

Kalamurina Wildlife Sanctuary Ecohealth Report 2020



Summary

Australian Wildlife Conservancy (AWC) has implemented an Ecological Health Monitoring Program (Ecohealth) to measure the changes in ecological health on Kalamurina Wildlife Sanctuary. This report provides information on the biodiversity and threat indicators monitored at Kalamurina; including a summary of the rationale for selecting indicators, the methods used for their survey, the calculation of metrics, and the status of those indicators in 2020 and trends in their values over time (where possible). Values of metrics derived in this report were based on data collected from 2009 to 2020. The metrics and their values are summarised in the accompanying Ecohealth Scorecard.

To date, on Kalamurina, birds and threatened species have been monitored annually, while the terrestrial vertebrate fauna survey is planned for every third year, alternating with related surveys at other sanctuaries in the region. Environmental change in arid environments is usually slow enough that surveys are not necessarily required every year.

In 2020, a bird survey, tracking survey and a terrestrial vertebrate fauna trapping survey were conducted on Kalamurina, however, the trapping survey was only partially completed due to Covid-related travel restrictions and adverse weather conditions. In total, survey effort in 2020 involved 960 trap nights, 207 bird surveys, 65 track and sign surveys, and four vegetation surveys at the permanently established monitoring sites.

A total of four species of native mammals, 12 species of reptiles and 110 species of birds were recorded on Kalamurina during the 2020 surveys. The abundance and species richness of small mammals and reptiles on Kalamurina is highly correlated with rainfall. Numbers recorded in 2020 were at the lower end of the cycle, an unsurprising outcome given the preceding years of severe drought. Nevertheless, two threatened mammals, Crest-tailed Mulgara and Dusky Hopping Mouse were detected at 46% and 35% of tracking sites, respectively, with both species being frequently detected at many of those sites. The number of bird species was higher in 2020 than recorded previously, with consistent survey effort between survey periods.

In 2020, following several very dry years, the region around Kalamurina returned to average rainfall, and there was a small flow in Warburton Creek. The higher rainfall likely had a positive influence on some of the survey results, such that some nomadic bird species were recorded, and resident birds and some small mammals and reptiles were more active.

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Cover photograph: Kalamurina dune and swale landform. AWC/David Roshier

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 is the first in the series of annual Ecohealth Reports for Kalamurina Wildlife Sanctuary (referred to here as Kalamurina). The companion Ecohealth Scorecard presents the indicators and their metrics in a summary format.

Kalamurina Wildlife Sanctuary

Kalamurina is located in north-eastern South Australia and is 667,000 ha in extent (Figure 1). It is one of AWC's largest properties and amongst the largest private conservation areas in the world. Kalamurina is adjacent to the Simpson Desert Regional Reserve to the north and to the Kati Thanda - Lake Eyre National Park to the south.

