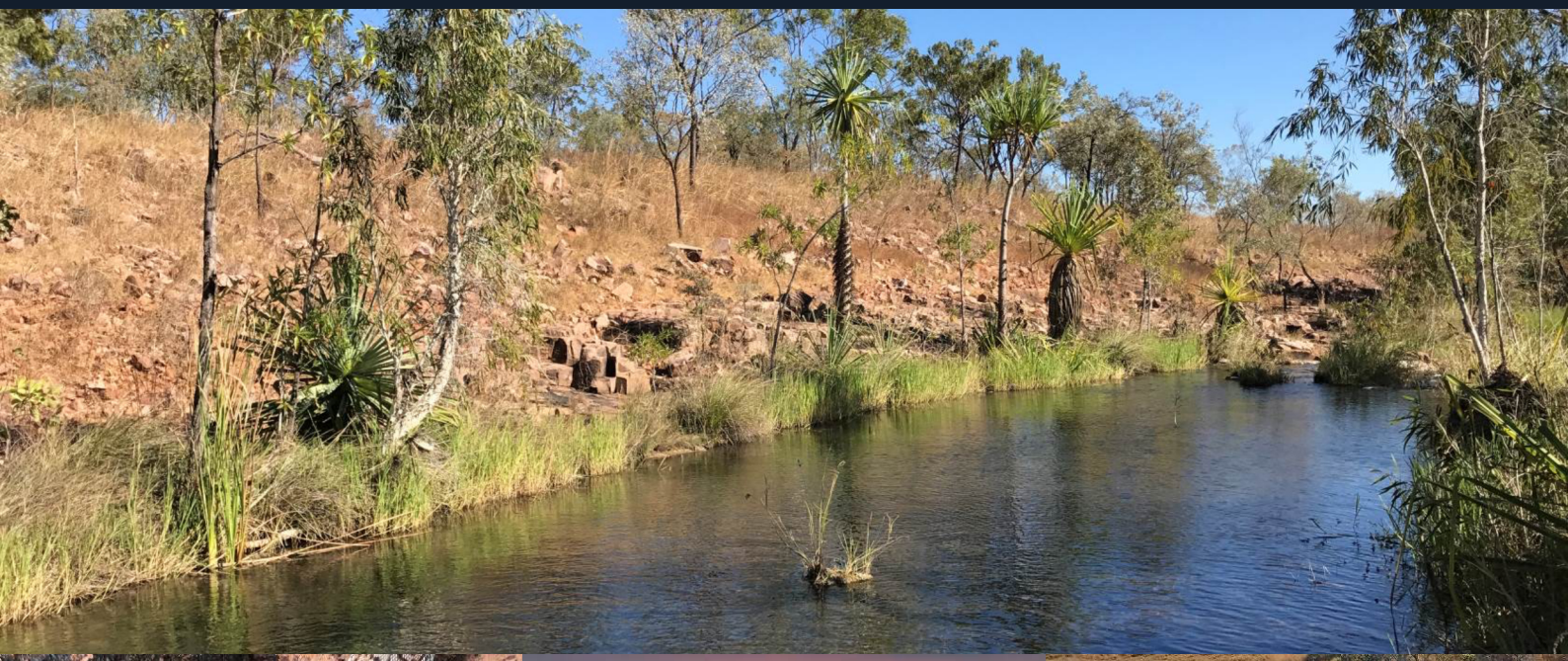
Pungalina - Seven Emu Wildlife Sanctuary

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 Pungalina-Seven Emu. Metrics from the program are reported in annual Ecohealth Reports and Scorecards. This is the Ecohealth Report for 2020. Values of metrics derived in this report were based on data collected during surveys carried out in 2017, 2018 and 2020. The complete set of metrics and their values are summarised in the accompanying Ecohealth Scorecard.

In 2017, a large live-trapping and camera survey was conducted in savanna habitats to target small-medium mammals and reptiles. This was followed by surveys in 2018 and 2020 to target specific ecosystems and animal taxa: rocky country fauna, bandicoots, Spectacled Hare-Wallabies, monitor lizards, wetland and riparian birds, wetland condition and feral predators.

Mammals

The camera survey conducted in 2017 detected a low average species richness of small-medium mammals across 48 savanna sites. Twelve species of small-medium mammal were detected in total, but on average, cameras detected less than one species per site. Small-medium mammals were only detected at 44% of trapping sites. These results are consistent with broader trends reported across the northern savannas.

In the 2018 camera survey of the rocky country, seven mammal species were recorded in total. On average, rocky sites contained slightly under two species at an abundance of 35/ 100 TN, largely reflecting the abundance of the Common Rock-rat in this habitat.

Bandicoots were relatively abundant (20/ 100 TN) and were detected at most riparian sites.

Large macropods were scarcely detected – only 0.2/ 100 TN and at 13% of sites.

Spectacled Hare-wallabies were not detected in a survey targeting the species.

Dingoes were ubiquitous across the property, detected on two-thirds of sites surveyed. These results were consistent with previous surveys of Dingoes on Pungalina-Seven Emu.

Reptiles

Thirty-five reptile species were detected in total across savanna sites during live trapping. Reptiles were recorded in moderate abundance (6.0/ 100 TN) and had moderate average diversity (3.3 species per site).

Monitors were present in low abundance (1.7/ 100 TN) and occupied 30% of the sites. The Yellow-spotted Monitor was not detected.

Birds

Riparian bird surveys detected 51 species in total (averaging 9.2 species per site). The threatened Purple-crowned Fairywren was found at all riparian sites.

Wetland surveys indicated that wetlands were in moderate health overall, with minor localised disturbance observed at most sites. Wetland bird surveys revealed a good diversity and abundance of bird life. On average, there were 176 individual birds and an average 10.1 species per site; 46 wetland bird species were detected in total.

Threats

Feral cats were detected on over one-third of sites, but in low numbers.

AWC's fire management has substantially reduced the extent of wildfires on the property.

Summary

The surveys undertaken between 2017 and 2020 largely represent the initial surveys of a long-term monitoring project. Future repeated surveys will allow identification of trends in the faunal assemblages of Pungalina-Seven Emu, with the 2017-2020 surveys forming a baseline from which these analyses can commence. Targeted surveys designed to detect species that are difficult to monitor using standard survey methods within the current suite of sites are in development and will be implemented in future Ecohealth surveys.

Contents

Cover photographs: Clockwise from top: creek (AWC/Andrew Howe); feral pigs (AWC/Eridani Mulder); Calvert River (AWC/Andrew Howe); Spiny-tailed Monitor (AWC/Andrew Howe)

Document citation: Nelson D, Watson A, Mulder E, Wauchope M, Hayes C, Joseph L, Kanowski J (2021) *Pungalina-Seven Emu Wildlife Sanctuary Ecohealth Report 2020*. Australian Wildlife Conservancy, Perth, WA.

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 that are 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 are developed describing the conservation values or assets of each property, and threats to these assets. In addition, the Ecohealth 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 Pungalina-Seven Emu Wildlife Sanctuary Ecohealth Report for 2020, draws on surveys conducted during 2017, 2018 and 2020 to calculate values for metrics that track the status and trend of the Ecohealth indicators. The companion Pungalina-Seven Emu Ecohealth Scorecard for 2020 presents these metrics in a summary format.

Pungalina-Seven Emu Wildlife Sanctuary

Covering over 306,000 hectares in the Gulf of Carpentaria, Pungalina-Seven Emu Wildlife Sanctuary ('Pungalina-Seven Emu') protects areas of conservation significance including 3,000 km^2 of the catchments of the Calvert and Robinson Rivers and 55 kilometres of coastline (Figure 1).

Pungalina-Seven Emu Wildlife Sanctuary is within the traditional lands of the Garawa and Yanyuwa people. This sanctuary was acquired by AWC in 2008 to protect the suite of ecosystems that extend from the ocean and its adjacent lowland plains to the top of the rugged sandstone plateau which dominates the Gulf region. Within this gradient lies a rich montage of habitats for flora and fauna including extensive savanna woodlands, significant areas of rocky escarpments and gorges, watercourses, springs and associated riparian forests, and coastal scrubs (Figure 2).

Pungalina and Seven Emu are both pastoral leases. AWC owns the Pungalina lease, while the Seven Emu lease belongs to the Shadforth family, with a section managed by AWC in a long-term conservation arrangement.

AWC undertakes a prescribed burning program on Pungalina-Seven Emu. The overarching aim of AWC's fire management program is to re-establish ecologically appropriate fire regimes that promote the conservation of species, ecological communities and ecosystem processes (Webb et al. 2020). Fire management on Pungalina-Seven Emu in recent years has largely involved prescribed burning using ground-lit storm burns at appropriate times during the wet season, and early season burns, either ground-based or ignited by dropping incendiaries from helicopters (Webb et al. 2020).

