Wongalara Wildlife Sanctuary
Ecohealth Report 2020

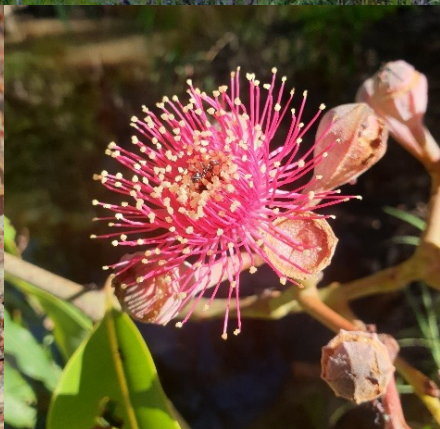australian wildlife conservancy

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 its properties. Metrics from the program are reported in annual Ecohealth Reports and Scorecards.

This is the Ecohealth Report for Wongalara Wildlife Sanctuary, Northern Territory, for 2020. Values of metrics derived in this report were based on data collected during surveys carried out between November 2019 and February 2021. The complete set of metrics and their values are summarised in the accompanying Ecohealth Scorecard.

In 2020, despite constraints on science activities due to the Covid-19 pandemic, AWC conducted five surveys on Wongalara: a Standard Camera Survey across the lowland savanna, a Rocky Area Camera Survey of the rocky gorges and escarpments, a Standard Bird Survey, a Waterhole Bird Survey and a Gamba Grass Survey.

The Northern Nailtail Wallaby and Agile Wallaby were the most commonly recorded native mammals in the Standard Camera Survey. The threatened Northern Brushtail Possum was recorded at two of 37 sites, consistent with low small-medium mammal abundance across the northern savannas generally.

Camera trapping of rocky areas showed presence of Wilkins' Rock-wallaby at 40% of the sites, at a relative abundance of 2.3 per 100 trap nights. The Common Rock-rat had the highest occupancy (present at 67% of survey sites). Average species richness of mammals across rocky sites was 3.4 species per site, with at least one species recorded at each site.

The Standard Bird Survey revealed low species richness across savanna sites, with an average of 12.3 species per site. Two threatened birds, the Gouldian Finch and Hooded Parrot, were recorded during Waterhole Bird Surveys with 6.7% and 16.7% occupancy, respectively, across 30 sites.

In surveys conducted in 2020, predators (Dingoes and feral cats) were detected more frequently in rocky areas than in more open savannas, likely due to these areas retaining water and providing refuge for potential prey species during prevailing drought conditions.

The area of infestation of gamba grass was mapped as 38 ha in 2020, prior to treatment with herbicide and manual removal. This weed is treated annually at Wongalara.

The 2020 fire metrics continue to indicate improvements from baseline values that are likely to benefit biodiversity on Wongalara. In particular, the area burnt by late dry season fire has reduced substantially since AWC commenced fire management; in 2020, no part of Wongalara was affected by late dry season fire.

Contents

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, above, Ecohealth Monitoring Plans are developed, describing the conservation values or assets of each property, and threats to these assets; and setting 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 Wongalara Wildlife Sanctuary Ecohealth Report 2020, draws on surveys conducted between November 2019 and February 2021 to calculate values for metrics that track the status and trend of the Ecohealth indicators. The companion Wongalara Wildlife Sanctuary Ecohealth Scorecard 2020 presents these metrics in a summary format.

Wongalara Wildlife Sanctuary

Covering over 190,000 hectares on the southern edge of Arnhem Land, Wongalara Wildlife Sanctuary (Wongalara) is situated in the 'Gulf Fall and Uplands' Bioregion. Wongalara is within the traditional lands of the Ngalakan and Rembarrgna people. The property is divided by three major drainage systems; from north to south by the Wilton River; along the north-western floodplain by the Mainoru River; and in the central/south-western region by the Jalboi River (Figure 1).
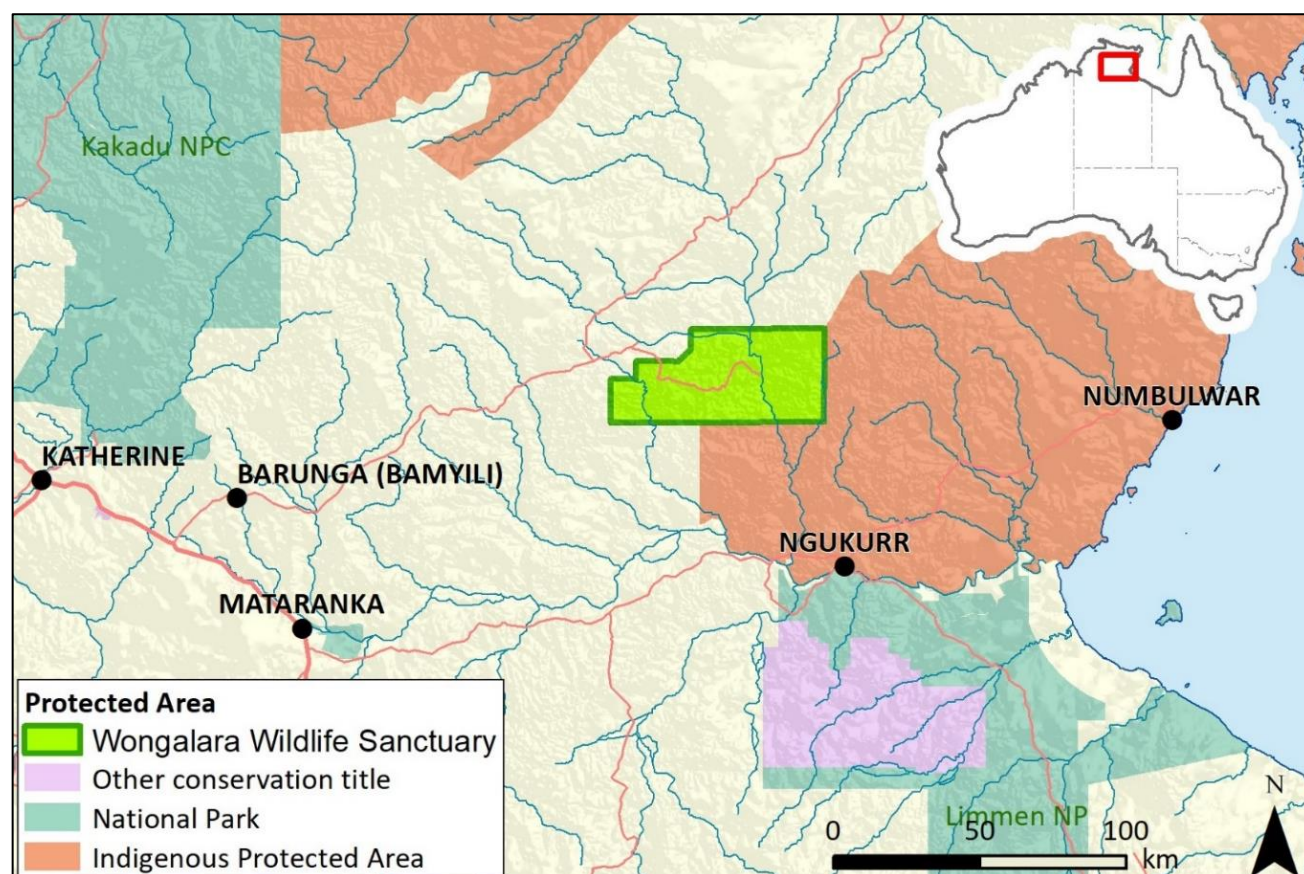

