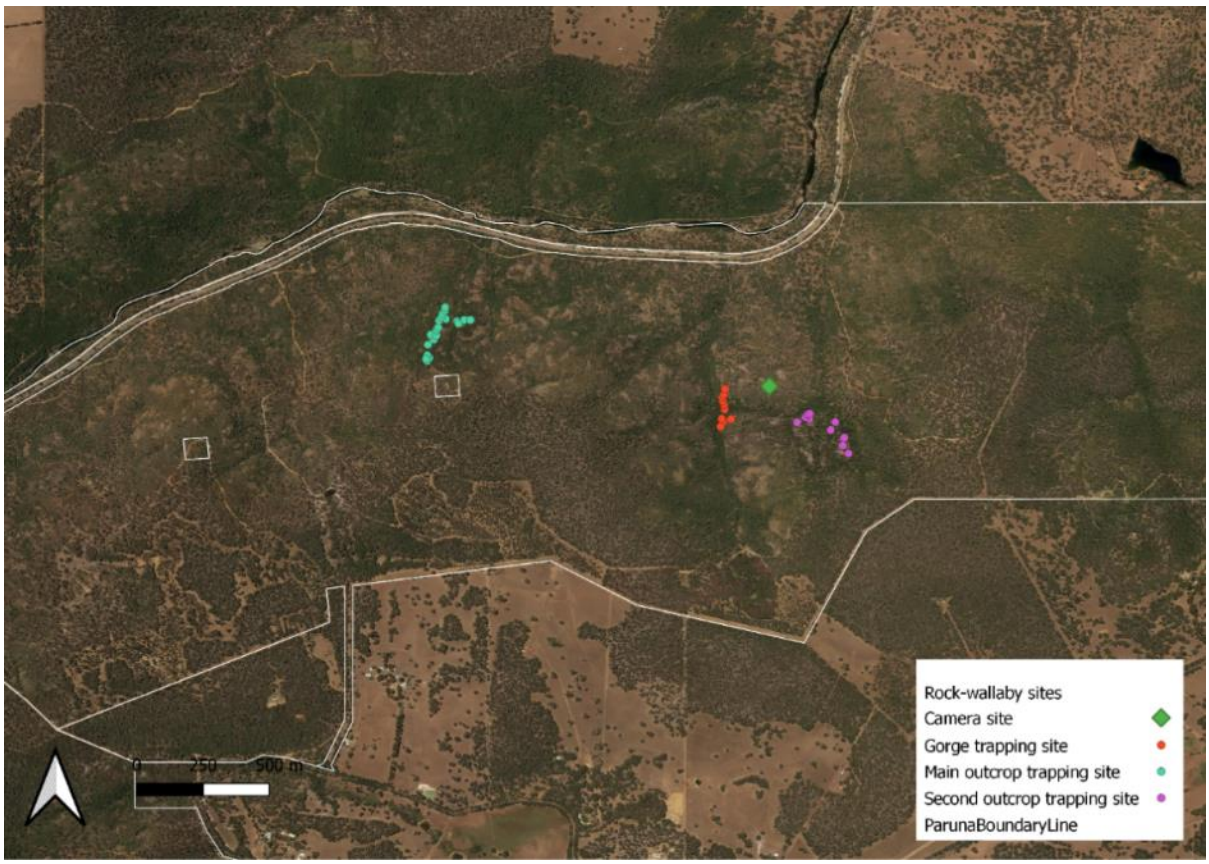

Figure 9. Black-flanked Rock-wallaby trapping sites at Paruna. Aqua circles = "main" outcrop; orange-red circles = "gorge" site; purple circles = "second" outcrop. The green diamond represents a previous Rock-wallaby detection on a camera trap.

Figure 10. Black-flanked Rock-wallaby trapping locations on Paruna. Red circles depict the individual trapping sites.

Sanctuary-wide Camera Survey

The Sanctuary-wide Camera Survey is used to monitor the occupancy of the native Chuditch, Tammar Wallaby, Koomal, Quenda, Western Grey Kangaroo, Black-gloved Wallaby and Short-beaked Echidna, and feral predators and feral herbivores including cats, foxes, rabbits, black rats, goats, pigs, sheep and deer. The camera array consists of 175 locations stratified by major habitat type and burn management areas (Figures 11 and 12). Cameras were deployed in a roughly equal pattern with one camera per 10 ha.

A total of 175 sites were surveyed in the Sanctuary-wide Camera Survey. Cameras were deployed at each site for 12-14 days, between May and July, divided into three rounds. Up to 60 cameras were deployed at one time. Each camera trapping site consisted of a single Reconyx white-flash camera (PC850 Hyperfire Pro White Flash) affixed to a fence dropper or tree at a height of 50 cm. The camera faced two lured canisters, one with cooked chicken, the other with apple and dairy crave. The cannisters were attached to a short fence dropper approximately 2 m from the camera. Cameras were programmed to take 3 images per trigger with no quiet period between triggers.