To date, 362 species of terrestrial vertebrates (18 amphibian, 215 bird, 46 mammal and 83 reptile species) have been recorded on Pungalina Seven-Emu. There are an additional 72 species found regionally that are considered 'likely' or 'very likely' to occur on the sanctuary. Ten species of fish are confirmed for waterways on Pungalina-Seven Emu, with a further 18 species of fish considered 'likely' or 'very likely' to occur on the sanctuary. Flora surveys by AWC have resulted in the collection of 431 plant specimens from the sanctuary to date, most of which have been formally identified in the Brisbane and Darwin herbaria.

There are 14 species of threatened vertebrate confirmed from the sanctuary: seven bird, one mammal and six reptile species. Of the seven threatened bird species, five are migratory shorebirds utilising the intertidal zone, and of the reptile species, three are marine turtles. The remaining six species are the Gouldian Finch (*Chloebia gouldiae*), Northern Crested Shriketit (*Falcunculus frontatus whitei*), Ghost Bat (*Macroderma gigas*),

Merten's Water Monitor (*Varanus mertensi*), Yellow-spotted Monitor (*Varanus panoptes*) and Gulf Snapping Turtle (*Elseya lavarackorum*).

Figure 1. Pungalina-Seven Emu Wildlife Sanctuary in its regional context

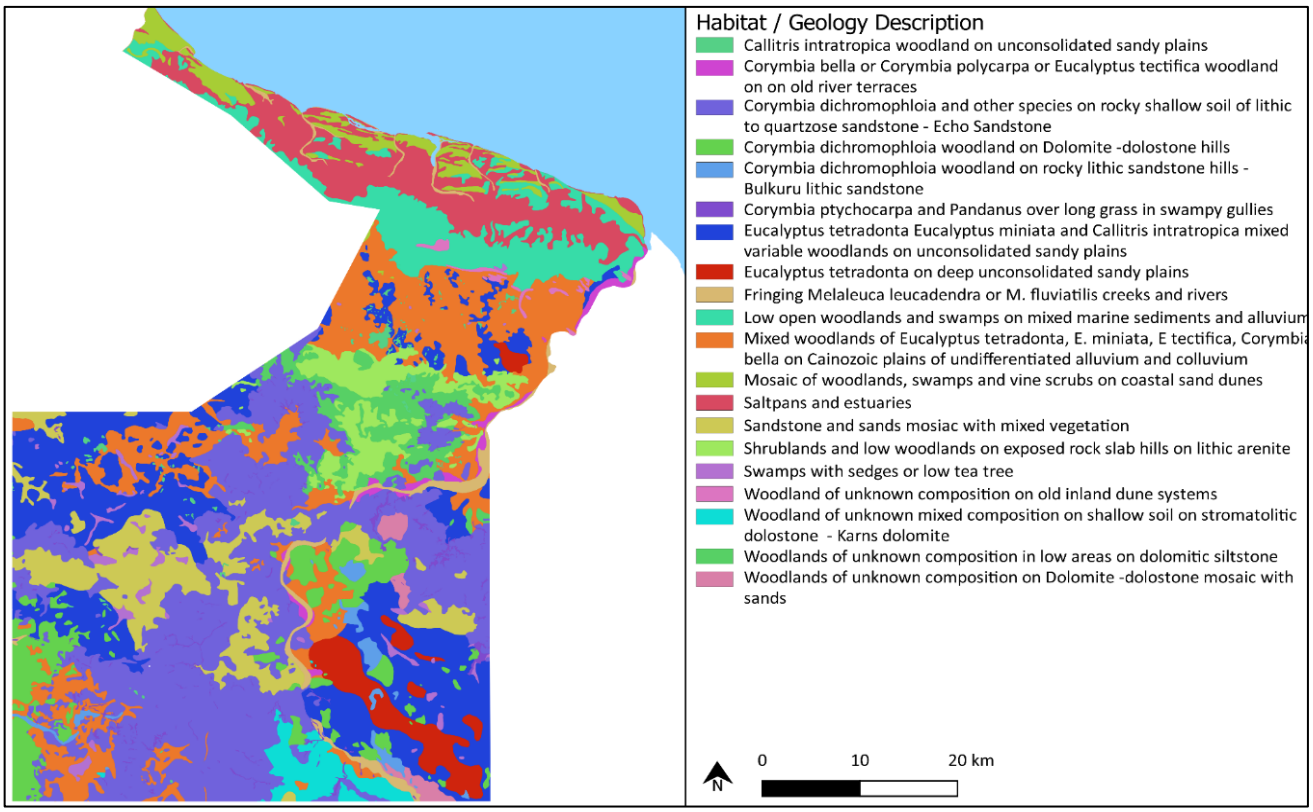


Figure 2. Vegetation and geology types on Pungalina-Seven Emu. This map combines geology polygons with vegetation descriptions from a combination of local knowledge, available vegetation mapping and imagery.

Vegetation and geomorphology

Pungalina-Seven Emu supports a range of ecosystems from sandstone uplands to coastal scrub. The beaches along the Seven Emu coast are bordered by she-oaks, while strips of mangrove forest line the estuaries and salt arms. South of the coastline the dune systems are a mosaic of monsoon vine-scrub and acacia thickets, with grasslands, salt flats and a network of freshwater and brackish lagoons.

Inland from the salt flats, the coastal plains support a variety of woodlands. In particular, belts of Northern Cypress Pine (*Callitris intratropica*) alternating with tall Darwin Stringybark (*Eucalyptus tetrodonta*) forests occur on deeper sands, while bloodwood and box woodlands, and patches of Paperbark (*Melaleuca sp.*) occur where the soils are heavier.

Further inland, the ancient sandstone rises closer to the surface and the woodlands become more open. In places, especially around the edge of the plateau, the sandstone breaks through as heavily weathered and gnarled outcrops studded by Cabbage Palms (*Livistona inermis*) and Cycads (*Cycas angulata*), as well as eucalypts.

The plateau inland of escarpment supports extensive savanna woodlands, with the vegetation varying with soil type. Sandy soils support stringybark forests, heavier soils bloodwoods (*Corymbia spp*) and Cooktown Ironwood (*Erythrophleum chlorostachys*), and skeletal soils on sandstone and limestone support woodlands dominated by the bloodwood *Corymbia dichromophloia*. Perched ephemeral wetlands on the plateau are surrounded by Coolibahs (*Eucalyptus coolabah*), Northern Swamp Box (*Lophostemon grandiflorus*), and paperbarks. An extensive system of ancient dolomite in the Karns Creek catchment supports a karst complex with a network of caves and ephemeral or permanent springs (Zaar 2009).

This ecosystem gradient, from ancient sandstone uplands to the coast, is connected by the Calvert River and its tributaries. The Calvert River cuts its way through the sandstone in a series of deep gorges, creating pockets of dry vine thicket and tall riparian forests of paperbarks, mixed with Pandanus Palms (*Pandanus spiralis*) and Freshwater Mangroves (*Barringtonia acutangula*).

Climate and weather summary

Pungalina-Seven Emu is located in Australia's monsoonal tropics. It has a warm temperature year-round and a highly seasonal rainfall pattern. Weather data reported are from Wollogorang Station (weather station number 014707), the closest weather station for which long-term data exist (Bureau of Meteorology 2021). In summary, the wet season (approximately December to April) is characterised by high maximum (~35 °C) and minimum (~25 °C) temperatures (Figure 3) and significant rainfall (Figure 4), while the dry season in the middle of the year has generally cool minimum temperatures (~12 °C), warm maximum temperatures (~30 °C) and little, if any rain. A substantial rainfall gradient exists from the wetter coastal north of the sanctuary (~870 mm annual average) to the drier interior (~700 mm annual average) of the sanctuary.

Cyclones regularly impact the region and, in combination with low-pressure systems and monsoonal troughs, contribute substantially to its rainfall. Total annual rainfall is consequently highly variable, both in timing and magnitude, from year to year. Rainfall measured at the Pungalina homestead preceding surveys described in this report indicates that the 2014-2015 and 2015-2016 wet seasons (July-June) were relatively dry, the 2016-2017 wet season was close to average, and the 2017-2018 wet season was well above average (Figure 5). The 2018-2019 wet season was well below average and the 2019-2020 wet season was close to average (Figure 5).

During wet periods, ephemeral waterholes retain water, springs draining the dolomite formations discharge at a high rate, and water levels in the Calvert River are correspondingly high. In dry times, the ephemeral springs, waterholes and creeks dry up, and only major waterholes in the Calvert River and major tributaries remain (Zaar 2009).