Figure 1. Location of Wongalara

The centre of the sanctuary is dominated by a deeply dissected sandstone plateau that supports the most southerly occurrence of Arnhem Land sandstone ecosystems. The ecosystems on Wongalara form an intricate and complex pattern, with fine-scale variation and numerous refugial habitats for wildlife. Wetlands, sandstone communities and patches of monsoon rainforest and heathland, alongside blacksoil plains and alluvial flats, provide a contrast to the drier, spinifex-clad ranges and sandstone plateaus that dominate much of the sanctuary. A range of soil types support diverse eucalypt and acacia-dominated woodlands. Shallow soils carry stringybark, woollybutt and acacia scrub with spinifex, annual sorghums and spear grass; whereas the valley floors carry silver box (*Eucalyptus pruinosa*), bloodwood, ti-tree, quinine (*Petalostigma* spp), bauhinia (*Lysiphyllum cunninghamii*), coolibah and paperbarks. Snappy gum (*Eucalyptus brevifolia*) and lancewood (*Acacia shirleyi*) are found on escarpment edges.

The sanctuary has over 560 plant species recorded, including many rare species and plants endemic to the top end of the Northern Territory.

Wildlife at Wongalara

The diversity of habitats on Wongalara, and its location on the edge of Arnhem Land and the Gulf bioregions, make it a hotspot for Top End wildlife including endemic species such as the Hooded Parrot (*Psephotellus dissimilis*). Wongalara is home to several threatened and declining species including the Gouldian Finch (*Chloebia gouldiae*), Orange Leaf-nosed Bat (*Rhinonicteris aurantia*), Spectacled Hare-wallaby (*Lagorchestes conspicillatus leichardti*), Northern Brown Bandicoot (*Isoodon macrourus*), Emu (*Dromaius novaehollandiae*), Australian Bustard (*Ardeotis australis*), Merten's Water Monitor (*Varanus mertensi*) and the Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis*).

The mammal fauna also includes a suite of macropods including Wilkins' Rock-wallaby (*Petrogale wilkinsi*), Agile Wallaby (*Macropus agilis*), Northern Nailtail Wallaby (*Onychogalea unguifera*), Common Wallaroo (*Macropus robustus*) and Antilopine Wallaroo (*Macropus antilopinus*). This is in addition to smaller marsupials and native rodents including Long-tailed Planigale (*Planigale ingrami*) and Grassland Melomys (*Melomys burtoni*). Rock Ringtail Possums (*Petropseudes dahli*) inhabit the isolated rocky outcrops and sheltered spring areas support Water Rats (*Hydromys chrysogaster*) and Rufous Owls (*Ninox rufa*).

With over 55 kilometres of two major rivers – the Wilton and the Mainoru – the property is home to both Saltwater (*Crocodylus porosus*) and Freshwater Crocodiles (*Crocodylus johnstoni*), at least one unidentified shark species (most likely Bull Sharks (*Carcharhinus leucas*))*,* turtles, water monitors and a large number of freshwater fish species.

Soils on Wongalara include alluvial and coarse-textured loams, red earths/red clayey loams and sands. Stringybark and Woollybutt *Eucalyptus* species dominate shallow soils along with Acacia scrub over spinifex, with annual sorghum and spear grass. Rocky ecosystems such as upland valley floors with limestone, sandstone and conglomerate base host Silver Box, Bloodwood, Tea Tree/Paperbarks and Coolibah. There are extensive areas of Lancewood and Snappy Gum type Eucalypts on escarpment edges.

In 2012, AWC established on Wongalara a large feral herbivore-exclusion fenced area, the largest on mainland Australia at the time. The fenced area has a perimeter of 160 km of fencing enclosing 100,000 ha of the sanctuary. Over one thousand feral herbivores were removed from inside the fence. A similar exclusion at Mornington-Marion Downs Wildlife Sanctuary, together with appropriate fire management, has resulted in a significant increase in the population of small-medium sized mammals (Legge et al. 2019). An increase in ground cover, and the recovery of riparian habitats, should provide additional food and cover for small mammals. Outside the fenced area, feral herbivore densities are generally low, although management is needed to control ongoing re-invasion from Arnhem Land.

Climate and weather summary

Wongalara is within the 650-1,200 mm annual rainfall zone of the monsoonal wet-dry tropics of central northern Northern Territory (Bureau of Meteorology 2021a). Wongalara is situated at the intersection of Rembarrgna and Ngalakan country. Rembarrgna people describe seven distinct seasons (Mimal Land Management 2021, pers. comm.). These seven seasons are:

- **Juwalkka** Jan into March: Wet season
- **Wularri** March and April: Knock 'em down

- **Marlawurru** end April to July: Cool season
- **Warlirr** Aug to mid-September: Hot season
- **Warlirr bultjjarn** late September and October: Middle of the hot season
- **Ga ngol-gaba** October and November: Build-up clouds
- **Gepjalk** December: New growth.

Rainfall records for Wongalara have been collected since 1999, but there are gaps in the series. Only 8 years have complete records, and the totals in these ranged from 411 to 1,257 mm (annual median 876 mm). In 2020, rainfall was well below the median (Figure 2): 563 mm compared to the annual median of 876 mm. Both 2018 and 2019 total annual rainfall was also below the median (659 mm and 545 mm respectively). Only 4 mm of rain fell in February 2020, following a very dry start to the 2019-2020 wet season, with just 14 mm of rain falling in November-December 2019 (median of 256 mm).
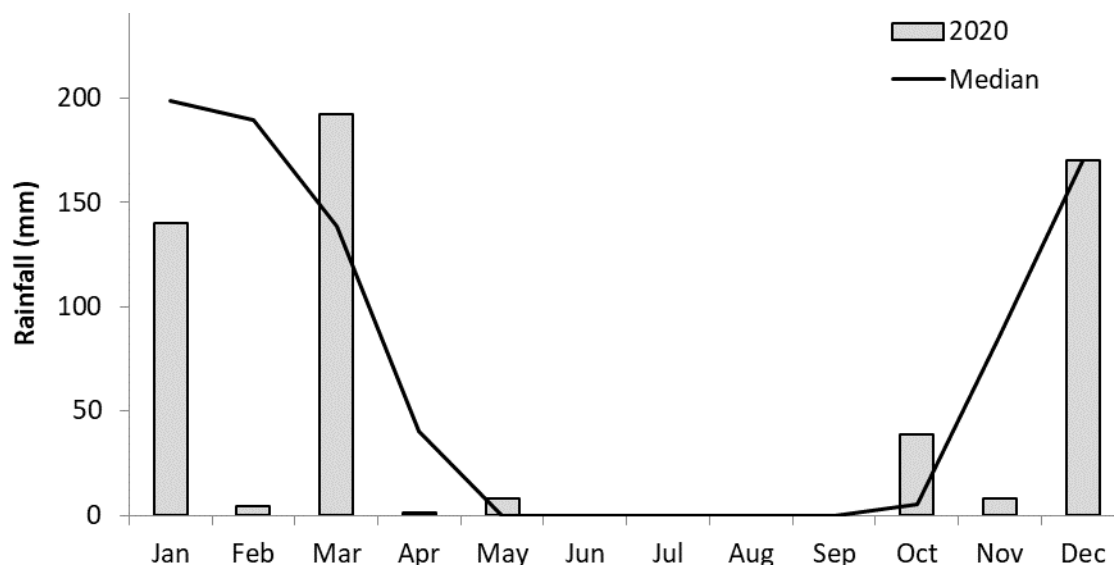

Figure 2. Monthy rainfall from 2020 compared with the median monthly rainfall, 1999-2020. Data sourced from Bureau of Meteorology 2021b, Wongalara Station Number 14602, with additions from Chris Whatley (Wongalara Sanctuary Manager).