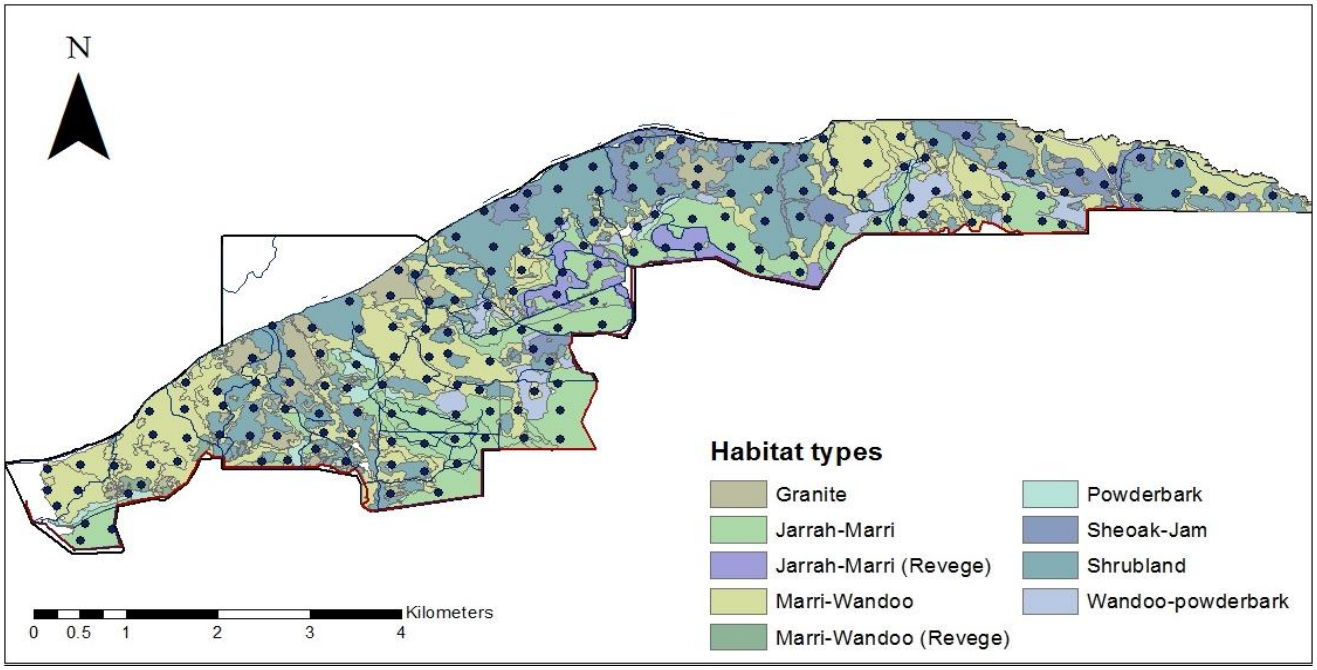

Figure 11. Sanctuary-wide Camera Survey camera trap locations (circles) in relation to major habitat types on Paruna

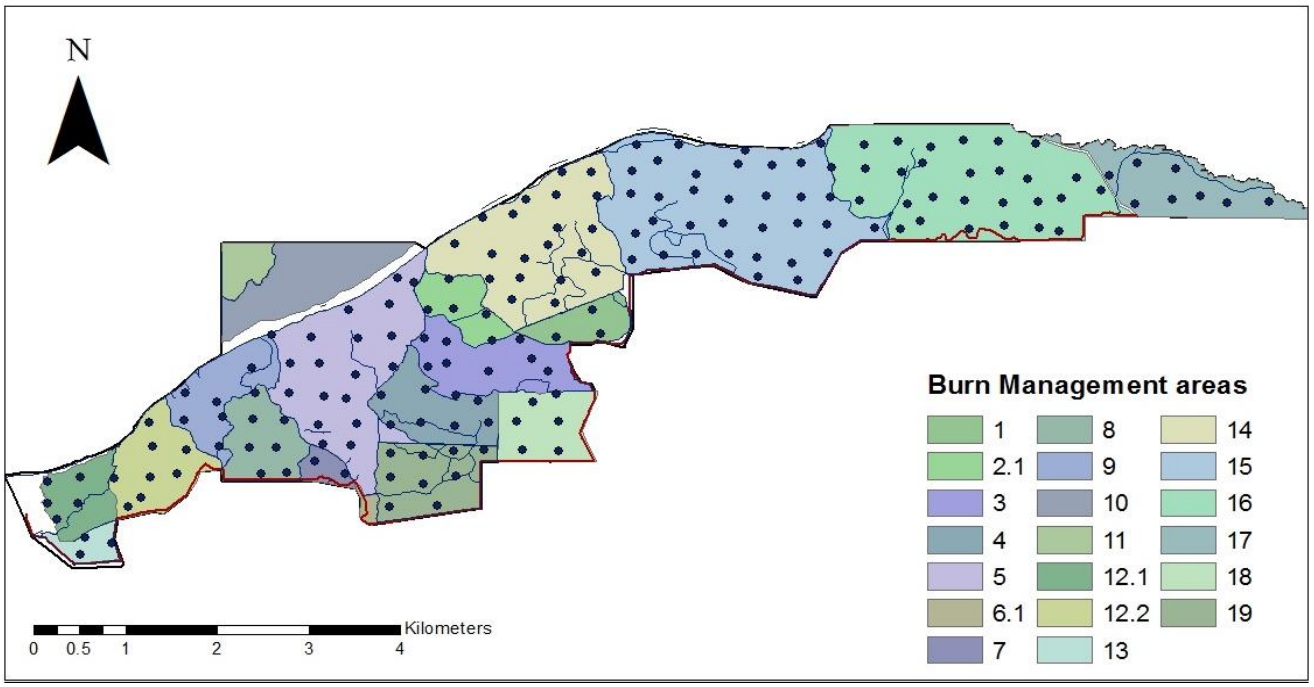

Figure 12. Sanctuary-wide Camera Survey camera trap locations (circles) in relation to burn management areas on Paruna

Diurnal Bird Survey

Diurnal Bird Surveys are conducted at the 20 Standard Trapping Survey sites. Bird surveys were repeated over four days. Bird surveys followed the 2 ha 20 minute search standard (Loyn 1986) consistent with BirdLife Atlas survey methods using a circular area with a radius of 80 m (Figure 13). Surveyors spent 20 minutes meandering throughout the site, always remaining within 80 m of the centre point. All bird species observed during the 20 minutes were recorded along with the method of observation (seen, heard or flyover).

The survey was conducted over four days by three teams, consisting of at least one AWC ecologist. Surveys commenced at dawn. The primary surveyor changed sites each day to minimise observer bias. The 20 sites were surveyed each day in a prescribed order, with the order of sites reversed every second day to minimise possible time-of-day or temperature bias.