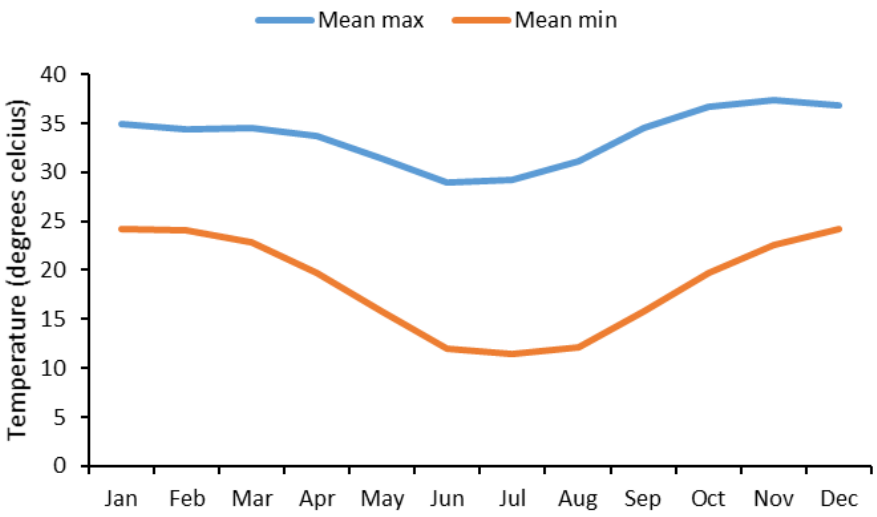


Figure 3. Average monthly temperature through the year from Wollogorang station (adjacent to Pungalina-Seven Emu), 1974-2015 (weather station number 014707)

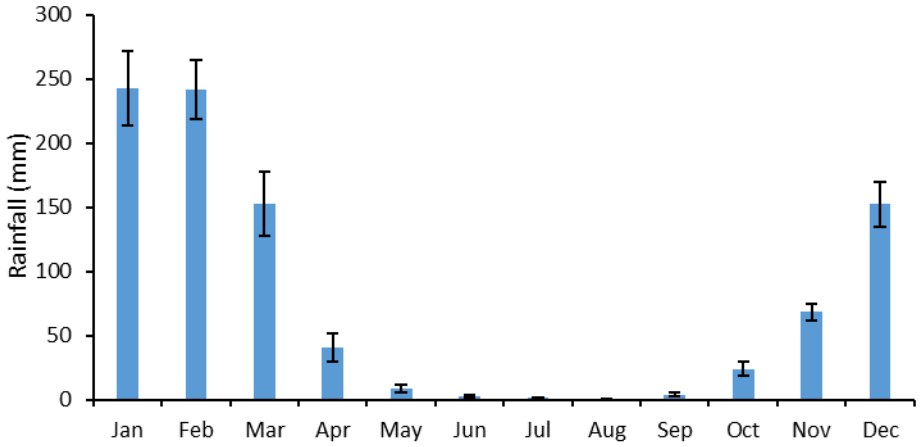


Figure 4. Mean rainfall through the year from Wollogorang station (adjacent to Pungalina-Seven Emu), 1974-2020 (weather station number 014707)

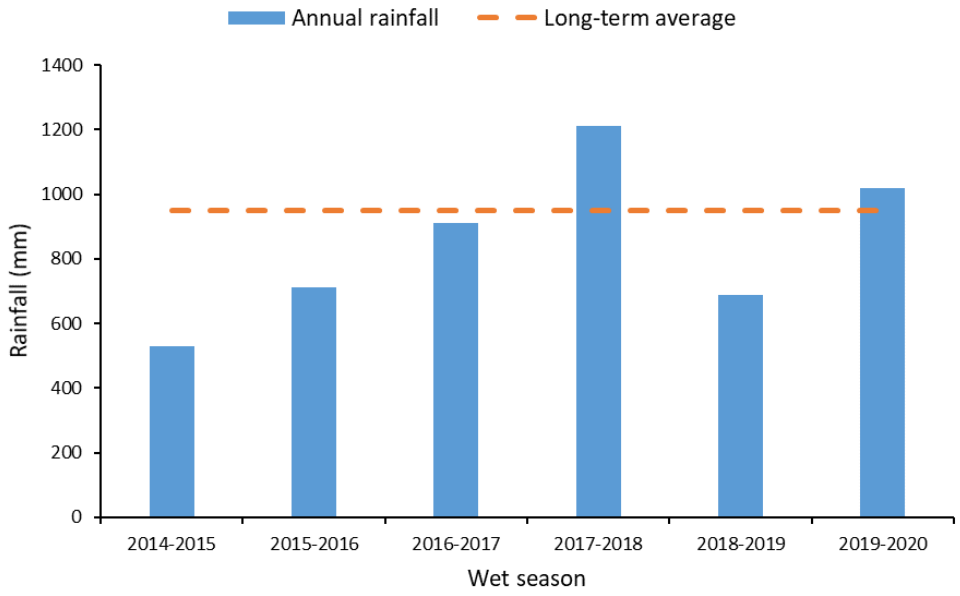


Figure 5. Total rainfall over wet seasons between 2014-2020 at Wollogorang station (adjacent to Pungalina-Seven Emu) with long-term average (1967-2020)

Methods

Indicators and metrics

Pungalina'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).

There are 21 biodiversity indicators (species and guilds); the rationale for their selection is recorded for each indicator in Table 1. In this report, the methods and results are presented for 19 of these indicators for which surveys have been carried out since 2017. Threat metrics are selected to ensure monitoring the status and trends of introduced weeds, predators and herbivores and changed fire regimes. There are 4 threat metrics (Table 1) of which 2 are reported on in this report based upon surveys.

Table 1. Ecohealth indicator metrics reported on in this document. Rationale: T = threatened or declining; D = strong driver of ecosystem function; S = surveillance monitoring. Metric definitions: abundance = average number of detections per 100 live trap or camera trap nights across all sites, or average abundance per site (for birds); occupancy = percentage of sites where species/ guild recorded; richness = average number of species per site; wetland assessment index = score reflecting extent and intensity of damage to wetland.

Indicator	**Rationale**			**Survey method**	**Metric/s**
	T	D	S		
Mammals					
Small-medium sized mammals					
Carpentarian Pseudantechinus, *Pseudantechinus mimulus*			●	Rocky Gorge Camera Survey	Abundance, Occupancy
Common Rock-rat, *Zyzomys argurus*			●	Rocky Gorge Camera Survey	Abundance, Occupancy
Spectacled Hare-wallaby, *Lagorchestes conspicillatus*			●	Spectacled Hare-wallaby Survey	Abundance, Occupancy
Sandstone Pseudantechinus, *Pseudantechinus bilarni*			●	Rocky Gorge Camera Survey	Abundance, Occupancy
Wilkin's Rock-wallaby, *Petrogale wilkinsi*			●	Rocky Gorge Camera Survey	Abundance, Occupancy
Northern Brown Bandicoot, *Isoodon macrourus*		●		Bandicoot Camera Survey	Abundance, Occupancy
Small-medium mammal guilds					
Savanna small-medium mammals			●	Standard Trapping Survey: Sensor cameras	Richness, Abundance, Occupancy
Rocky Gorge small-medium mammals			●	Rocky Gorge Camera Survey	Richness, Abundance, Occupancy
Arboreal mammals					
Rock Ringtail Possum, *Petropseudes dahli*			●	Rocky Gorge Camera Survey	Abundance, Occupancy
Bats					
Ghost Bat, *Macroderma gigas*	●			Ghost Bat Survey: methods under development	Roost count
Large herbivores					
Large macropods			●	Standard Trapping Survey: Sensor cameras	Richness, Abundance, Occupancy
Predators					
Dingo, *Canis dingo*		●		Predator Camera Survey	Abundance, Occupancy
Reptiles					
Small-medium reptile guilds:					
Savanna reptiles			●	Standard Trapping Survey: Sensor cameras and live trapping	Richness, Abundance, Occupancy
Other reptiles					
Yellow Spotted Monitor, *Varanus panoptes*	●	●		Varanid Camera Survey	Abundance, Occupancy
Merten's Monitor, *Varanus mertensi*	●			Varanid Camera Survey	Abundance, Occupancy
Terrestrial monitors			●	Varanid Camera Survey	Richness, Abundance, Occupancy
Birds					
Eastern Purple-crowned Fairywren, *Malurus coronatus macgillivrayi*	●			Riparian Bird Survey	Abundance, Occupancy
Gouldian Finch, *Chloebia gouldiae*	●			Finch Survey: methods under development	Abundance, Occupancy
Bird guilds					

Indicator	Rationale			Survey method	Metric/s
	T	D	S		
Riparian birds			●	Riparian Bird Survey	Richness
Wetland birds			●	Wetland Bird Survey	Richness
Ecological processes					
Wetland health		●		Wetland Condition Survey	Wetland Assessment Score
Threats					
Cat, *Felis catus*		●		Predator Camera Survey	Abundance, Occupancy
Pigs, *Sus scrofa*		●		Pig Survey: methods under development	Abundance, Occupancy
Cattle, *Bos taurus*		●		Aerial Herbivore Survey: methods under development	Abundance, Occupancy
Fire					
Suite of ecologically relevant metrics, calculated for (i) all fire; and (ii) wildfire		●		Remote sensing	Extent (% of sanctuary) Distance to unburnt (mean)

Survey types and history

To report on the Biodiversity and Threat Indicators, AWC survey teams conduct a variety of surveys over a period of 1-5 years. AWC conducted annual inventory surveys on Pungalina-Seven Emu from 2009 to 2016 (Kanowski et al. 2009, 2010, 2011; Moran and Kanowski 2012; Mulder et al. 2012, 2014, 2017; Kemp et al. 2015, 2016). This report presents the results of surveys undertaken since 2017 under the Ecohealth Monitoring Program. The surveys conducted since 2017 and associated effort and history are outlined in Table 2. The methodology is described, and results of these surveys are reported on in this document.