Temperature data are taken from the Bulman weather station, approximately 55 km north of Wongalara. This station has collected temperature data since 2002, although some years have incomplete data. The 2020 mean maximum temperature was 0.6°C higher than average (Figure 3). Minimum temperatures were also above average, except for a cold snap in July 2020 (7.6°C, compared with 13.8°C long term average; Figure 3).
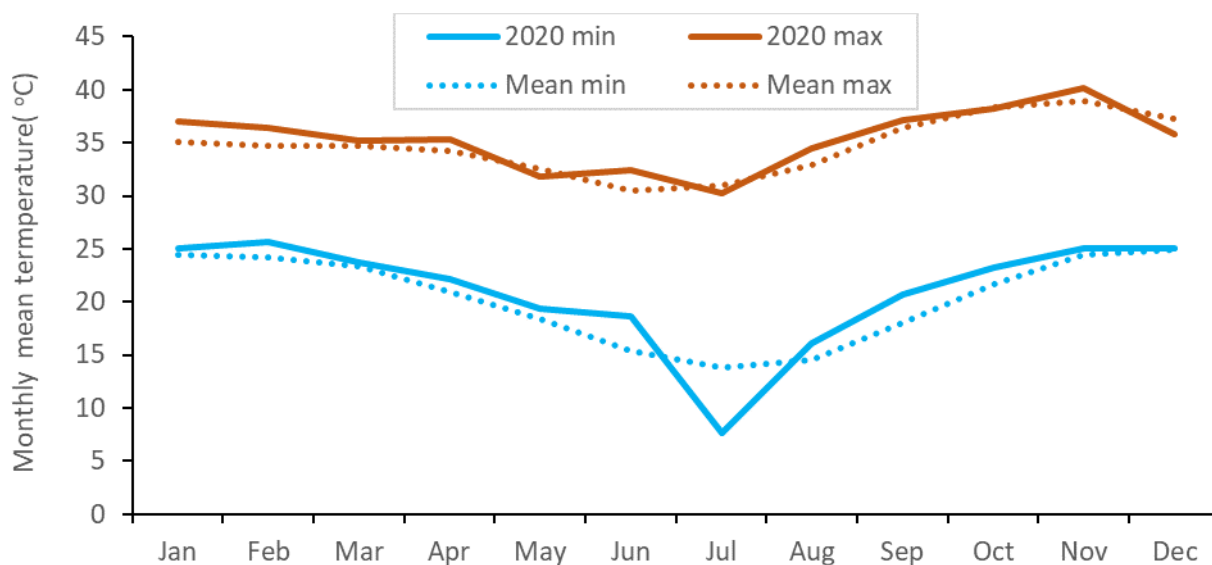

Figure 3. Mean monthly minimum and maximum temperatures in 2020 compared with averages 2002-2020 (Bulman, weather station number 14627; Bureau of Meteorology 2021c, 2021d)

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Methods

Indicators and metrics

Wongalara's Ecohealth Monitoring Program has been designed to measure and report on the status and trends of species, ecological processes 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). On Wongalara, 28 biodiversity (species and guilds) indicators have been selected for monitoring (Table 1). Of these, 15 indicators were reported on in 2020. Threat metrics are selected to ensure monitoring of the status and trends of introduced weeds, predators and herbivores and inappropriate fire regimes. Eleven threat indicators have been selected for monitoring (Table 2), of which three were reported on in 2020.

Table 1. Biodiversity indicators for Ecohealth Monitoring Program for Wongalara. Rationale for selection: T = threatened or declining; D = strong driver of ecosystem function; S = surveillance monitoring. Metric definitions: abundance = number of detections per 100 trap nights, or number of individuals per site, or number of individuals per 100 m (for the Buff-sided Robin only); occupancy = percentage of sites recorded; richness = mean number of species/site; activity = number of records/survey.

Indicator	Rationale			Survey method	Metric/s
	T	D	S		
Mammals					
Small-medium mammals (rocky habitat)					
Saxicoline small-medium mammal guild (dasyurids, rodents)		*		Rocky Area Camera Survey	Richness, Abundance (detections/100 trap nights), Occupancy
Common Rock-rat (*Zyzomys argurus*)			*	Rocky Area Camera Survey	Abundance (detections/100 trap nights), Occupancy
Wilkins' Rock-wallaby (*Petrogale wilkinsi*)	*		*	Rocky Area Camera Survey	Abundance (detections/100 trap nights), Occupancy
Rock Ringtail Possum (*Petropseudes dahli*)			*	Rocky Area Camera Survey	Abundance (detections/100 trap nights), Occupancy
Short-beaked Echidna (*Tachyglossus aculeatus*)			*	Rocky Area Camera Survey	Abundance (detections/100 trap nights), Occupancy
Small-medium mammals (savanna habitat)					
Savanna small-medium mammal guild (dasyurids, rodents)		*		Standard Trapping Survey	Richness, Abundance (individuals/site). Not surveyed 2020
Northern Brown Bandicoot (*Isoodon macrourus*)			*	Northern Brown Bandicoot Targeted Survey	Abundance (detections/100 trap nights), Occupancy. Not surveyed 2020
Spectacled Hare Wallaby (*Lagorchestes conspicillatus*)			*	Spectacled Hare Wallaby Targeted Survey	Abundance (detections/100 trap nights), Occupancy. Not surveyed 2020
Large herbivores					
Agile Wallaby (*Macropus agilis*)		*	*	Standard Camera Survey	Abundance (detections/100 trap nights), Occupancy
Antilopine Wallaroo (*Macropus antilopinus*)		*	*	Rocky Area Camera Survey	Abundance (detections/100 trap nights), Occupancy
Common Wallaroo (*Macropus robustus*)		*	*	Rocky Area Camera Survey	Abundance (detections/100 trap nights), Occupancy
Northern Nailtail Wallaby (*Onychogalea unguifera*)		*	*	Standard Camera Survey	Abundance (detections/100 trap nights), Occupancy
Arboreal mammals					
Savanna Glider (*Petaurus ariel*)			*	TBD	TBD. Not surveyed 2020
Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis*)			*	Standard Camera Survey	Abundance (detections/100 trap nights), Occupancy
Predators					
Dingo (*Canis dingo*)		*		Standard Camera Survey, Rocky Area Camera Survey	Occupancy
Bats					