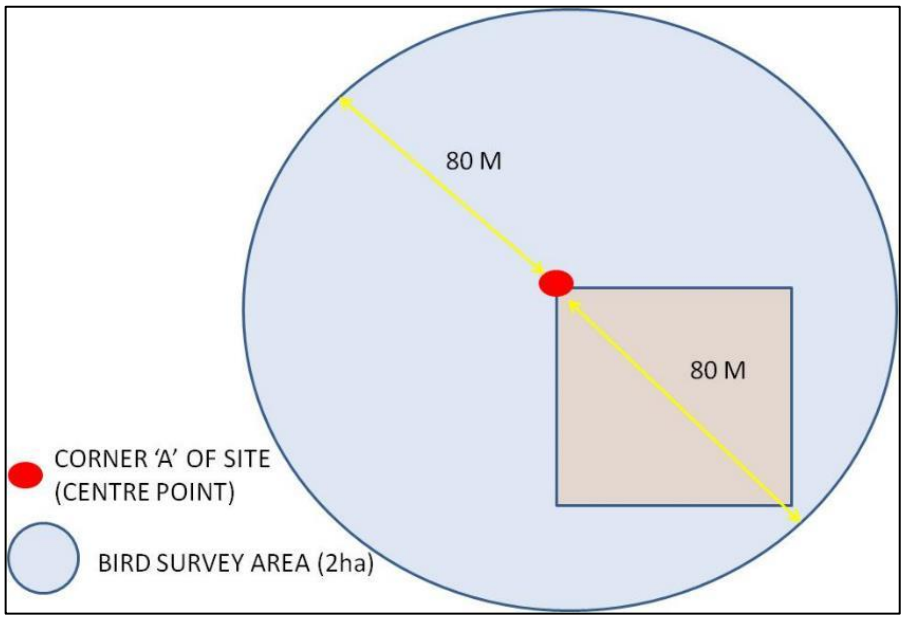

Figure 13. The standardised 2-ha bird survey site layout

Black Cockatoo Survey

The objective of this survey is to confirm the occupancy of, and habitat use by, threatened Black Cockatoo species at sites, by searching for Marri nuts with distinctive feeding signs. Three threatened species rely on Marri nuts as an important food source: Forest Red-tailed Black Cockatoo, Baudin's Black Cockatoo and Carnaby's Black Cockatoo. Searches for feeding signs were conducted at up to 20 sites, comprised of eight dams, Figure 14).

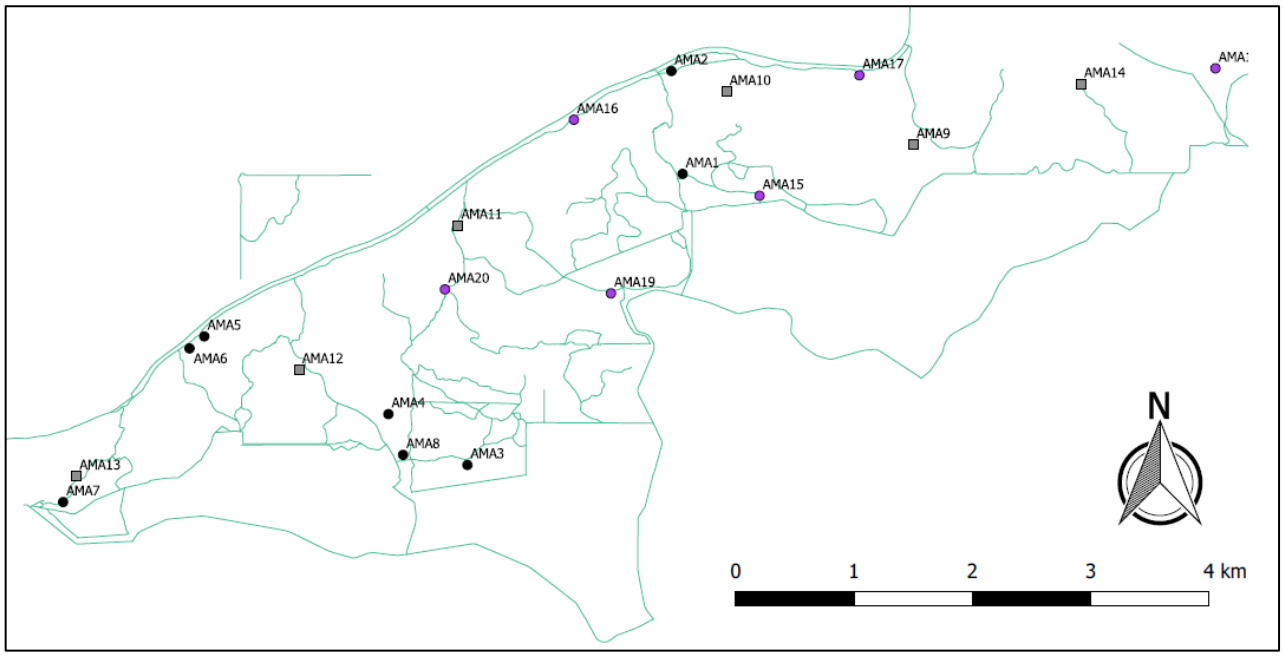

Figure 14. Map of Black Cockatoo Survey sites on Paruna. Black circles represent dams, squares rocky outcrops and purple circles ephemeral creeks, seeps or swamps.

A search was undertaken for Marri nuts on the ground. Differences in mandible size between the species produce noticeably different feeding marks on the nuts, which were examined to determine a species' presence (Figure 15; Fleming 2018). Searches were conducted by a single staff member and concentrated on ground under Marri trees where possible. All species identified from feeding signs were recorded, as was the freshness of the nuts (green, red/brown, brown/grey).

Figure 15. Marri nuts with distinctive feeding markings present

Analysis methods

Small and arboreal mammals, reptiles and house mouse

Live trapping data from the Standard Trapping Survey were used to calculate occupancy (proportion of sites at which each species was detected) for native small mammals and reptiles, and the introduced house mouse. Data from these surveys were also used to calculate richness for the small reptile guild as the average number of small reptile species detected at each site.

Medium sized mammals, macropods, and feral predators and herbivores

Occupancy for each species was calculated as the proportion of sites of the Sanctuary-wide Camera Survey at which that species was detected.

Black-flanked Rock-wallaby

Population estimates were generated using Spatially Explicit Capture-Recapture methods (Efford and Fewster 2013). Package OSCR (Sutherland et al. 2019) run within R software (R Core Team 2013) was used (Australian Wildlife Conservancy (2021a)).

Diurnal birds

Data from terrestrial bird surveys (2 ha plots) were used to calculate the average number of species detected at each site and across all sites during the four-day survey period.

Black Cockatoos

The proportion of sites detected (occupancy) was calculated for each of the three Black Cockatoo species at Paruna.

Results

Biodiversity indicators

Small-medium mammals

Small and arboreal mammals

Three native small mammals were captured in pitfalls during the 2020 Standard Trapping Survey (Figure 16). Of these, only the Western Pygmy Possum was also captured during the 2019 survey.