Table 2. Survey effort for Ecohealth surveys conducted between 2017 and 2020

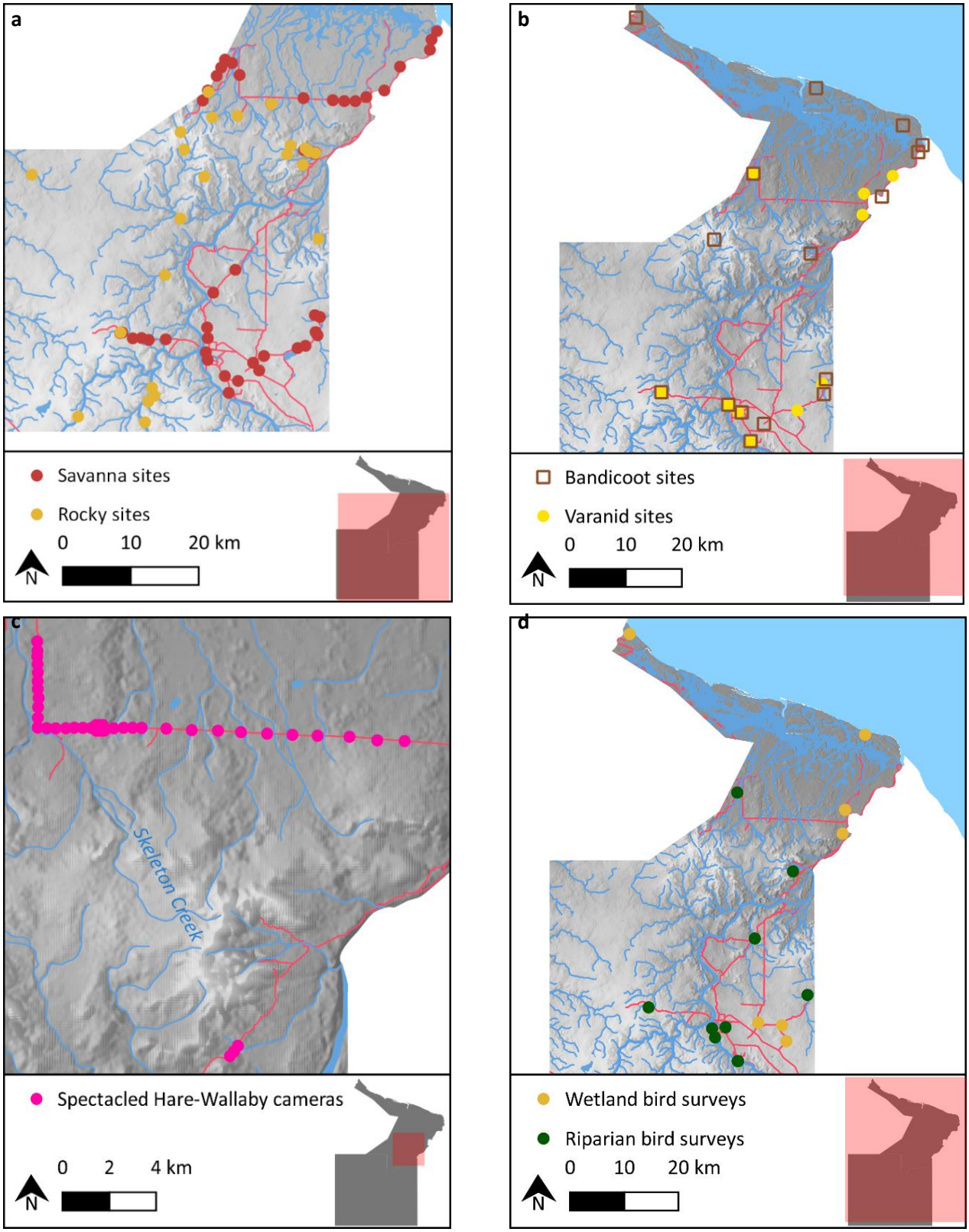
Survey name	Year(s)	Sites	Per-site effort
Standard Trapping Survey	2017	48	4 pitfalls, 6 funnels, 20 box traps*, 3 nights 4 cameras, 14 nights
Wetland Condition Assessment Survey	2018	28	1 assessment
Bandicoot Camera Survey	2018	16	2 cameras, 14 nights
Varanid Camera Survey	2018	10	8 cameras, 7 nights
Rocky Gorge Camera Survey	2018	22	2 cameras, 14 nights
Wetland Bird Survey	2018	7	1-4 point-counts
Riparian Bird Survey	2018	21	1-4 '20-minute' bird surveys
Spectacled Hare-wallaby Survey	2020	43	1 camera, 17 nights
Predator Camera Survey	2020	20	1 camera, 22 nights (first deployment) or 40 nights (second deployment); 620 camera trap nights total

**Box trapping was undertaken in conjunction with the 2017 standard survey, but the results were not used to calculate any metrics in this report.*

Survey design

Maps indicating the location and layout of survey sites on Pungalina-Seven Emu surveyed between 2017 and 2020 are provided in Figure 6. These surveys were based on a number of taxa-specific designs:

1) **Standard Trapping Survey**: a standardised fauna survey using live trapping and sensor cameras was conducted at 48 savanna woodland sites across Pungalina-Seven Emu, selected to represent the variety of habitat types found within this broad ecosystem type. This suite of sites was first surveyed in 2017, though some sites were established prior to 2017. These sites will be monitored every 2-3 years.
2) **Rocky Gorge Camera Survey**: cameras targeting the rocky gorge small-medium mammal guild were deployed at 22 rocky locations in 2018. Sites were selected on the basis of historical detections of target species; the Carpentarian Pseudantechinus, the Sandstone Pseudantechinus, the Rock Ringtail Possum and Wilkin's Rock-wallaby.
3) **Bandicoot Camera Survey**: sensor camera surveys were undertaken at 16 sites in 2018. Sites were situated at riparian locations where bandicoots were detected in previous surveys.
4) **Varanid Camera Survey**: sensor camera surveys were conducted in 2018. Cameras were deployed at ten sandy, relatively open riparian areas, such as those along river and creek banks and fringing permanent wetlands.
5) **Riparian Bird Survey**: 21 permanent sites were established in 2018 in riparian areas across the sanctuary to survey the bird fauna of this habitat.
6) **Wetland Bird Survey**: Complete counts of all wetland bird species using a telescope or binoculars were also conducted at seven permanent lakes and lagoons.
7) **Spectacled Hare-wallaby Survey**: sensor camera surveys were undertaken in 2020 at 43 sites situated at and near locations where the species had been previously detected.
8) **Predator Camera Survey**: sensor cameras were deployed at roads and creeks in 2020 to detect Dingos and feral cats.
9) **Wetland Condition Assessment Survey**: aerial surveys were conducted by helicopter at 28 sites in 2018, located mainly in the north and south of the sanctuary.


a
Savanna sites
Rocky sites
0 10 20 km
N
b
Bandicoot sites
Varanid sites
0 10 20 km
N
c
Skeleton Creek
Spectacled Hare-Wallaby cameras
0 2 4 km
N
d
Wetland bird surveys
Riparian bird surveys
0 10 20 km
N