Indicator	Rationale			Survey method	Metric/s
	T	D	S		
Microbats guild			*	Bat Targeted Survey	Richness, Abundance (individuals/site), Occupancy, Activity (number of records/survey). Not surveyed 2020
Reptiles					
Small-medium-sized reptiles					
Small reptiles (diurnal skinks and dragons)			*	Standard Trapping Survey	Richness, Abundance (individuals/site). Not surveyed 2020
Small reptiles (nocturnal geckoes and flap-footed lizards)			*	Standard Trapping Survey	Richness, Abundance (individuals/site). Not surveyed 2020
Other reptiles					
Large reptiles (goanna and snakes)			*	Standard Trapping Survey	Richness, Abundance (individuals/site). Not surveyed 2020
Merten's Water Monitor (*Varanus mertensi*)	*			Water Monitor Targeted Survey	Occupancy. Not surveyed 2020
Birds					
Savanna birds					
Savanna bird guild			*	Standard Bird Survey	Richness
Granivorous birds					
Gouldian Finch (*Chloebia gouldiae*)	*			Waterhole Bird Survey	Occupancy
Hooded Parrot (*Psephotellus dissimilis*)	*			Termite Mound Survey Waterhole Bird Survey	Occupancy
Riparian birds					
Buff-sided Robin (*Poecilodryas cerviniventris*)	*			Buff-sided Robin Targeted Survey	Abundance (number of individuals per km), Occupancy. Not surveyed 2020
Nocturnal birds					
Nocturnal bird guild			*	Nocturnal Bird Survey	Occupancy. Not surveyed 2020
Frogs					
Frog guild			*	Call Survey	Richness. Not surveyed 2020
Ecological processes					
Number of obstructions to waterflow on soil surface		*		Targeted Survey	Average number per 100 m. Not surveyed 2020
Melaleuca thickening			*	Targeted Survey	Tree density. Not surveyed 2020

Table 2. Threat indicators for Ecohealth Monitoring Program for Wongalara. <u>Metric definitions:</u> Population density = number of individuals/ unit area (ha or km^2); abundance = number of detections per 100 trap nights; occupancy = proportion of sites recorded.

Indicator	Rationale	Survey method	Metric/s
Feral predators			
Cat (*Felis catus*)	Major threat to wildlife	Standard Camera Survey, Rocky Area Camera Survey	Population density, Abundance, Occupancy
Feral herbivores			
Cattle (*Bos taurus*)	Threat to wildlife, vegetation	Feral Herbivore Survey	Population density. Not surveyed 2020
Buffalo (*Bubalis bubalis*)	Threat to wildlife, vegetation	Feral Herbivore Survey	Population density. Not surveyed 2020
Donkey (*Equinus asinus*)	Threat to wildlife, vegetation	Feral Herbivore Survey	Population density. Not surveyed 2020
Pig (*Sus scrofa*)	Threat to wildlife, vegetation	Feral Herbivore Survey	Population density. Not surveyed 2020
Horse (*Equus caballus*)	Threat to vegetation	Feral Herbivore Survey	Population density. Not surveyed 2020
Other threats			
Cane toad (*Rhinella marina*)	Threat to wildlife	Standard Trapping Survey	Population density. Not surveyed 2020
Weeds			
Grader grass (*Themeda quadrivalvis*)	Class B and C weed, threat to vegetation and wildlife	Grader Grass Survey	Area of infestation (ha). Not surveyed 2020
Gamba grass (*Andropogon gayanus*)	Class A and C weed, Weed of National Significance, threat to vegetation and wildlife	Gamba Grass Survey	Area of infestation (ha)
Sicklepod (*Senna obtusifolia*)	Class B and C weed, threat to floodplains and river systems	Sicklepod Survey	Extent of infestation. Not surveyed 2020
Fire			
Suite of ecologically-relevant metrics, calculated for (i) all fire; and (ii) wildfire	Key driver of vegetation dynamics, structure and composition, habitat attributes	Fire Scar Analysis	Extent by season Frequency (no. times burnt in given period) Time since fire Distance to unburnt

Survey types and history

To report on the Biodiversity and Threat Indicators, AWC conducts a variety of surveys including:

- Standard Trapping Survey
- Standard Camera Survey
- Rocky Area Camera Survey
- Standard Bird Survey
- Waterhole Bird Survey
- A variety of targeted surveys (including Northern Brown Bandicoot, Spectacled Hare Wallaby, Microbats, Buff-sided Robin (*Poecilodryas cerviniventris*)
- Feral Herbivore Survey, and
- Weed surveys.

In addition to ground-based ecological surveys, satellite data are analysed to compile the:

- Fire Scar Analysis.

Five ground-based surveys were completed at Wongalara in 2020: a Standard Camera Survey in August, a Rocky Area Camera Survey between November 2019 and March 2020, a Standard Bird Survey in August and a Waterhole Bird Survey in October/November. Targeted mapping of the extent of Gamba grass infestation was also undertaken. The Fire Scar Analysis has been completed using satellite data from 2000 (seven years prior to acquisition) to 2020. The methodology is described and results of these surveys and computations are reported on in this document. The total 2020 survey effort on Wongalara is presented in Table 3.

Inventory fauna surveys commenced at Wongalara in 2007, immediately after acquisition by AWC. A Standard Trapping Survey was established across the sanctuary for mammals and reptiles in 2008. Standard Bird Surveys were also undertaken across multiple years. These surveys continued annually, in August, augmented by various targeted surveys. From 2018, the surveillance surveys have been conducted every two years.

In 2012, the Bush Blitz program visited Wongalara, surveying terrestrial and aquatic vertebrates, invertebrates and plants (Commonwealth of Australia 2012). In 2012-2014, a translocation of Long-haired (*Rattus villosissimus*) and Pale Field Rats (*Rattus tunneyi*) was undertaken as part of an experimental program investigating impacts of feral cats (Frank et al. 2014; Tuft et al. 2021).

Table 3. Survey effort for 2020 Ecohealth surveys on Wongalara Wildlife Sanctuary

Survey name	Effort	Description/comment
Standard Camera Survey	1,555 trap nights	37 of 48 standard sites surveyed in 2020. 74 camera traps deployed; 2 per site for 14 nights.
Rocky Area Camera Survey	7,696 trap nights	85 cameras deployed at 18 sites in arrays of typically 5 cameras spaced approximately 150-200 m apart. Some sites had 3 cameras.
Standard Bird Survey	29 surveys	2 ha/20 minute surveys at 18 of 48 standard trapping sites. One or two surveys per site.
Waterhole Bird Survey	30 surveys	2 hour surveys with observers at independent waterholes for concurrent 2 hr surveys.
Gamba Grass Survey	1 survey	Extent of infestation mapped on-ground prior to treatment. Annual treatment program.