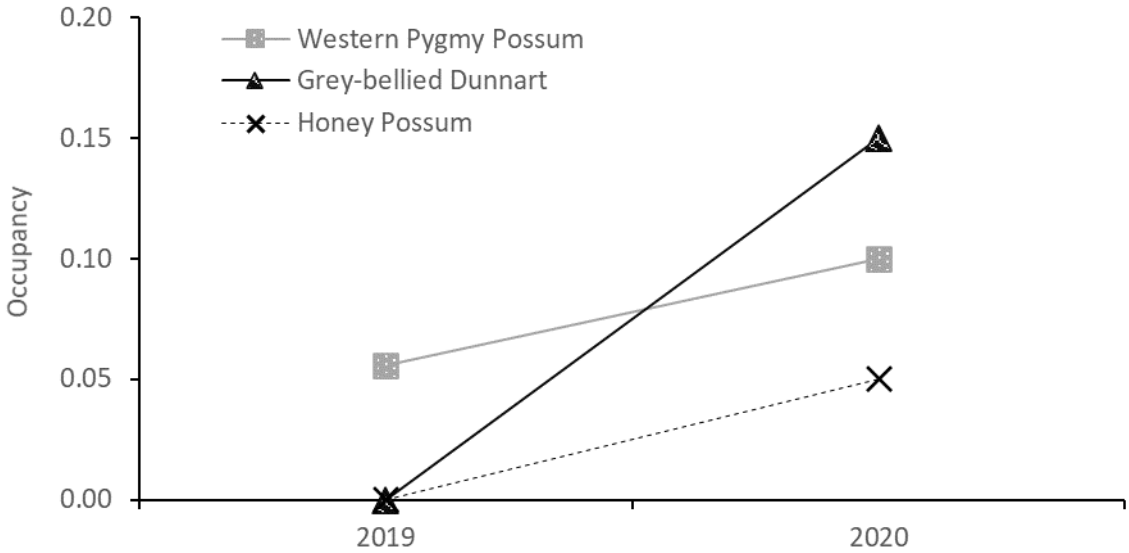

Figure 16. Proportion of sites where Western Pygmy Possum, Grey-bellied Dunnart, and Honey Possum detected in trapping surveys at Paruna, 2019-2020

Medium sized mammals

One breeding male Koomal and one breeding male Chuditch were captured during the 2020 live trapping survey. No Quenda were captured.

In the 2020 Sanctuary-wide Camera Survey, there were 18 Quenda detections, 9 Chuditch detections, and 4 Koomal detections. Comparison with results from surveys conducted since 2016 (Figure 17) show that Chuditch and Koomal detections have varied over the years, with a decline since 2018, whereas Quenda detections have remained stable over the last few years.

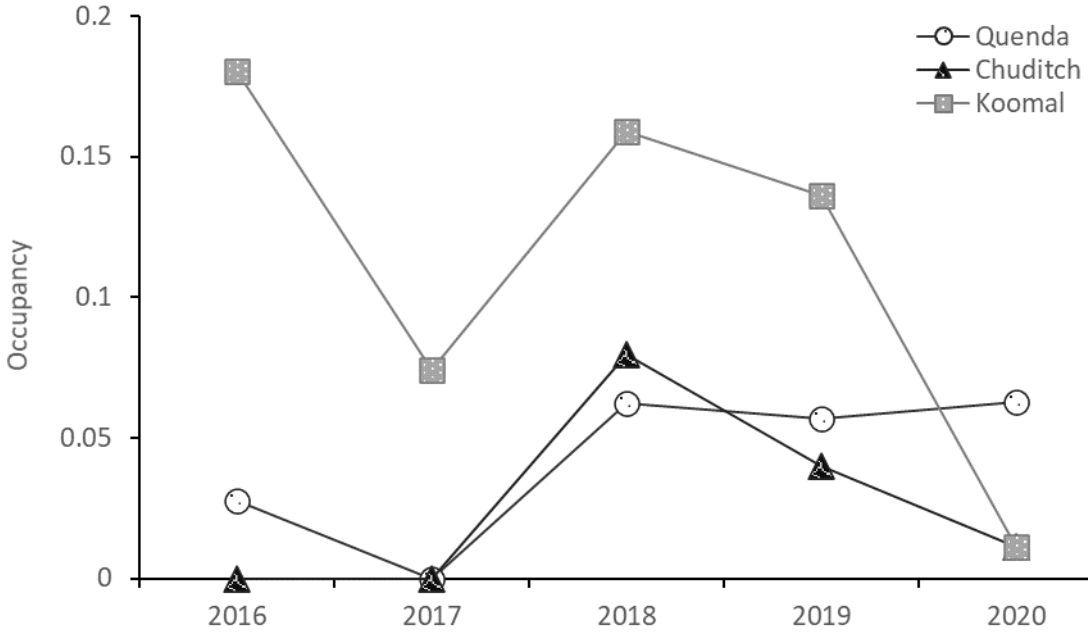

Figure 17. Proportion of sites where Quenda, Chuditch and Koomal were detected in the Sanctuary-wide Camera Survey, 2016-2020

There were 105 detections of Echidna during the 2020 Camera Survey. Detections of the Echidna have increased since 2017, although not to the levels detected in 2016 (Figure 18).

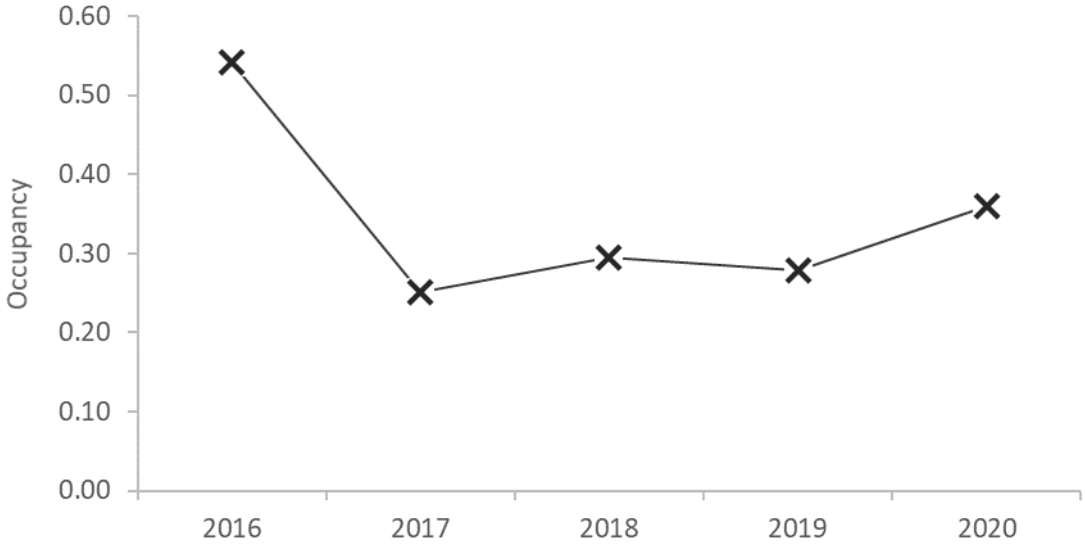

Figure 18. Echidna occupancy (proportion of sites detected) over the period 2016-2020