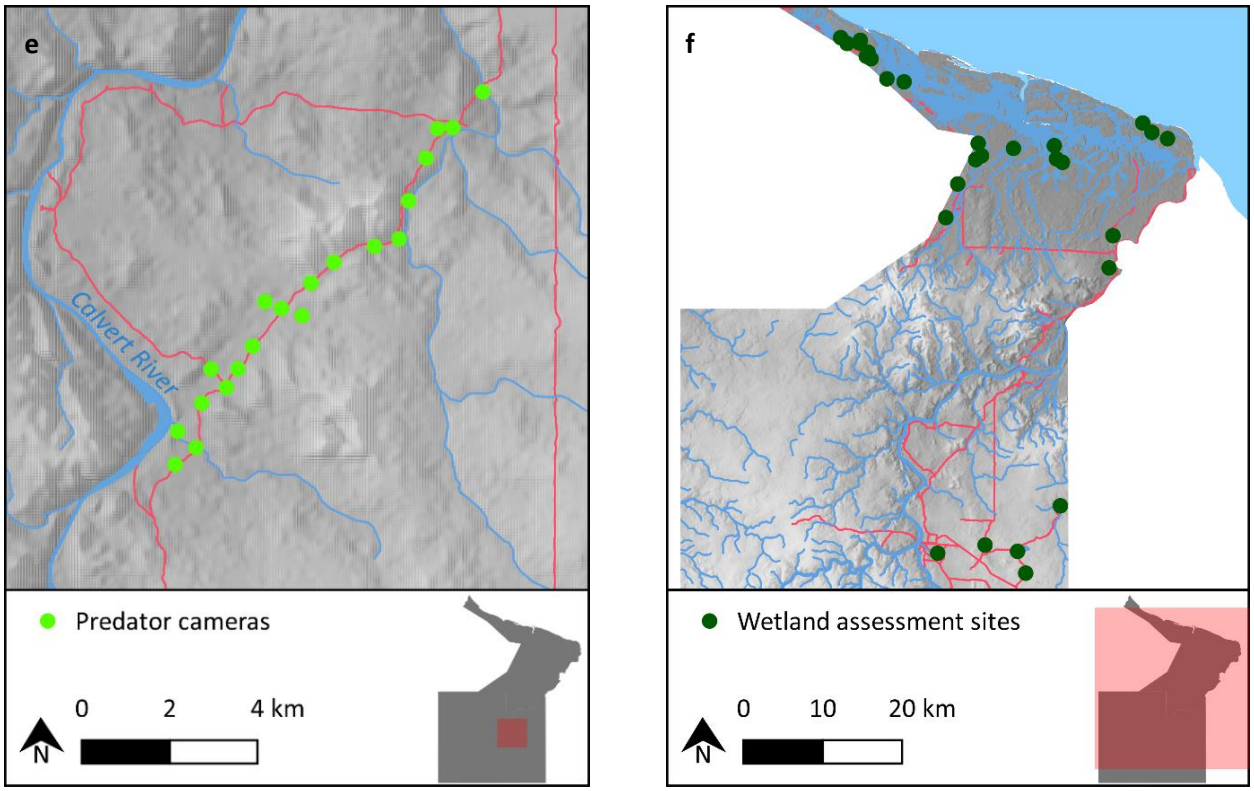


Figure 6. Maps indicating location and layout of survey sites on Pungalina-Seven Emu 2017-2020.
a) Savanna Standard Trapping Survey sites (2017) and Rocky Gorge Camera Survey sites (2018); b) Targeted camera arrays for Bandicoot and Varanid Surveys (2018); c) Targeted camera array for Spectacled Hare-wallaby survey (2020); d) Bird survey sites at wetlands and riparian locations, 2018; e) Predator Camera Survey array along road/ creeks (2020); f) Wetland Condition Assessment survey locations (2018).

Survey methods

Standard Trapping Survey (2017)

A pitfall array targeting small-medium reptiles was constructed, consisting of four pitfall traps (20 L plastic buckets 450 mm deep by 300 mm diameter) and six funnel traps, connected by 30 cm high drift fence erected in a 'T' shape (a 20 m and a 10 m section). Pitfalls were set near the end of each section of fence. Pairs of funnel traps were located at the centre of each section and covered with insulation. Traps were opened for three consecutive nights and days. Pitfall and funnel traps were checked early in the morning and again in the late afternoon.

Four Reconyx Whiteflash PC850 camera traps were deployed at each of the 48 standard live trapping survey sites and left in place for 14 nights. Each camera was set at a low angle to maximise good images of medium-sized mammals such as bandicoots and hare-wallabies. The camera faced a PVC baitholder secured with a tent peg, containing a bait ball composed of rolled oats, peanut butter and Dairy Krave. Two of the sensor cameras were also baited with Feralmone, a synthetic fermented egg lure spray. Cameras were set at approximately 50 cm height, with 2 m between the base of tree and the baitholder. Camera settings were: five photos per trigger, rapid-fire, high sensitivity, no delay between photos. Cameras were left in place for a minimum of 14 nights.

Rocky Gorge Camera Survey (2018)

Sensor-cameras were deployed at most of the 22 rocky gorge locations via helicopter and the others were accessed from tracks. At each site, two Reconyx PC850 Whiteflash cameras were set approximately 50 m apart. Cameras were set ~20 cm from the ground and slightly angled down to obtain a wide field of view, while excluding the area above the horizon. A PVC baitholder with standard bait (peanut butter, oats, vanilla, sardines) was pegged to the ground or secured beneath a rock ~90 cm from the camera. Camera settings were: five photos per trigger, rapid-fire, high sensitivity, no delay between photos. Cameras were left in place for a minimum of 14 nights.

Bandicoot Camera Survey (2018)

At each site, two Reconyx PC850 Whiteflash cameras were set approximately 50 m apart in riparian habitat. Cameras were set 100 cm off the ground, angled to point directly at the bait container. A laser pointer was used to ensure the camera was angled correctly. A PVC baitholder with standard bait was pegged to the ground or secured beneath a rock 150 cm from the base of the tree on which the camera was set. Camera settings were: five photos per trigger, rapidfire, high sensitivity, no delay between photos. Cameras were left in place for a minimum of 14 nights.

Varanid Camera Survey (2018)

In sandy, relatively open riparian areas, such as those along river and creek banks and fringing permanent wetlands, one Reconyx PC850 Whiteflash camera was set every 150 m, for up to 1,500 m sections. Ten sites were selected with eight cameras deployed at each site.

Cameras were set at an approximately 45° angle to the ground, with the camera aimed at a ground point ~1.3 – 2.0 m distant. Cameras were baited with one whole raw egg buried to 15 cm, one cracked open raw egg at the surface, a piece of raw beef and tinned tuna.

Cameras were deployed for a minimum of seven nights. If left in the field longer, data were used for seven nights and detections after that were retained as incidental records. Cameras were set at least five metres from and facing toward the water's edge, to ensure safety when deploying cameras in areas inhabited by estuarine crocodiles. Camera settings were: five photos per trigger, rapidfire, high sensitivity, no delay between photos.

Riparian Bird Survey (2018)

At each survey location, a survey plot of 250 x 80 m was surveyed by listening for and observing birds within the plot for 20 minutes, walking slowing along the centre of the plot (Figure 7).

If the riparian vegetation was less than 80 m in width, the length of the plot was adjusted accordingly to survey a two-hectare area.

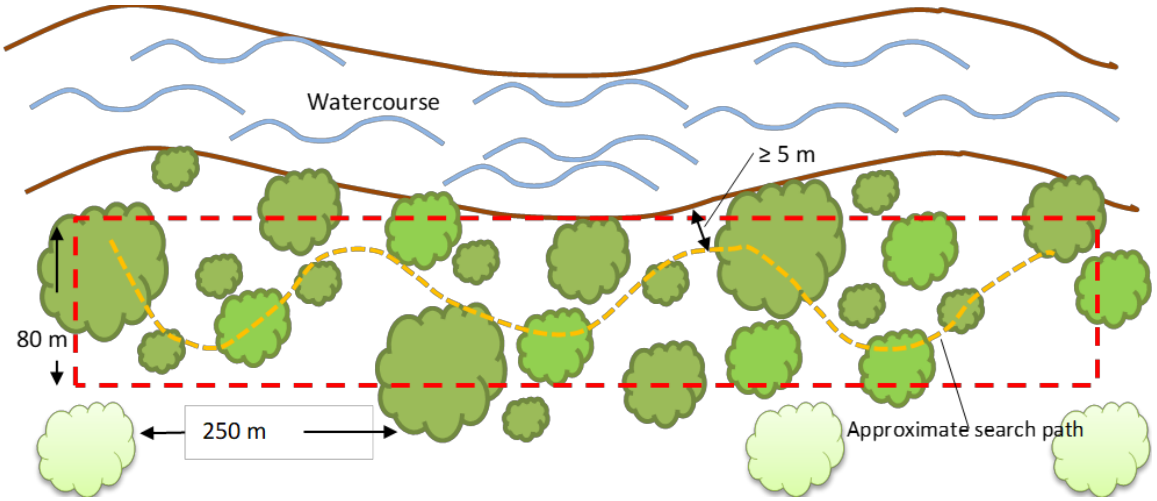


Figure 7. Survey method for riparian bird surveys

Each site was surveyed up to four times. Surveys were conducted after sunrise and before sunset, avoiding the heat of the day (usually 0700 – 1000 and 1600 – dusk). The four repeat surveys were completed across different times of the day for each site. Any birds observed outside the strict 20 minute time limit were not included in the survey count. If more than one person was available to conduct surveys, plots were split in half and surveyed for 10 minutes each half.