Survey design and methods

Standard Camera Survey

Forty-eight sites were selected in major vegetation types across Wongalara, located in wetland fringes, savanna woodland and riparian strips (creek banks), to monitor a suite of native and introduced taxa, including small-medium mammals, small-medium reptiles, large herbivores, Dingoes and feral cats (Figure 4). These sites were established in 2008. Usually, a Standard Trapping Survey (using the standard techniques of pitfall trapping, funnel trapping and box trapping) would be undertaken in conjunction with the Standard Camera Survey at each of these sites. Due to logistical constraints imposed by the Covid-19 pandemic, only the Standard Camera Survey was undertaken in 2020, at 37 of the 48 standard sites. Accordingly, only a subset of mammals was monitored in 2020 (large herbivores, arboreal mammals, Dingoes), and feral cats.
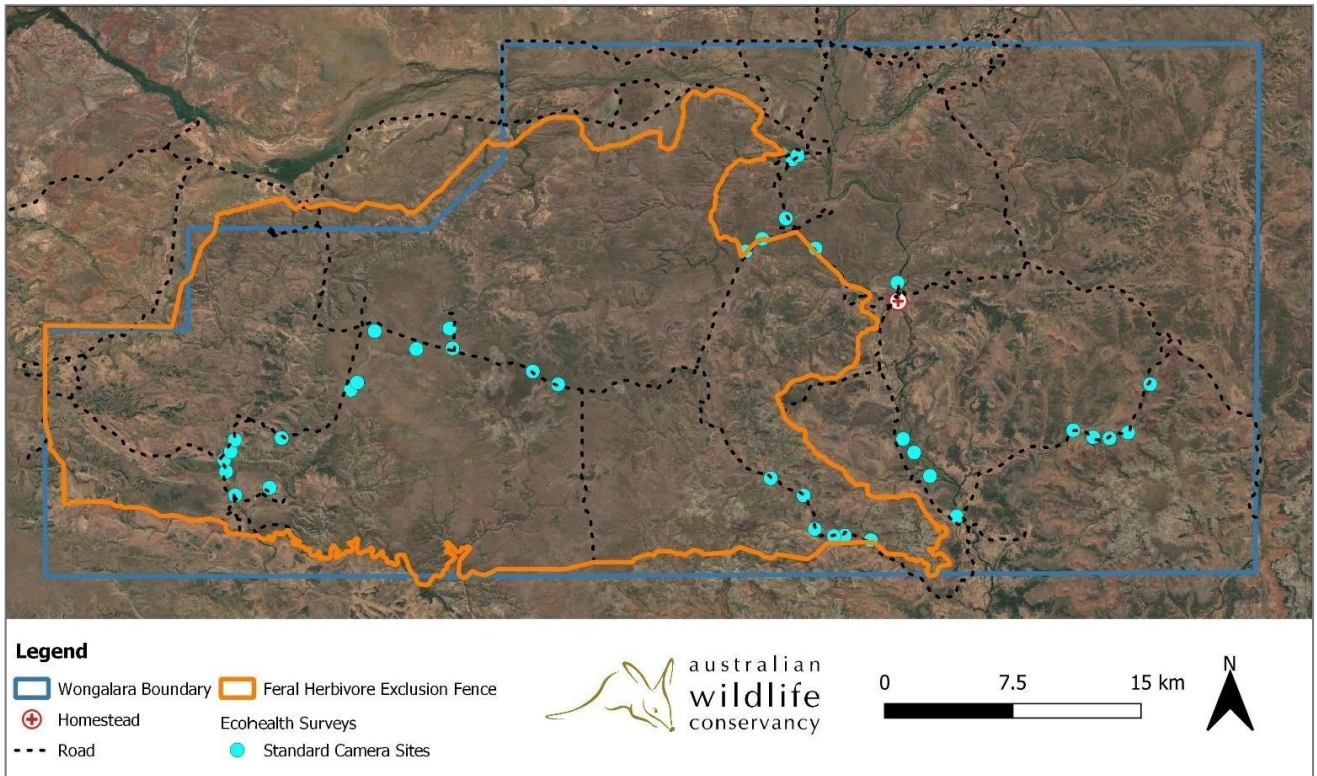

Figure 4. Standard Trapping Survey sites camera-trapped at Wongalara in 2020

Two camera traps (Reconyx PC850 white flash) were set at each of the 37 sites. The sites encompassed a 1 ha survey area (Figure 5). The two camera traps were set at the locations shown with a star, 70 m from the central pitfall trap. Each camera was set 0.7 m above the ground, angled to face a baitholder set 1.5 m from the base of the tree or post to which the camera was secured. The baitholder contained a ball of standard bait composed of peanut butter, rolled oats, sardines and vanilla essence. The following settings were used: motion pictures on; five pictures per trigger; 'Rapidfire' interval; 'No delay' quiet period and high sensitivity. Cameras were deployed in August 2020 for 14 nights.
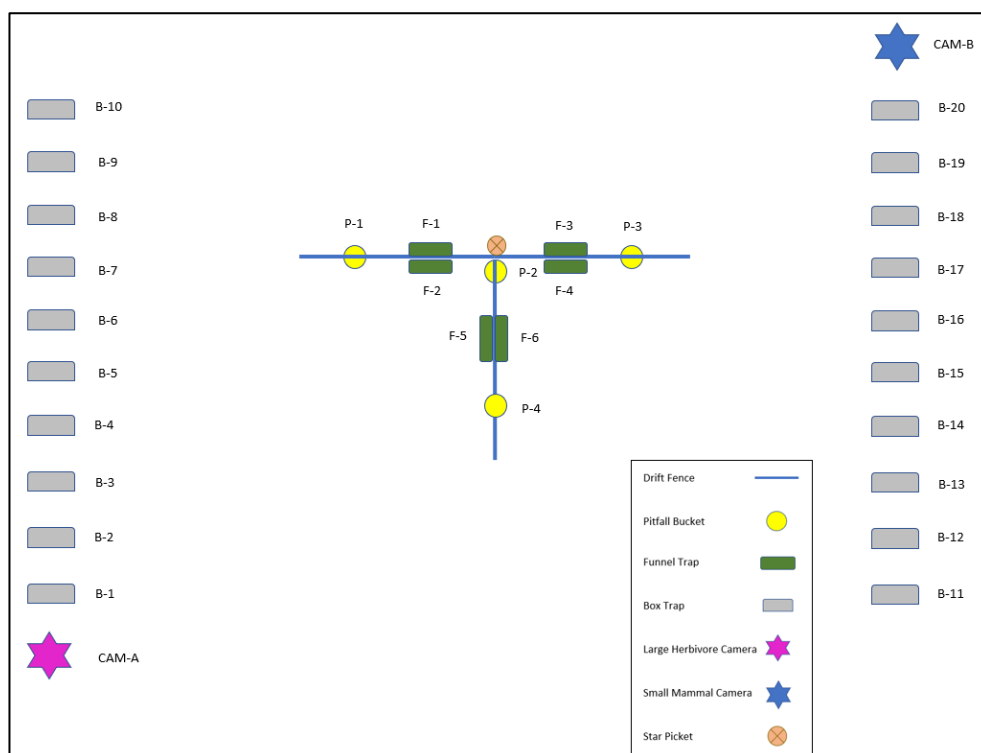
Figure 5. Set up of 'T' standard survey site