Medium-large mammals

Macropods: Tammar Wallaby, Black-gloved Wallaby, Western Grey Kangaroo

In 2020, there were 96 detections of Tammar Wallaby in the Camera Survey, including 12 ear-tagged individuals (i.e., individuals that were translocated from Karakamia). There were only 4 detections of Black-gloved Wallaby. Detections of Western Grey Kangaroo remain high, with the species recorded at ~50% of sites. The results show that the proportion of sites occupied by medium-large mammals declined from 2016 to 2017; detections appear to have stabilised subsequently (Figure 19).

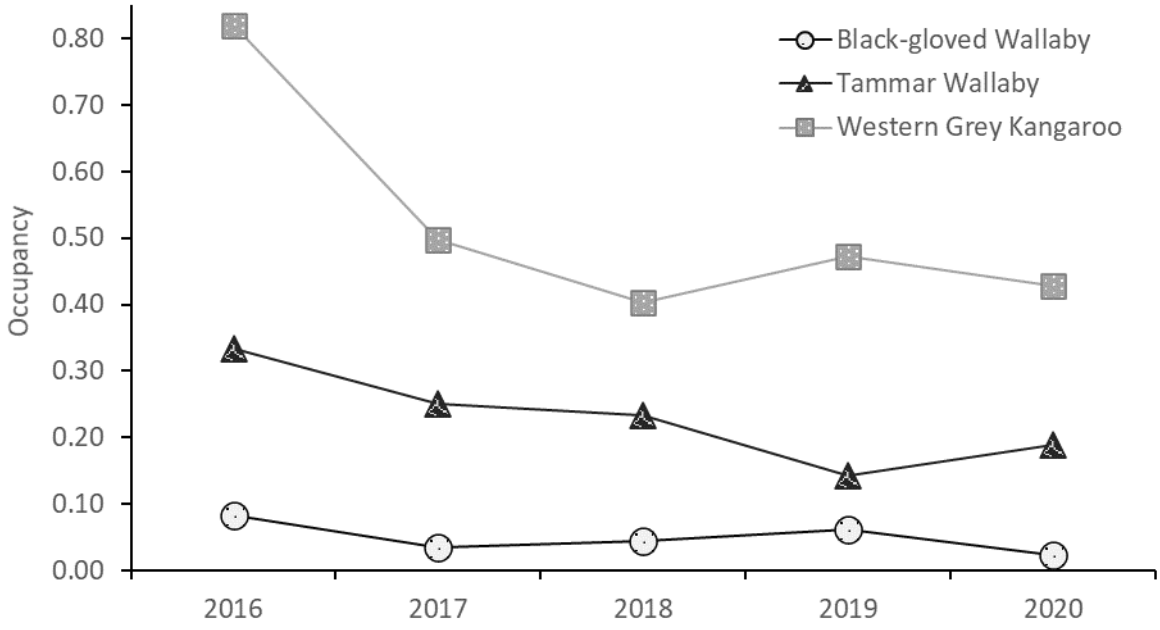

Figure 19. Occupancy (proportion of sites detected) for medium-large macropods (Tammar Wallaby, Black-gloved Wallaby, Western Grey Kangaroo) over the period 2016-2020

Black-flanked Rock-wallaby

In 2020, there were 18 captures of 8 individuals Black-flanked Rock-wallabies. Three new individuals were captured, including two subadults (both males), and all three of the captured females had pouch young or were lactating. Six individuals were captured at the "main" outcrop (the original translocation release site), and the remaining two were captured in the "gorge" site (see Figure 9). No individuals have been trapped at the "second" outcrop since a single male was captured at this site in 2018. Individuals GPS-collared in 2019 were also shown to not visit this outcrop, however, a single Black-flanked Rock-wallaby was detected during

the Camera survey between the "gorge" and "second" outcrop sites (see Figure 9). The Black-flanked Rock-wallaby scat distribution survey is due to be conducted in 2021. This survey is expected to reveal further information on the distribution of the species on Paruna.

Based on trapping results, the rock-wallaby population size was estimated to be 17 individuals. The estimated population size has varied between 10 and 25 individuals over the past decade (Figure 20). The relatively substantial confidence intervals around estimates are a product of the analysis method; a simpler mark-recapture estimate may be more appropriate in this species, given that trapping is conducted around day refuges, rather than across home ranges (as assumed by spatially-explicit capture-recapture methods).