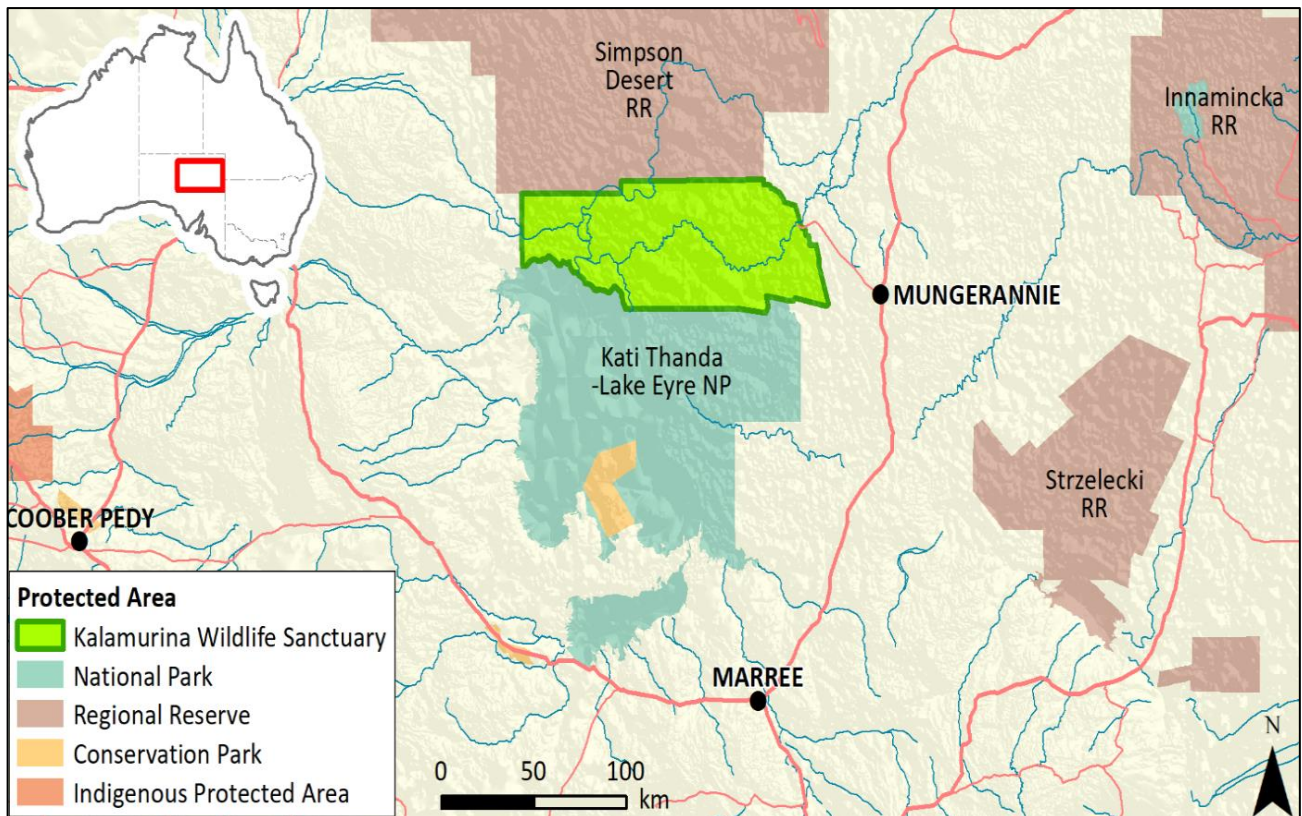


Figure 1. Location and regional context of Kalamurina Wildlife Sanctuary in north eastern South Australia