Rocky Area Camera Survey

Eighteen survey sites were selected to monitor the native mammal fauna of the rocky upland areas (small-medium mammals, large herbivores, Dingoes) and feral cats (Figure 6). Each site has between three and five camera traps set at 150-200 m spacing. A total of 85 cameras were deployed between November 2019 and March 2020, for 90 nights.
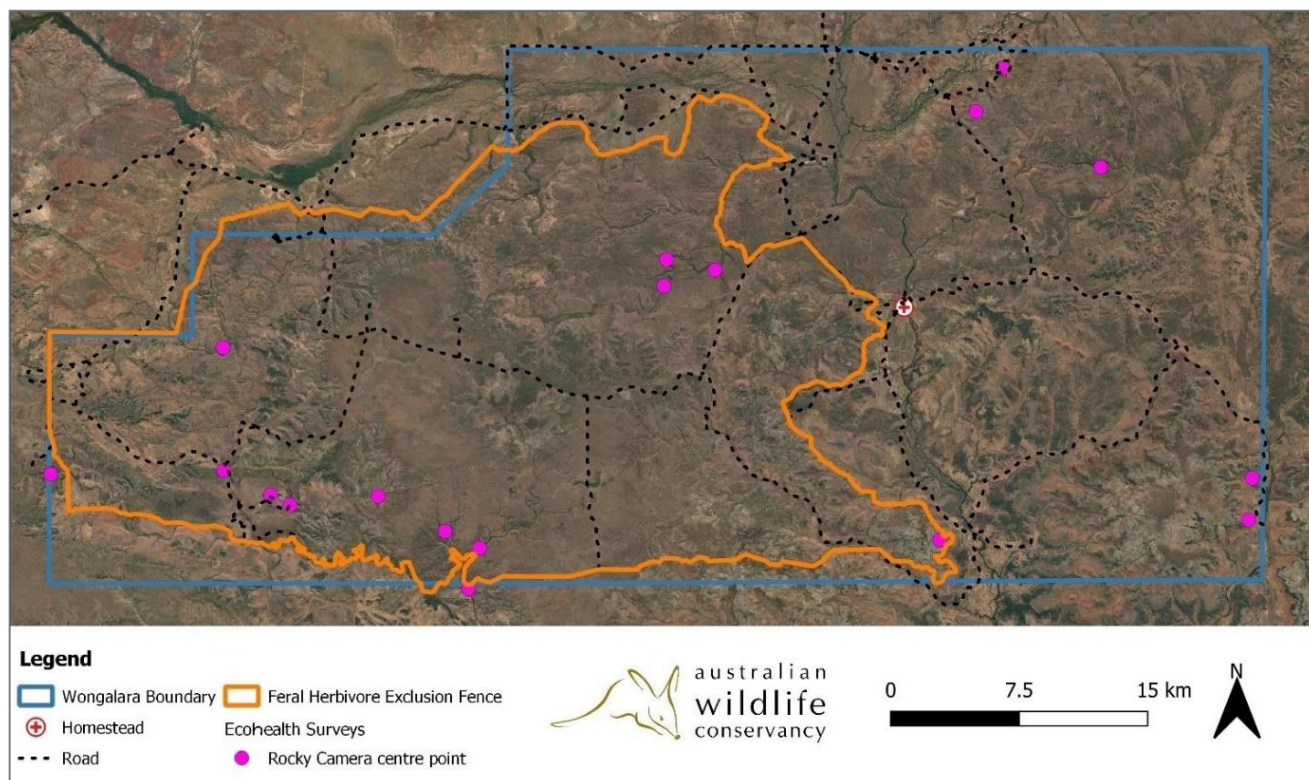

Figure 6. Location of camera traps across the rocky upland areas of Wongalara in 2020

Each camera was set up as close as possible to the pre-existing survey points from 2018. The camera was set at a height of 0.7 m, attached to a tree with an elastic/bungy cord and angled slightly downward, centred on a PVC bait holder, placed 1.5 m from the camera. Where possible, cameras were directed toward rock faces. Bait holders were placed at the base of the rock faces and secured with large rocks. One large bait ball consisting of rolled oats, peanut butter and sardines was placed within each bait holder. Additional sardines were added to the standard bait mixture to enhance the chance of detecting carnivorous species. The camera settings were as described in the Standard Camera Survey.

Standard Bird Survey

Eighteen of the 48 Standard Trapping Survey sites were surveyed for savanna birds in the Standard Bird Survey, using the standard two hectare, 20 minute search (Figure 7).
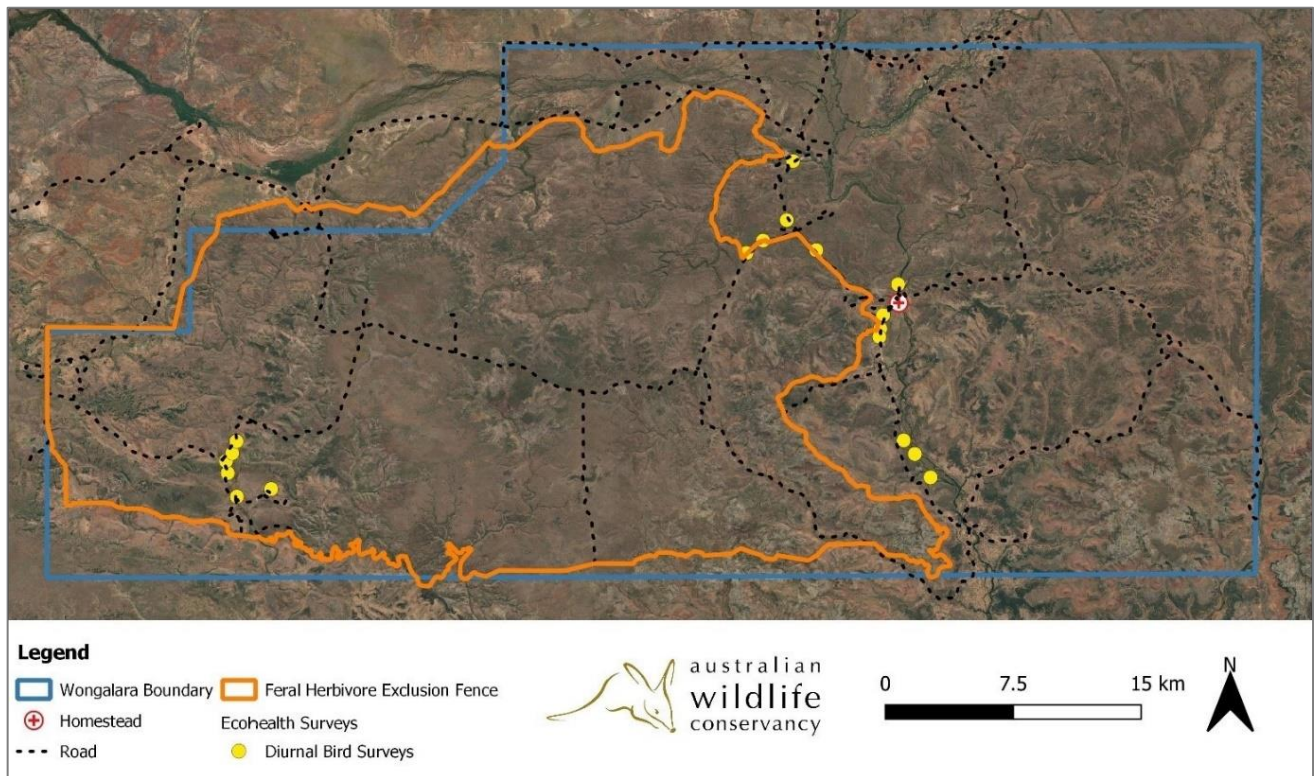

Figure 7. Two-hectare bird survey sites at Wongalara in 2020

The Standard Bird Survey was based on BirdLife Australia's standard 2 ha, 20 minute search (Birdlife Australia 2021). Surveys were conducted by staff familiar with Australian savanna birds.

Each site was surveyed by one observer. The preferred design of BirdLife Australia is a 100 m by 200 m area (Figure 8). However, other shapes such as a circle with an 80 m radius, or a strip transect (e.g., 250 m by 80 m) were used if the habitat did not allow for a rectangle, such as in rocky gorge or riparian habitats.