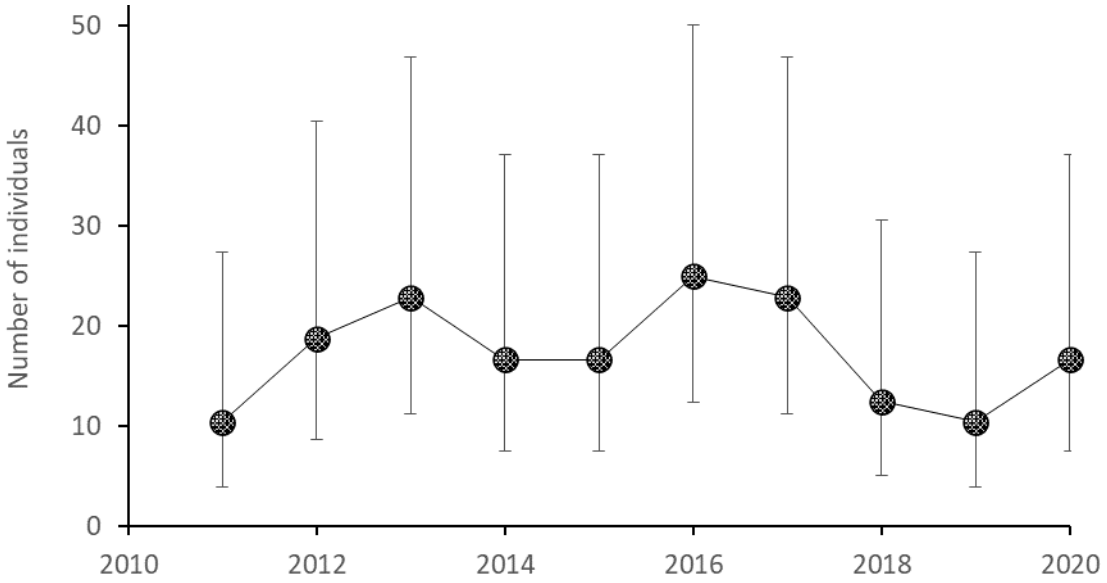

Figure 20. Estimated population size of Black-flanked Rock-wallabies at Paruna (95% CI), 2011-2020.

Small reptiles

A total of 77 small reptiles, comprised of 19 species, were trapped with pitfall and funnel traps during the 2020 Paruna Sanctuary Standard Trapping Survey. Average species richness across Paruna was 2.3 species per site. Wandoo-Marri habitat supported the highest average species richness and Jarrah-Marri habitat the lowest average species richness.

In comparison to the 2019 survey, the 2020 survey yielded greater small reptile captures and 9 additional species. This included the addition of the Reticulated Velvet Gecko (*Hesperoedura reticulata*) to the Paruna species list. The installation of two additional sites, and the timing of the 2020 survey (2020 conducted in Spring/Summer, 2019 in Autumn), may have contributed to the change in captures, despite sites being opened for only 3 nights, compared to 4 nights in 2019.

Skinks

Three native indicator skink species were captured in the Standard Trapping Survey (Figure 21). For the period 2019-2020, the occupancy of Buchanan's Snake-eyed Skink remained stable, whilst it increased for Common Dwarf Skink and South-western Orange-tailed Slider (Figure 21).

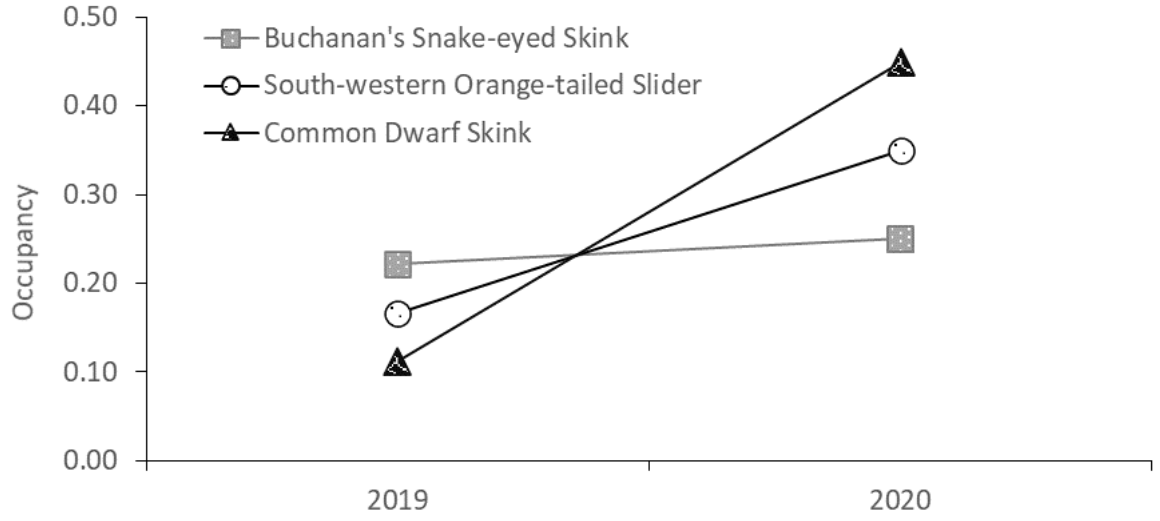

Figure 21. Occupancy for three indicator native skink species (Buchanan's Snake-eyed Skink, South-western Orange-tailed Slider, and Common Dwarf Skink) at Paruna over the period 2019-2020

Geckoes

Two native indicator gecko species were captured in pitfalls during the live-trapping stage of the 2020 Standard Trapping Survey (Figure 22). One species, the Marbled Gecko, was not captured in 2019.

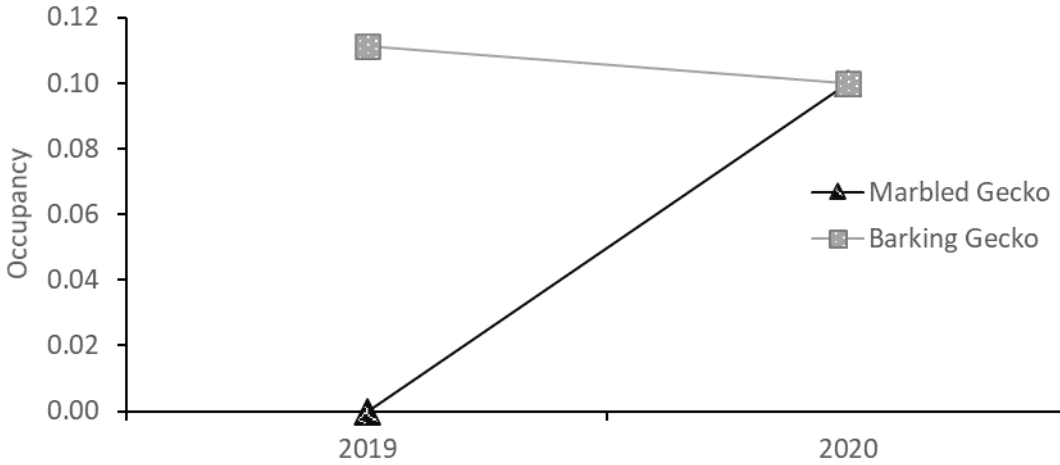

Figure 22. Proportion of sites where two native gecko species (Marbled Gecko, Barking Gecko) were detected at Paruna, 2019-2020

Medium reptiles

Bobtails

Bobtails were detected at over half the Standard Trapping Sites (occupancy = 0.55) across all habitat types. Bobtails were detected by both the forward- and downward-facing cameras.