For each survey, the observer noted all individual birds seen or heard in the plot. Birds recorded as 'heard' were updated to 'seen' if observed later in the survey. Birds seen or heard outside the plot during the survey time, or seen flying overhead, were recorded as incidental records. However, common species were not recorded as incidental observations if this reduced the time available for recording species within the plot.

Wetland Bird Survey (2018)

Complete counts of all waterbird species were conducted on four consecutive days at road accessible sites. Single total counts were undertaken at helicopter accessible sites.

For each point count (Figure 8), the observer chose a location which: was a safe distance from the water's edge (to limit the danger posed by estuarine crocodiles), was not so close as to flush waterbirds, had the sun behind the observer, and with good visibility. If the entirety of the wetland was not visible, multiple observers assessed separate sections of the wetland. Results were then pooled into a total count. Observers worked systematically across the wetland, being careful not to recount areas already surveyed.

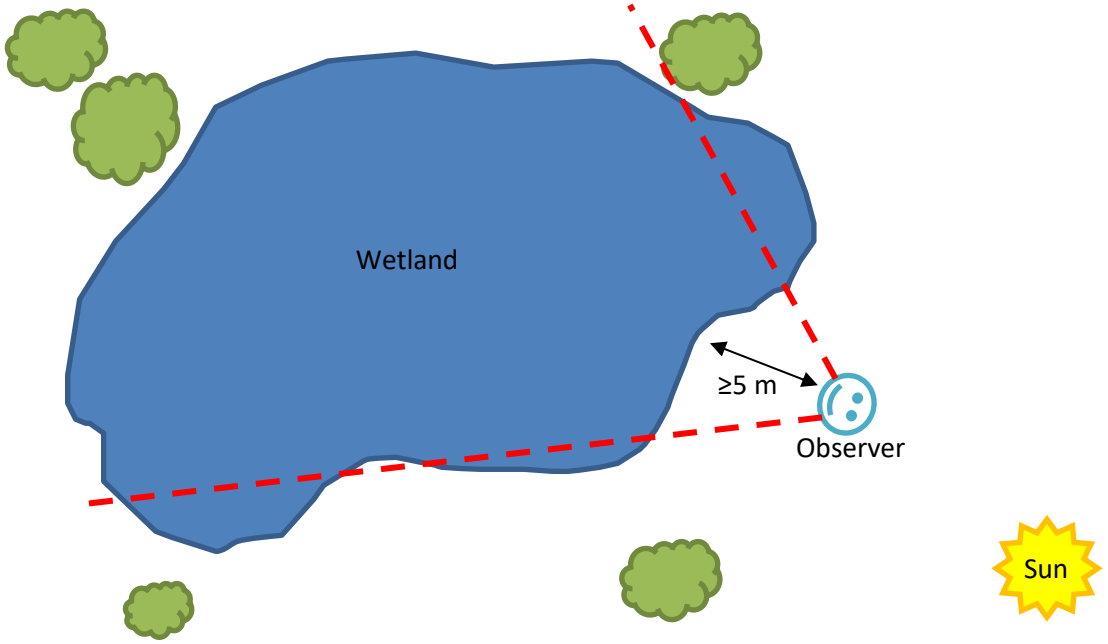


Figure 8. Survey method for wetland bird surveys

Spectacled Hare-wallaby Survey (2020)

Forty-three sensor cameras were set along the edge of the Skeleton Creek track. The camera array was structured to determine: a) persistence at a known site (grid of nine cameras centred around previous detection); b) presence in the immediate vicinity of previous detection (21 cameras spaced 200 m apart in suitable habitat along Skeleton Creek track; and c) presence in suitable habitat further afield (10 cameras spaced 1 km apart on eastern Skeleton Creek track, plus three cameras 200 m apart in a southern habitat patch) (Figure 6c; Figure 9). Reconyx HP2W Whiteflash cameras were set at 70 cm height. A baitholder with bait (peanut butter, oats and vanilla) was placed 150 cm from the base of the tree on which the camera was set, with the baitholder raised 20 cm from the ground on a metal stake. Cameras were in place for 17 nights.

Predator Camera Survey (2020)

Twenty Reconyx sensor cameras (18 Whiteflash and two Infrared) were deployed, unbaited, approximately 700 m apart along the 'Mystery Shovel Road' and on nearby creek-lines (Figure 6e) in mid-2020. Cameras were deployed in two sessions of 10 cameras each, for 40 days (first session) or 22 days (second session). Cameras were set level to the ground (i.e. not angled down), perpendicular to the road or creek-line, 50 cm above the ground. The first session of camera trapping was conducted from May - July and the second in July.

Wetland Condition Assessment Survey (2018)

Each wetland was assigned a rating of 0 – 4. The methodology is based on the approach developed by Russell-Smith and Bowman (1992) and used in Moran and Kanowski (2012). The method describes the severity and extent of the degree of damage caused by large animals by making a visual assessment of the impacts (e.g. pugging, grazing, wallows etc.). Impacts were assessed on a scale of 0 - 4 (0 = impacts absent, 1 = minor localised disturbance; 2 = minor widespread disturbance; 3 = severe but localised disturbance, 4 = severe and widespread disturbance). Although this score does not distinguish between damage intensity and extent nor damage caused by native or feral species, it provides a rapid, repeatable metric by which damage to these sensitive habitats can be monitored over time.

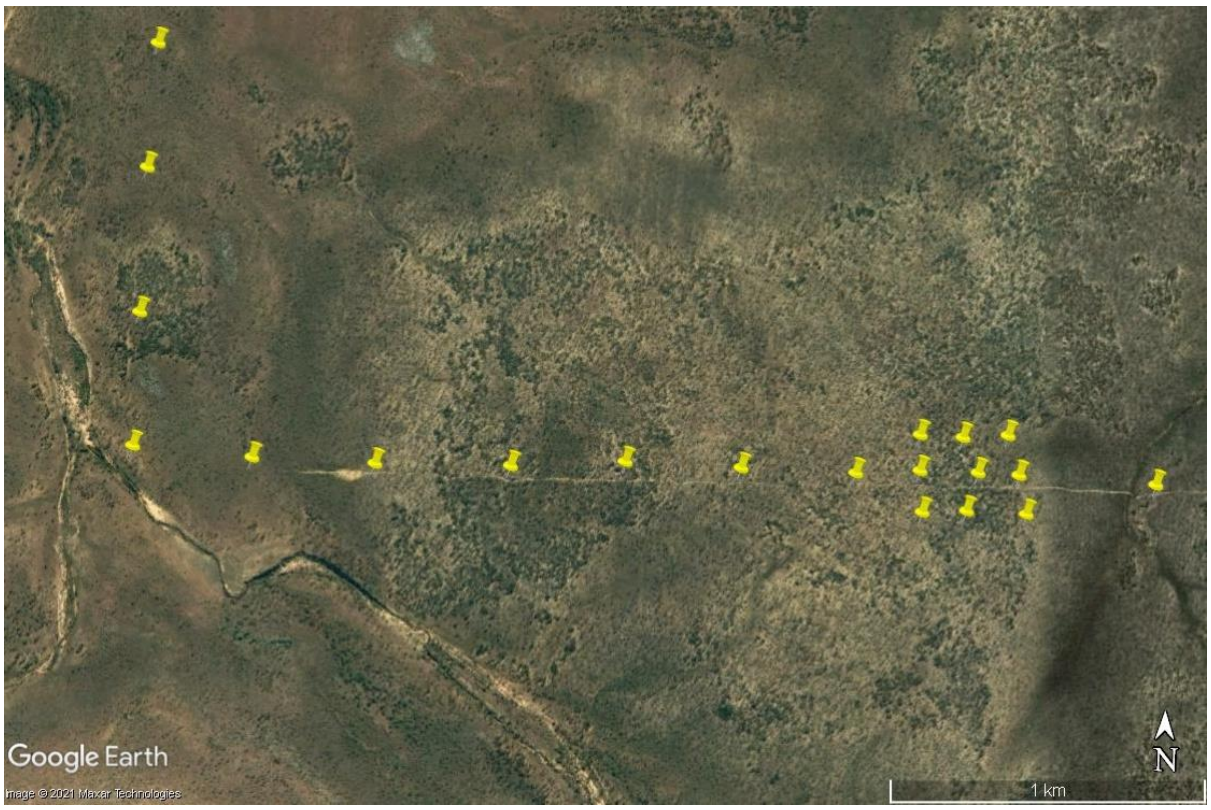


Figure 9. Grid of nine cameras around previous Spectacled Hare-wallaby detection, and 200 m spaced cameras in suitable habitat to the west

Analysis methods

Biodiversity and threat metrics

Camera images were manually reviewed and captures identified to species level where possible by a single observer. A 'capture event' for a species was defined as one record of that species per 12 hour period, and thus repeat same-species detections within a 12 hour period were removed. In instances where cameras were deployed beyond the minimum deployment period (e.g. 15 days when minimum deployment time was 14 days), any data collected after that time were excluded from analysis. Where a site consisted of multiple cameras, the data were pooled.