Eighteen of the 48 standard monitoring sites (Figure 8) were surveyed one or two times during the Standard Bird Survey, where timing permitted. During surveys, the observer recorded all birds seen and/or heard within the 2 hectare area during the 20 minute period. Surveys started at sunrise and were completed by three hours post-sunrise.
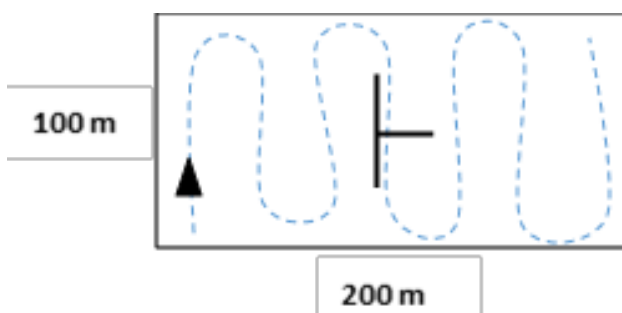

Figure 8. Layout of bird survey route across a standard monitoring site

Waterhole Bird Survey

A total of 30 waterholes were surveyed for Gouldian Finches and Hooded Parrots using a two-hour survey (Figure 9). This survey has been conducted annually in October/November (late dry season). Sampling effort for the Waterhole Bird Survey changes from year to year due to uncontrollable annual changes in water availability, suitable drinking holes, and logistical constraints. Exact waterhole locations are not repeatable year to year.

Two indicator species, the Hooded Parrot and the Gouldian Finch, were surveyed at waterholes. Each waterhole was observed for two hours on one morning per waterhole, between 5.45-7.45 am.
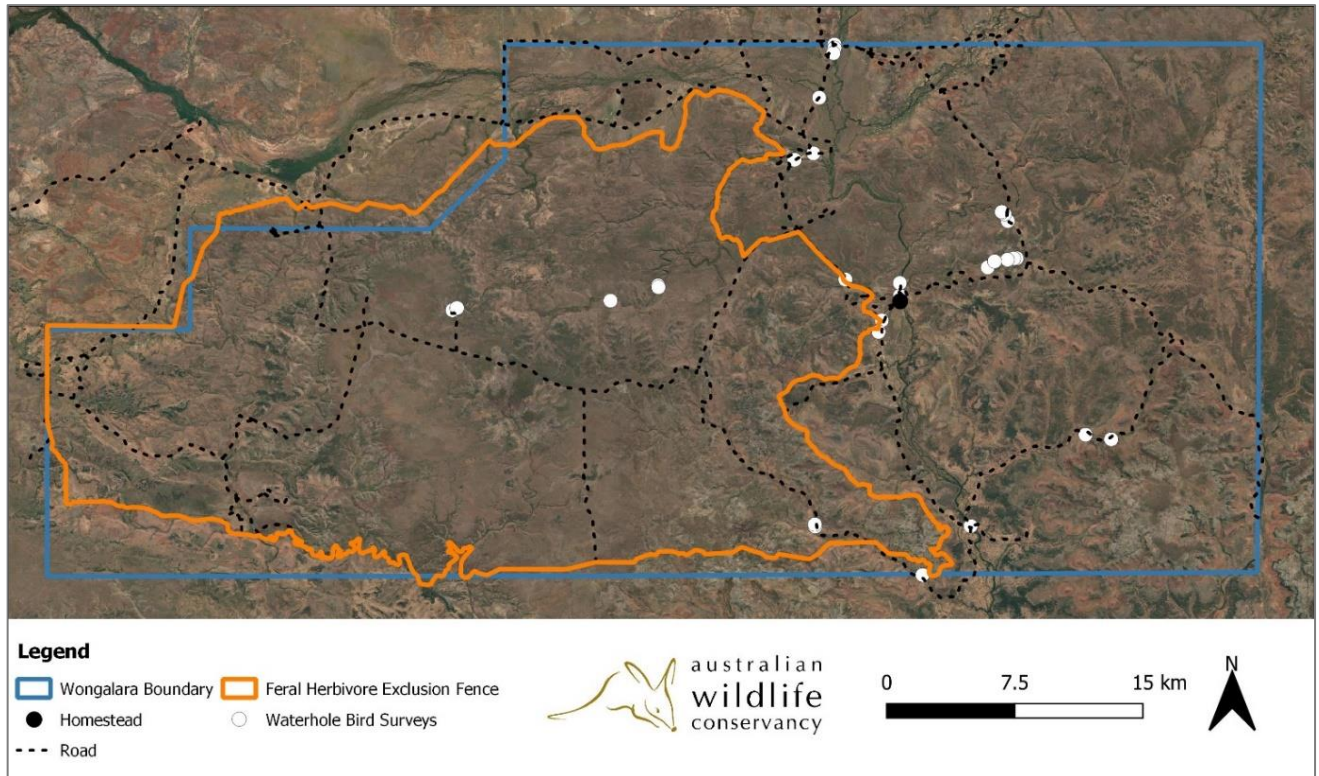

Figure 9. Waterhole bird survey sites at Wongalara in 2020

Gamba Grass Survey

Known infestations were monitored by the land management team during the annual herbicide treatment program, with constant vigilance throughout the year for observations outside of known areas. The extent of the infestation was mapped using a handheld GPS. Infestations of gamba grass were treated (with glyphosate) with additional manual removal of flower heads as growth progressed.

Analysis methods

Biodiversity and threat indicators

Camera trap image analyses

For sensor-camera data, repeat same-species detections within a 12-hour period were removed (i.e. one record of a species per 12-hour period per camera was retained). Records that occurred after the set period of deployment for that set of sites were excluded (e.g. any records on day 15 or later were excluded when the set deployment time was 14 days). For sites with multiple cameras, data from multiple cameras were pooled.

For each survey method, a site × species matrix of abundance was generated using the individual animal records, standardized for effort. The abundance and occupancy metrics were then calculated as described below.

Metric calculations

For mammals, abundance was measured as the average number of detections per 100 trap nights (100 TN) across all trap sites, where one trap night was one camera trap operating for one night.

For waterhole bird surveys, abundance was measured as the average number of individuals across the survey sites. As it was not possible to determine if the same individuals were counted during each replicate, the highest recorded abundance for each species was taken from each survey and used to calculate site abundance.

For all taxa, occupancy was measured as the proportion of sites at which the taxon was detected (occupancy).

Species richness was calculated for each site and averaged across sites (with standard error).

Gamba Grass Survey
The area of infestation (in hectares) was calculated using the path recorded during the on-ground mapping of the infested area.

Fire Scar Analysis
Fire scar data were obtained for 2000 to 2020 from the North Australia Fire Information (NAFI) website. Each scar was attributed by year, month and season. For season, scars detected from January to July (inclusive) were attributed as "Early", whereas those detected August to December were attributed as "Late". The maps and statistics for the analyses were created using ArcGIS with Spatial Analyst, and were semi-automated using Python scripting. Cooper et al. (2020) provide further detail on the annual fire scar mapping and analysis undertaken.

Results

Biodiversity indicators

A total of 11 native species were recorded across the 37 savanna sites in the Standard Camera Survey, comprising 6 species of mammal and 5 species of bird. A total of 30 species were recorded across 18 sites in the Rocky Area Camera Survey, comprising 9 species of mammal, 12 birds, 7 reptiles and 2 amphibians.