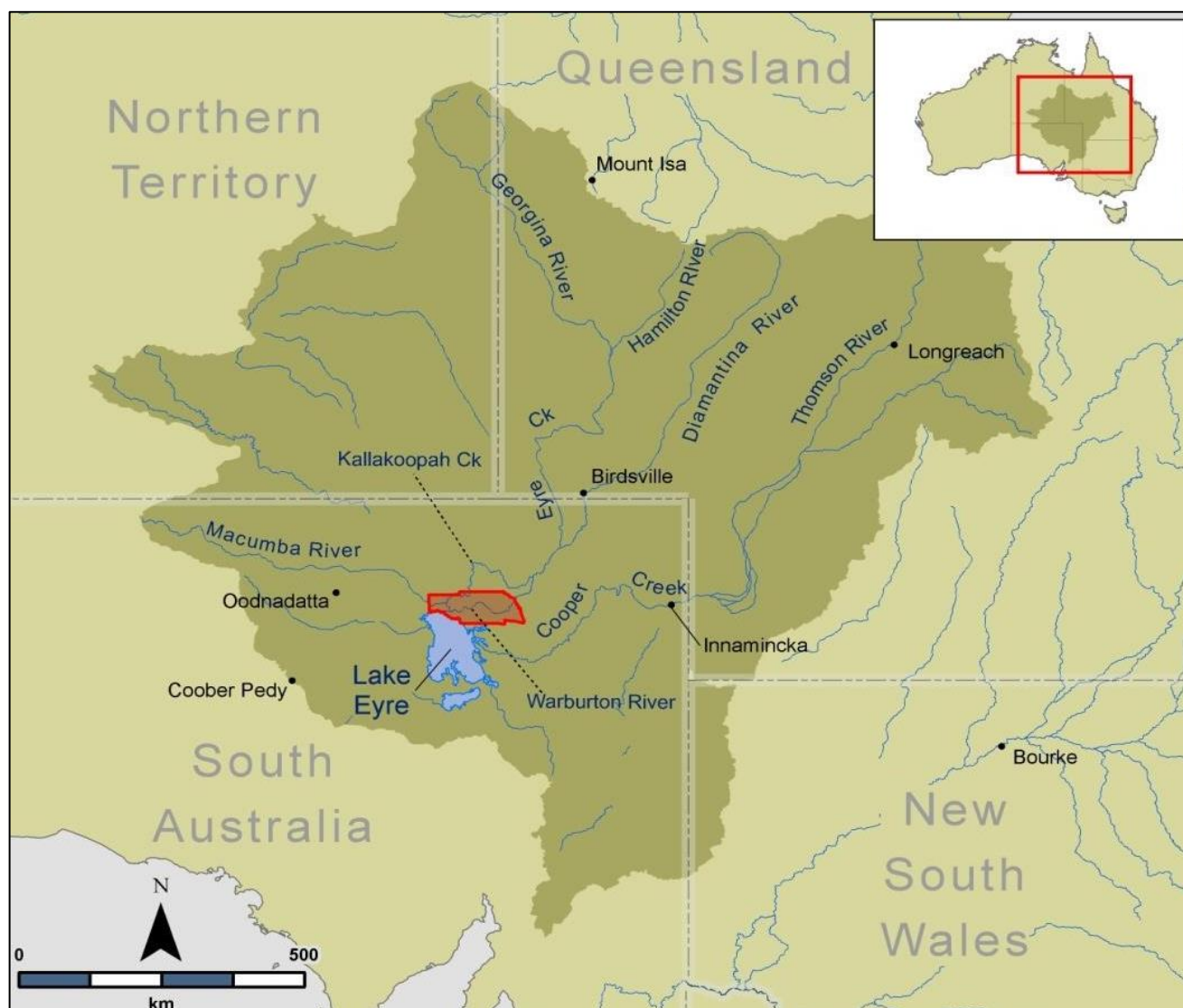


Figure 2. Location map of Kalamurina Wildlife Sanctuary in relation to major watercourses within the Lake Eyre Basin (darker shaded area)

Kalamurina was acquired from private pastoral interests in late 2007 and comprises two pastoral leases: Crown Lease Pastoral No. 2412 (Kalamurina) and Crown Lease Pastoral No. 2534 (Kallakooah West). Kalamurina is notable for its contribution to the protection of the ecosystems of the Simpson Strzelecki Dunefields Bioregion (IBRA 7.0). In particular, lower reaches of three significant creeks, Warburton, Kallakooah and Macumba Creek, meander through the sanctuary and terminate in Kati Thanda - Lake Eyre. The sanctuary also protects a small section of the Channel Country bioregion. It occupies a key position within the Lake Eyre Basin (Figure 2).

Pastoral occupation in the north-east of SA began in the northern extremities of the Flinders Ranges in the 1850s. The Cowarie lease (part of which is now on Kalamurina) was taken up in 1875. The *Crown Lands Consolidation Act* of 1878 required that leases were to be stocked, and kept stocked, for the term of the lease. The Kalamurina property consists of two separate pastoral leases that have been run as one: Kalamurina and Kallakooah West. With an average annual rainfall of 145 mm and no permanent surface water, pastoral development and occupation was intermittent until the development of the Poonarunna Well No 1 – drilled for oil exploration in the 1960s – as a bore to supply water from the Great Artesian Basin. There were long periods when no pastoralism was occurring on the property, even after the development of the bore, particularly on Kallakooah West where there is no water. The South Australian Pastoral Board had a maximum stocking rate of 4,650 cattle equivalents ($0.52/\text{km}^2$) for the property – 4,000 for the Kalamurina lease and 650 for the Kallakooah West lease. From stock returns, the 20-year average from 1980-99 was 1,540 cattle equivalents ($0.22/\text{km}^2$; Kutsche and Jay, 2000). In the mid-1980s, an area near the bore was developed for the experimental growing of irrigated lucerne.

Kalamurina protects more than 205 native plant species, several of which have state conservation status (National Parks and Wildlife ACT 1972). Kalamurina contains nine broad vegetation communities (Figure 3). The most extensive vegetation community is the Sandhill Canegrass (*Zygochloa paradoxa*) tall hummock grassland +/- emergent *Acacia* spp., *Senna* spp., *Dodonaea* spp., and *Hakea* spp. that occupies 82% of the total sanctuary area. This vegetation community dominates the extensive dune and swale land system on Kalamurina with Sandhill Canegrass more common and shrubs less common on the dune crests and slopes while the mixed species shrubs are more common and the Sandhill Canegrass less common on the inter-dune areas.