A 'site by species' matrix of abundance was generated for each survey, using individual animal records and standardised for survey effort (trap nights).

Averaged abundance (with standard error) was calculated as live captures or camera trap detections per 100 trap nights at each site, averaged across all sites. One trap night = one trap operating for one night.

For wetland bird surveys, abundance was calculated as the average number of individual birds per site. This was calculated by first, averaging the number of birds at each individual site across the four repeat survey sessions, and second, averaging this value across the seven wetland sites.

Occupancy was measured as the percentage of sites at which the taxon was detected.

For guild metrics, species richness was calculated for each site and averaged across sites (with standard error).

The mode was calculated for the wetland condition assessment scores across the 18 wetland survey sites.

Fire metrics

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

Results

Biodiversity indicators

Mammals

Small and medium mammals

Across all savanna trapping sites, a total of 12 species of small and medium mammal in total were detected with sensor cameras. Across all rocky sites, a total of 7 mammal species were recorded. Individual sites had low richness in general; on average less than 1 species per site at savanna sites, and 2 species per site at rocky sites (Table 3). There was low occupancy of the small-medium mammal guild across the savanna; with no small-medium mammals detected at more than half the sites.

Sites in rocky areas had twice the diversity and seven times the abundance of mammals compared with sensor camera surveys in savanna sites (Table 3). This was largely driven by a single abundant, often-present and easily detected species, the Common Rock-rat. This species was found at 83% of rocky sites, with an average abundance of 27.6 detections/ 100TN.

Table 3. Small and medium mammal metrics. Species richness is average number of species per site; abundance is the number of detections per 100 trap nights averaged across all sites; occupancy is the percentage of sites at which the species/ guild was detected.

Indicator	Year surveyed	Method	Species richness (±SE)	Abundance (±SE)	Occupancy
Carpentarian Pseudantechinus	2018	Rocky Gorge Camera Survey	-	1.9 ± 0.9	26%
Common Rock-rat	2018	Rocky Gorge Camera Survey	-	27.6 ± 4.7	83%
Spectacled Hare-wallaby	2020	Spectacled Hare-wallaby Survey	-	0	0%
Sandstone Pseudantechinus	2018	Rocky Gorge Camera Survey	-	1.1 ± 0.8	13%
Wilkin's Rock-wallaby	2018	Rocky Gorge Camera Survey	-	2.3 ± 1.3	26%
Northern Brown Bandicoot	2018	Bandicoot Camera Survey	-	19.9 ± 5.8	63%
Savanna small-medium mammals	2017	Standard Trap Survey (cameras)	0.8 ± 0.2	4.6 ± 1.4	44%
Rocky small-medium mammals	2018	Rocky Gorge Camera Survey	1.9 ± 0.2	35.4 ± 5.0	87%
Rock Ringtail Possum	2018	Rocky Gorge Camera Survey	-	0.2 ± 0.2	4%

These results represent metrics for the suite of 48 savanna sites and 22 rocky sites surveyed in 2017 and 2018 respectively.

The low species richness and moderately low abundance of small-medium mammals across the savanna sites may broadly reflect the general trend of declines in small-medium mammal populations across northern Australian savannas (Woinarski et al. 2011). However, further monitoring sessions are required before any inferences can be made in this regard. These metrics may also indicate substantial differences in the species assemblages across the 48 sites surveyed, which represent a variety of ecosystems.

Northern Brown Bandicoot occupancy (63% of sites) and abundance (19.9/ 100TN) were relatively high (Table 3).

The Spectacled Hare Wallaby was not detected in the 2020 targeted survey for this species. This is potentially concerning given this species had been detected at the same location in three previous surveys. Anecdotally, from AWC properties and elsewhere, the Spectacled Hare Wallaby can be difficult to detect.

The Rock Ringtail Possum had low occupancy (it was detected at 4% of sites) and very low abundance (0.2/ 100 TN). In future monitoring sessions for these species, effort will focus upon establishing presence at a set of sites, and may include alterations to methods, for example by increasing the number of cameras deployed at a site or extending deployment periods, or alternatively by searching for sign (its distinctive scat).

Large herbivores

Large macropods were recorded at very low richness and abundance across the savanna sites (Table 4). No large macropods were detected at almost 90% of sites. The low occupancy may reflect a very low density of these species in the landscape, although further surveys are needed to better clarify the status of this group. A relatively low species richness measure is to be expected, as there are only four possible species in this guild and they tend to occur in different habitat types in the landscape; for example Agile Wallabies (*Macropus agilis*) are common in riparian habitats, and rarely overlap with Common Wallaroos (*Macropus robustus*) which prefer rocky and hilly country.

Table 4. Large herbivore metrics. Species richness is average number of species per site; abundance is the number of detections per 100 trap nights averaged across all sites; occupancy is the percentage of sites at which large macropods were detected.

Indicator	Year surveyed	Method	Species richness (±SE)	Abundance (±SE)	Occupancy
Large macropods	2017	Standard Trapping Survey (cameras)	0.1 ± 0.05	0.2 ± 0.1	13%

Mammalian predators

Dingos were abundant and present at most survey sites (Table 5). These results are similar to those reported by previous surveys (noting designs were not identical): for example, Kemp et al. (2014) detected Dingoes on 8 of 10 camera trap sites; Kemp et al. (2015) detected Dingoes on 37 of 40 camera trap sites; Mulder et al. (2016) from 32 of 41 camera traps sites.

Table 5. Mammalian predator metrics. Abundance is the number of detections per 100 trap nights averaged across all sites; occupancy is the percentage of sites at which dingos were detected.

Indicator	Year surveyed	Method	Abundance (±SE)	Occupancy
Dingo	2020	Road and creek Predator Camera Survey array	10.3 ± 2.3	65%

Reptiles

At savanna sites, 35 reptile species were detected in total during live trapping. Reptiles occurred in moderate numbers and at moderate diversity; on average there were 3.3 reptile species per site, at an abundance of 6.0/ 100TN (Table 6).

Table 6. Reptile metrics. Species richness is average number of species per site; abundance is the number of live captures or detections per 100 trap nights averaged across all sites; occupancy is the percentage of sites at which the species/ guild was detected.

Indicator	Year surveyed	Method	Richness (±SE)	Abundance (±SE)	Occupancy
Savanna reptiles	2017	Standard Trapping Survey	3.3 ± 0.2	6.0 ± 0.7	92%
Yellow-spotted Monitor	2018	Varanid Camera Survey	-	0	0%
Merten's Water Monitor	2018	Varanid Camera Survey	-	1.7 ± 1.1	30%
Terrestrial monitors	2018	Varanid Camera Survey	0.3 ± 0.2	1.7 ± 1.1	30%

The targeted Varanid Camera Survey generated low numbers of detections (Table 6). Only one species was detected, Merten's Water Monitor, which was present at 30% of sites, at a low average abundance of less than 2/ 100TN (Table 6). Future surveys will provide greater insight into the status of the terrestrial monitor group on Pungalina-Seven Emu, including whether additional targeted surveys are required to detect those species that are difficult to survey using the standard monitor array. No Yellow-spotted monitors were detected at any sites. This species, however, has very rarely been detected with any survey method in the past; only one record exists (from 2016) in the sanctuary's fauna database.

Birds

Fifty-one species of bird were recorded in total at wetland sites and 46 species at riparian sites. Species richness was similar for both survey types (Table 7). Wetland birds were extremely variable in number between sites (ranging from 10 to 1,023 individuals per site). This was due to the variable presence of large flocks (e.g. of ducks), which may number in their hundreds.

Purple-crowned Fairywrens were present at all riparian sites surveyed.