Mammals

Small-medium mammals (rocky habitat)

The average species richness of saxicoline (i.e., rock-dwelling) small-medium mammals recorded in the survey of rocky sites averaged 3.4 (± 1.7) species/site. All sites recorded at least one mammal species; the occupancy of the saxicoline guild was therefore 100%. At present, there are five species of saxicoline mammals on Wongalara: two other possible species (Northern Quoll *Dasyurus hallucatus* and Sandstone False Antechinus *Pseudantechinus bilarni*) have not been detected at Wongalara since acquisition by AWC.

The Common Rock-rat was widespread, being detected at 67% of sites at an average abundance of 0.5 (± 0.1) individuals per 100 trap nights. Wilkins' Rock-wallaby was detected at 40% of sites, and an abundance of 2.3 individuals (± 1.1) per 100 trap nights. Rock Ringtail Possums were found at 6% of the sites, at an average abundance of 0.21 (± 0.2) per 100 traps nights. Short-beaked Echidnas were found at 33% of sites at an average abundance of 0.66 (± 0.5) per 100 trap nights.

Large herbivores

In the rocky area survey, large macropods were common, with the Antilopine Wallaroo found at 22% of sites at an average abundance of 0.42 (± 0.2) per 100 trap nights. The Common Wallaroo had an average abundance of 2.37 (± 0.5) per 100 trap nights and was detected at 89% of sites.

Across the 37 savanna sites, the Northern Nailtail Wallaby and Agile Wallaby were the most commonly recorded native mammals. The Northern Nailtail Wallaby was recorded at 16% of sites with an average abundance of 0.75 (± 0.4) per 100 trap nights. The Agile Wallaby was aso recorded at 16% of sites at an average abundance of 0.4 (± 0.2) per 100 trap nights. In part, the higher abundance of the Northern Nailtail Wallaby was due to a high number of records at a single site, where it was recorded on five separate nights.

Arboreal mammals

The Northern Brushtail Possum was recorded at 2 of the 37 savanna sites (5% occupancy) at an average abundance of 0.19 (± 0.1) per 100 trap nights (Figure 10).

This Northern Brushtail Possum has declined across much of the its range in northern Australia, especially the more semi-arid parts, and was recently listed as Vulnerable by the Commonwealth Government. Northern Brushtail Possums persist at a small number of sites at Wongalara.

Predators

Dingoes, the only native mammalian predator still present at Wongalara, were detected at 33% of rocky sites. Dingoes were not detected at any savanna camera trapping sites. This disparity was likely due to lack of food resources for Dingoes at these sites in the late dry season (September) when savanna sites were surveyed. Dingoes are highly mobile and will utilise all habitats where prey is available.

Figure 10. Northern Brushtail Possum on camera trap at Wongalara, 2020 survey.

Birds

Savanna bird guild

Across the 18 savanna sites, 52 bird species were detected during the Standard Bird Survey. The most commonly detected species was the Rufous Whistler (*Pachycephala rufiventris*) at 12 sites.

The most diverse site was a riparian site on the Jalboi River, where 27 species were detected. Average species richness per site was at 8.5 (± 0.7).

In 2020, 44% of sites (8 of 18) were burnt during prescribed fire management, and in combination with three very dry preceding wet seasons, bird activity was low in general. Future surveys at these sites will allow for further insight into the dynamics of the savanna bird guild, particularly for sedentary and detectable species such as Red-backed Fairy-wrens (*Malurus melanocephalus*) which have high site fidelity, and are known to be affected by land management actions such as fire (Murphy et al. 2010).

Indicator bird species

Waterhole Bird Surveys for water-dependent granivorous birds resulted in 428 observations of 87 species across 30 surveys. Both indicator species were detected (Table 4). Gouldian Finches (8 individuals) were detected at 2 sites along Fay's Creek, giving an occupancy of 6.7%. Hooded Parrots were detected at 5 sites (occupancy 16.7%) spread across Kangaroo Valley and the northern Wilton River and associated drainage.

Unseasonal rain in October likely reduced detections of granivorous birds, as there were many widespread small pools of water available for birds to visit.

Table 4. Bird indicator species and associated metrics from 2020 waterhole surveys

Indicator	Occupancy	Abundance
Gouldian Finch	6.7%	0.27 ± 0.17
Hooded Parrot	16.7%	4.0 ± 3.0

Threat indicators

Feral cats

Detections from camera traps gave an occupancy of 33% for feral cats in rocky areas, and 22.6% in savanna sites. This difference is likely because water sources and therefore potential prey had retracted into small areas within gorges and outcrops by the time of the survey. In rocky areas, cats were recorded at an average abundance of 0.21 (± 0.08) per 100 trap nights and in savanna habitats average abundance was 0.6 (± 0.2) per 100 trap nights.

Gamba grass

The area of the gamba grass infestation was 38 ha in 2020.

Fire

During 2020, ground-based and aerial prescribed burning was conducted by the Wongalara Sanctuary Manager. All 2020 metrics indicate improvements considered to be beneficial for ecological health since the commencement of AWC fire management (Table 5). The area burnt by early dry season fire has increased, and no late dry season fires occurred in 2020. The mean distance to unburnt and long-unburnt vegetation has decreased substantially compared to baseline values. More detail on the Wongalara fire program is in the annual Fire Report (Cooper et al. 2020).

Table 5. Fire metrics for 2020. Baseline values for metrics are the average for the years immediately prior to acquisition of Wongalara by AWC: i.e., 2000-2007 for annual metrics, and 2002-2007 for 3 year metrics. AWC management values for metrics are the average for the years following acquisition of Wongalara by AWC: i.e., 2008 onwards, for annual metrics, and 2010-2020, for 3 year metrics.

Metric	Baseline 2000/02-07	AWC management 2008/10-20	2020 Result	Change since AWC management
Area burnt by early dry season (EDS) fire (%)	9	20	25	↑
Area burnt by late dry season (LDS) fire (%)	28	3	0	↓
Cumulative extent burnt by LDS fire in past 3 years (%)	65	9	0	↓
Mean distance to unburnt vegetation (km)	1.5	0.6	0.5	↓
Mean distance to vegetation unburnt by LDS fire for 3 or more years (km)	1.8	0.6	0.0	↓

Discussion

Ecohealth survey programs were affected by the Covid-19 pandemic in 2020, with border closures restricting the movements of staff and volunteers, as well as availability of resources for fieldwork. However, five surveys were undertaken by AWC and provided metrics for a range of mammal and bird indicators.

All results for 2020 should be considered in the light of the very dry conditions prevailing after three years of below average rainfall. The drought was exacerbated by heatwaves in late 2019 with temperatures above 45°C for extended periods, and little surface water remaining. For example, average species richness of birds across the savanna sites was low, at 12.3 species/site.

Despite the conditions, large macropods were widely distributed across the sanctuary and were the most commonly detected mammal in both savanna and rocky area habitats. A diverse small-medium mammal fauna persisted in rocky habitats, at an average richness of 3.4 species/site, and with at least one small mammal species detected per site.

Presumably reflecting the occurrence of water and potential prey, both Dingoes and feral cats were detected more commonly at rocky sites than in open savannas.

All fire metrics indicate improvements that are likely to benefit ecological health on Wongalara, in particular the substantial reduction in the area affected by late dry season fire (which in 2020 was zero) and the reduction in distance to unburnt vegetation.

Acknowledgments

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