Birds

Diurnal birds

A total of 46 bird species were observed during the first Ecohealth Diurnal Bird Survey in Spring 2020. Average species richness across Paruna was 15.3 species per site. Species with the greatest site occupancy were predominantly small passerine birds (Table 4). The threatened Red-tailed Black Cockatoo also exhibited high site occupancy (20% of sites).

Black Cockatoos

Evidence of all confirmed black cockatoo species: Red-tailed Black Cockatoo; Carnaby's Cockatoo; and Baudin's Cockatoo, feeding upon Marri nuts was detected (Table 5). Evidence of non-target species feeding upon Marri nuts detected in searches included: Red-capped Parrots and Australian Ringnecks.

Table 4. Proportion of sites where birds were detected at Paruna, 2019-2020

Common name	Scientific name	Occupancy
Inland thornbill	*Acanthiza apicalis*	0.40
Yellow-rumped thornbill	*Acanthiza chrysorrhoa*	0.35
Western thornbill	*Acanthiza inornate*	0.45
Western spinebill	*Acanthorhynchus superciliosus*	0.20
Western wattlebird	*Anthochaera lunulata*	0.20
Black-faced woodswallow	*Artamus cinereus*	0.05
Australian ringneck	*Barnardius zonarius*	0.60
Fan-tailed cuckoo	*Cacomantis flabelliformis*	0.35
Forest red-tailed black cockatoo	*Calyptorhynchus banksii naso*	0.20
Horsfield's bronze cuckoo	*Chrysococcyx basalis*	0.05
Shining bronze cuckoo	*Chrysococcyx lucidus*	0.35
Rufous treecreeper	*Climacteris rufus*	0.20
Grey shrikethrush	*Colluricincla harmonica*	0.40
Black-faced cuckooshrike	*Coracina novaehollandiae*	0.25
Australian raven	*Corvus coronoides*	0.25
Brown quail	*Coturnix ypsilophora*	0.05
Grey butcherbird	*Cracticus torquatus*	0.05
Laughing kookaburra	*Dacelo novaeguineae*	0.20
Galah	*Eolophus roseicapilla*	0.35
Western yellow robin	*Eopsaltria griseogularis*	0.10
Singing honeyeater	*Gavicalis virescens*	0.25
Western gerygone	*Gerygone fusca*	0.75
Australian magpie	*Gymnorhina tibicen*	0.40
Welcome swallow	*Hirundo neoxena*	0.10
Brown honeyeater	*Lichmera indistincta*	0.75
Splendid fairywren	*Malurus splendens*	0.40
Brown-headed honeyeater	*Melithreptus brevirostris*	0.05
Gilbert's honeyeater	*Melithreptus chloropsis*	0.10
Jacky winter	*Microeca fascinans*	0.10
Elegant parrot	*Neophema elegans*	0.05
Western whistler	*Pachycephala occidentalis*	0.60
Rufous whistler	*Pachycephala rufiventris*	0.50
Spotted pardalote	*Pardalotus punctatus*	0.05
Striated pardalote	*Pardalotus striatus*	0.90
Scarlet robin	*Petroica boodang*	0.20
Red-capped robin	*Petroica goodenovii*	0.05
Common bronzewing	*Phaps chalcoptera*	0.10
White-cheeked honeyeater	*Phylidonyris niger*	0.35
New Holland honeyeater	*Phylidonyris novaehollandiae*	0.70
Red-capped parrot	*Purpureicephalus spurius*	0.30
White-breasted robin	*Quoyornis georgianus*	0.05
Grey fantail	*Rhipidura albiscapa*	0.90
Willie wagtail	*Rhipidura leucophrys*	0.10
Spotted scrubwren	*Sericornis maculatus*	0.25
Weebill	*Smicrornis brevirostris*	1.00
Silvereye	*Zosterops lateralis*	0.45

Table 5. Occupancy for the three Black Cockatoo species at Paruna in 2020

Species	Occupancy Value
Forest Red-tailed Black Cockatoo	0.65
Carnaby's Black Cockatoo	0.45
Baudin's Black Cockatoo	0.45

Threat indicators

Feral predators

Sanctuary-wide Camera Survey results indicate that the proportion of sites occupied by feral cats remains relatively stable (0.04 in 2020, 0.06 in 2019), with a decrease from a peak of 0.13 in 2018 (Figure 23). Similarly, fox occupancy has declined since 2018 (Figure 24). These declines presumably reflect the ongoing, intensive feral animal control conducted by AWC's Paruna operations staff.