Table 7. Bird metrics. Species richness is average number of species per site; abundance is the average number of individuals per site; occupancy is the percentage of sites at which the species/ guild was detected.

Indicator	Year surveyed	Method	Species richness (±SE)	Abundance (±SE)	Occupancy
Eastern Purple-crowned Fairywren	2018	Riparian Bird Survey	-	2.2 ± 0.6	100%
Wetland birds	2018	Wetland Bird Survey	10.1 ± 1.6	175.5 ± 127.1	-
Riparian birds	2018	Riparian Bird Survey	9.2 ± 0.8	-	-

Ecological processes

Wetland health

Wetland health appears to be moderately good; the mode of the wetlands surveyed in 2018 was '1' (minor localised disturbance; Table 8). In future, the wetland condition assessment methodology may be expanded to include recording additional variables of condition, remote-sensing or drone-mapping.

Table 8. Ecological process metrics. Method = scale rating of 0 - 4 (0 = impacts absent, 1 = minor localised disturbance; 2 = minor widespread disturbance; 3 = severe but localised disturbance, 4 = severe and widespread disturbance).

Indicator	Year surveyed	Method	Value (Mode)
Wetland Health	2018	0-4 scale	1

Threat indicators

Feral predators

Cats were detected at around one-third of sites, but at low abundance (Table 9). These detections were generally from cameras located on creek-lines rather than on roads. These abundance and occupancy measures are substantially lower than for Dingos surveyed with the same camera array (see Table 5).

Table 9. Feral predator metrics. Abundance is the number of detections per 100 trap nights averaged across all sites; occupancy is the percentage of sites at which cats were detected.

Indicator	Year surveyed	Method	Abundance (±SEM)	Occupancy
Feral cat	2020	Predator Camera Survey	1.7 ± 0.6	35%

Fire

In 2020, a total of 15% of the sanctuary was burnt: 7% in early dry season fire and 8% in late dry season fire. The mean distance to unburnt vegetation and the mean distance to vegetation unburnt by a late dry season fire for 3 or more years both remained well below baseline levels (Table 10). The prescribed burning program on Pungalina-Seven Emu has resulted in substantial improvements from baseline levels including reducing the extent of late dry season fire (Webb et al. 2020).

Table 10. 2020 Fire metrics. Baseline values for metrics are the average for the years immediately prior to acquisition of Pungalina-Seven Emu by AWC: i.e., 2000-2008, for annual metrics, and 2002-2008, for 3 year metrics. AWC management values for metrics are the average for the years following acquisition of Pungalina-Seven Emu by AWC: i.e., 2009 onwards, for annual metrics, and 2011-2020, for 3 year metrics.

Metric	**Baseline** 2000/02 – 2008	**AWC management** 2009/11 - 2020	**2020 result**	**Change since AWC management**
Area burnt by early dry season fire (% of property)	5	15	7	↑
Area burnt by late dry season (LDS) fire (% of property)	21	7	8	↓
Cumulative extent of sanctuary burnt by LDS fire in previous three years (% of property)	58	19	30	↓
Mean distance to unburnt vegetation (km)	1.5	0.8	0.7	↓
Mean distance to vegetation unburnt by LDS fire for three or more years (km)	2.5	0.8	0.9	↓

Discussion

Pungalina-Seven Emu has important populations of many small and medium mammals and a high diversity of reptiles. It contains regionally significant wetlands supporting large bird populations, and riparian zones home to the threatened Merten's Water Monitor and the Purple-crowned Fairywren.

A significant amount of survey work has been conducted on Pungalina-Seven Emu since 2009. These surveys were conducted largely for the purpose of inventory; that is, understanding which species live and utilise resources on the sanctuary. This has resulted in a sound knowledge of which species are found on Pungalina-Seven Emu, and where they occur.

This report details the results of a variety of surveys conducted between 2017 and 2020 to assess the ecological health of Pungalina-Seven Emu. Overall, small-to-medium mammal diversity was low, with slightly higher diversity and abundance in rocky habitats, with the latter driven by high detection rates of the Common Rock-rat. These results may reflect low abundance and richness of mammals in the landscape generally, and differences in the species assemblage across the variety of habitat types surveyed. With regards to individual indicator species, the results were varied. Northern Brown Bandicoots and Common Rock Rats had high abundance and occupancy, particularly relative to other indicator species. There were no detections of the Spectacled Hare Wallaby during the 2020 targeted survey. This cryptic species can be difficult to detect and alterations to methods to increase detection rates are under consideration.

Reptile diversity and abundance were moderate across savanna sites.

In 2018, bird surveys detected 10 species on average at wetland sites and 9 species on average at riparian sites. The Purple-crowned Fairy-wren was detected at all 21 riparian sites.

With regards to threats, feral cats were detected on over one-third of survey sites.

The Ecohealth monitoring results presented here constitute baseline data. Few inferences can be made at this stage on the current status of the indicator species and guilds. Assessing trends that indicate changing populations or threats on the sanctuary, as well as the influence of extrinsic factors such as rainfall, will require long-term surveys. Information obtained from the surveys will allow AWC to determine areas for targeted research or management interventions.

Moving forward, the developing Ecohealth program on Pungalina-Seven Emu will focus on selecting appropriate and efficient methods for priority indicators, then repeating surveys at consistent sites over time, as well as completing baseline feral herbivore surveys. The results discussed above will assist in the development of these programs.

Acknowledgments

AWC's Ecohealth Program is only possible because of the generosity of AWC's supporters.

AWC acknowledges the Yanyuwa and Garawa people, the Traditional Custodians, of Garawa and Yanyuwa Country on which Pungalina-Seven Emu Sanctuary resides. We also acknowledge their continuing connection to land, culture and community. We pay our respects to Yanyuwa and Garawa Elders past present and emerging.

References

Bureau of Meteorology (2021) Climate statistics for Australian locations: Wollogorang.

Kanowski J, Jensen R, Lloyd R, Middleton J, Lawler W, Legge S (2009) *Wildlife Survey of Pungalina – Seven Emu.* Australian Wildlife Conservancy.

Kanowski J, Joseph L, Kavanagh R, Fleming A (2018) Designing a monitoring framework for Australian Wildlife Conservancy, a national conservation organisation. In: *Monitoring Threatened Species and Ecological Communities* (Eds S Legge, DB Lindenmayer, NM Robinson, BC Scheele, DM Southwell, BA Wintle) pp 241-253. CSIRO, Melbourne.

Kanowski J, Mulder E, Jensen R (2011) *Pungalina – Seven Emu Wildlife Sanctuary: 2011 Survey Report*. Australian Wildlife Conservancy.

Kanowski J, Mulder E, Jensen R, Lloyd R, Murphy S, Legge S (2010) *Pungalina – Seven Emu Wildlife Survey May-June 2010*. Australian Wildlife Conservancy.

Kemp J, Mulder E, Jackson C, Barnett G, Kanowski J (2016) *Pungalina - Seven Emu Wildlife Sanctuary Ecological Survey Report 2015*. Australian Wildlife Conservancy.

Kemp J, Mulder E, Jensen R, Kanowski J (2015) *Pungalina - Seven Emu Wildlife Sanctuary Ecological Survey Report 2014*. Australian Wildlife Conservancy.

Moran C, Kanowski J (2012) Report on joint ecological survey by AWC and Garawa Rangers, 2012. Australian Wildlife Conservancy.

Mulder E, Barnett G, Jensen R, Kanowski J (2014) *Pungalina-Seven Emu Fauna Survey Report 2013*. Australian Wildlife Conservancy.

Mulder E, Barnett G, Zimny A, Kemp J, Kanowski J (2017) *Pungalina -Seven Emu Wildlife Sanctuary Survey Report 2016*. Australian Wildlife Conservancy.

Mulder E, Jensen R, Heathcote J, Kanowski J (2012) *Coastal Survey of Pungalina – Seven Emu November 2011*. Australian Wildlife Conservancy.

Russell-Smith J, Bowman DMJS (1992) Conservation of monsoon rainforest isolates in the Northern Territory, Australia. *Biological Conservation* 59, 51–63.

Webb T, Cooper, T, Lewis F, Mulder E, Watson A, White T, Kanowski J (2020) *Pungalina-Seven Emu Wildlife Sanctuary: 2019 Fire Pattern Analysis*. Australian Wildlife Conservancy, Perth WA.

Woinarski JCZ, Legge S, Fitzsimons JA, et al. (2011) The disappearing mammal fauna of northern Australia: context, cause, and response. *Conservation Letters* 4, 192-201.

Zaar U (2009) Gulf Region Water Study: Robinson and Calvert Rivers. NRETAS, Darwin.

Enquiries should be made to John.Kanowski@australianwildlife.org