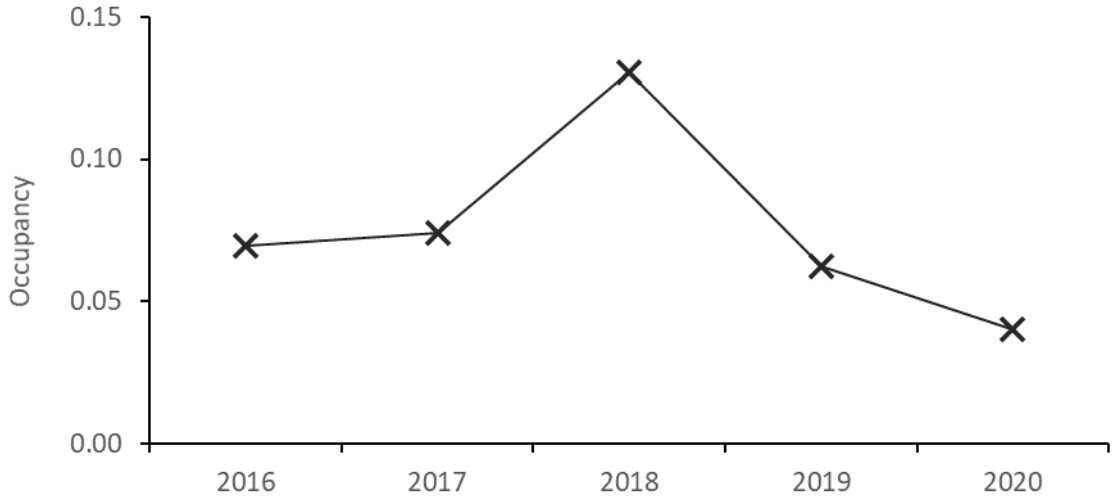

Figure 23. Occupancy of feral cats at Paruna for the period 2016-2020

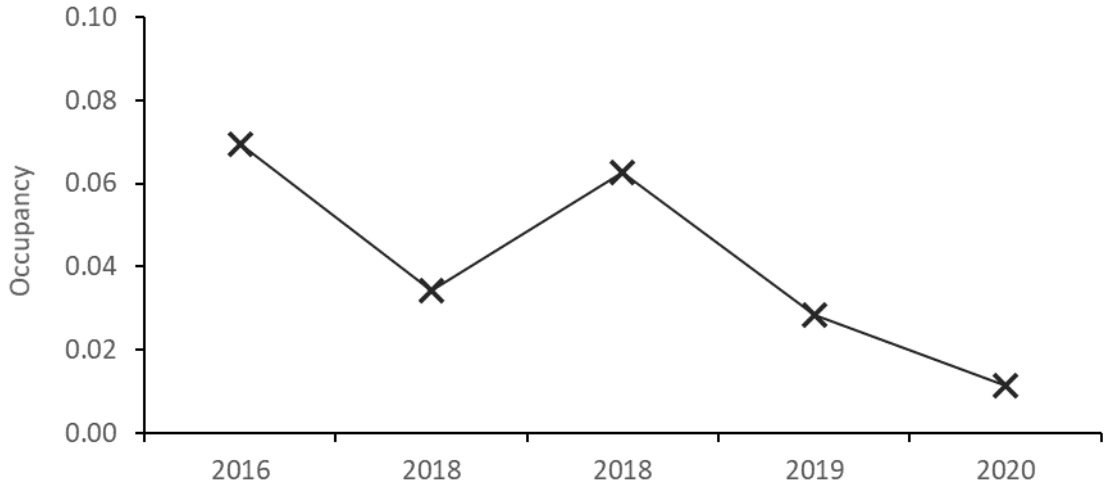

Figure 24. Occupancy (proportion of sites detected) for red foxes at Paruna for the period 2016-2020

Feral herbivores

Goat, pig, rabbit, sheep and deer

The occupancy of introduced herbivores at Paruna was found to be very low. During the Sanctuary-wide Camera Survey only 1 goat, 1 pig and 2 rabbits were detected, and no sheep or deer. AWC's control efforts have increased dramatically in recent years, and detections of many of these feral animals are now minimal.

House mouse

The number of house mice trapped during the Standard Trapping Survey decreased, with the occupancy of house mice decreasing from 0.45 (45% of sites) in 2019 to 0.15 in 2020. The abundance of house mice, like many small rodents, are often driven by factors beyond the control of land managers, such as rainfall and subsequent food availability.

Fire

Prescribed burns occurred across 4 ha on Paruna in 2020.

Discussion

With regards to small to medium indicator mammals, most were found to have low, but stable occupancy. However, Chuditch and Koomal occupancy has declined over recent years.

Of the reintroduced species, Tammar Wallabies have successfully established at Paruna, likely benefitting from ongoing cat and fox control. The abundance of ear-tagged Tammars (tagged upon translocation) has declined, but this is to be expected as there has not been a translocation to Paruna for several years. In contrast, the reintroduced population of Black-flanked Rock-wallabies remains small. Conservation of this species may require enhanced control efforts directed at cats and foxes, and presumably re-establishment of other populations in the Avon Valley.

Alterations to the number of sites and timing of Standard Trapping Surveys generated better results for reptiles compared to those in 2019. The Standard Trapping Survey in 2020 yielded an average reptile species richness of ~2 species per site, with 9 additional species captured compared to prior year. This also included the addition of the Reticulated Velvet Gecko to the Paruna species list.

In 2020, the first Ecohealth bird surveys were conducted at Paruna. Diurnal Bird Surveys detected a total of 46 species, averaging ~15 species per site. The Black Cockatoo Survey confirmed the presence of three threatened species across 45% to 65% of survey sites.

The Sanctuary-wide Camera Trapping Survey confirmed that there have been decreases in the occupancy and distribution of feral predator and herbivore species, presumably a direct consequence of ongoing threat management undertaken by AWC.

Acknowledgements

This work was conducted on Noongar Country. AWC acknowledges the traditional owners of this land and pays respect to Noongar Elders; past, present and emerging.

AWC's Ecohealth Program is only possible because of the generosity of AWC's supporters. Thank you to our dedicated and passionate volunteers who donate their time in assisting the science team in their work. Thank-you to the entire South-West Science and Operations teams for their hard work at Paruna that has made the running and collection of data from all our surveys possible.

References

Australian Wildlife Conservancy (2021a) *SECR Analysis using R-Package oSCR.* Australian Wildlife Conservancy, Perth, Western Australia.

Australian Wildlife Conservancy (2021b) *A guide to multi-species, multi-season occupancy analysis*. Australian Wildlife Conservancy, Perth, Western Australia.

Efford MG, Fewster RM (2013) Estimating population size by spatially explicit capture–recapture. *Oikos* 122, 918–928.

Fiske I, Chandler R (2011) unmarked: An R Package for Fitting Hierarchical Models of Wildlife Occurrence and Abundance. *Journal of Statistical Software* 43, 1–23.

Fleming R (2018) Identification of chewed Marri nuts eaten by cockatoos and parrots.

Goijman AP, Conroy MJ, Bernardos JN, Zaccagnini ME (2015) Multi-season regional analysis of multi-species occupancy: Implications for bird conservation in agricultural lands in east-central Argentina. *PloS one* 10, e0130874–e0130874.

Loyn RH (1986) The 20 minute search - A simple method for counting forest birds. *Corella* 10, 58–60.

R Core Team (2013) *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria.

Smith M, Jackson C, Palmer N, Palmer B (2020) A structured analysis of risk to important wildlife elements in three Australian Wildlife Conservancy sanctuaries. *Ecological Management & Restoration* 21, 42–50.

Sutherland C, Royle JA, Linden D (2019) oSCR: A Spatial Capture-Recapture R Package for Inference about Spatial Ecological Processes. *Ecography*.

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