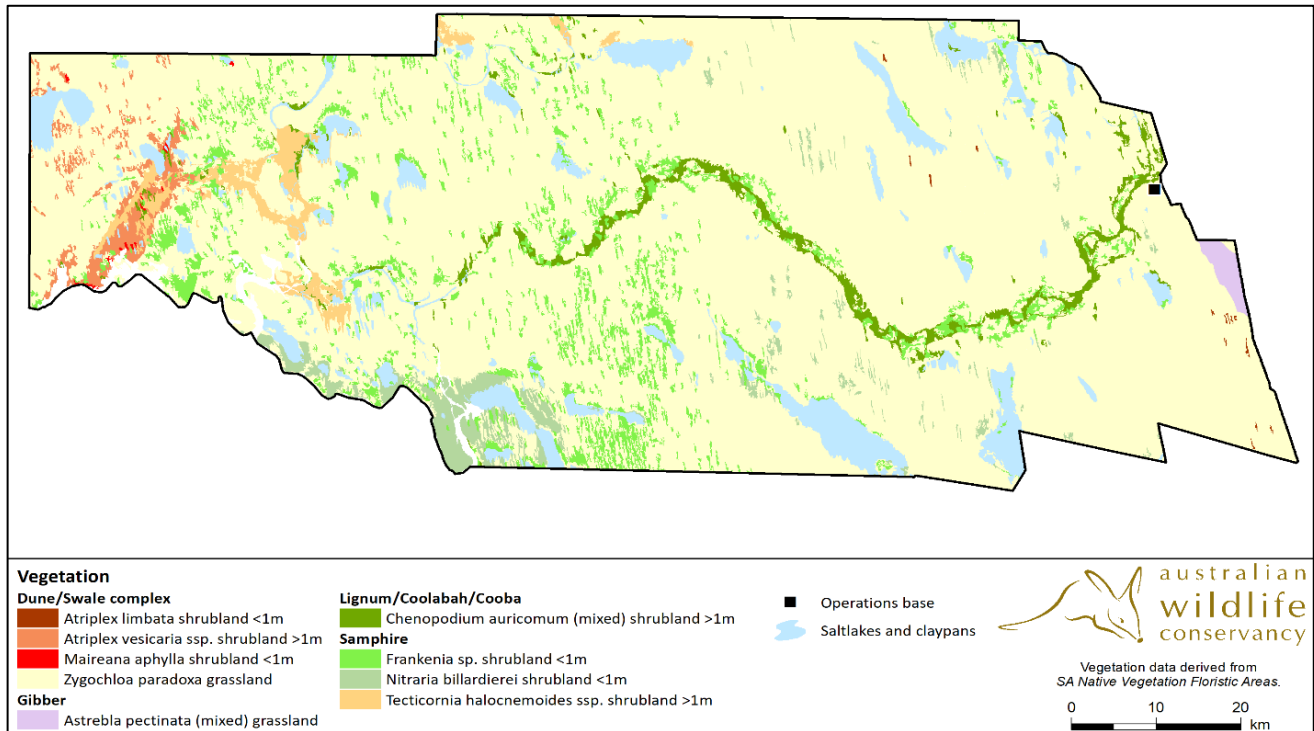


Figure 3. Vegetation communities of Kalamurina Wildlife Sanctuary (based on SA DEWNR mapping)

Over 263 species of native vertebrates are currently known or considered likely to occur on Kalamurina. These include 23 mammal, 169 bird, 57 reptile, 4 frog and 12 fish species. Twenty of these species are listed as threatened on the federal (Environment Protection and Biodiversity Conservation Act 1999) or state (National Parks and Wildlife Act 1972) legislation.

Aboriginal cultural knowledge (Aiston and Horne, 1924), and the collecting records of early naturalists such as Spencer (1896), Morton and Mulvaney (1996), confirm that Kalamurina's native mammal fauna was much more diverse prior to European occupation. The presence of some mammal species prior to European occupation is reasonably well known but for others it needs to be inferred from records outside of the region and from present known habitat requirements of the species. Based on this, approximately 13 species have been lost from Kalamurina: seven of which are globally extinct and six being regionally extinct. There are several species of threatened small mammals known or potentially extant on Kalamurina, two of which are included in performance metrics - Crest-tailed Mulgara (*Dasycercus cristicauda*) and Dusky Hopping Mouse (*Notomys fuscus*).

The Bush Stone-curlew (and possibly the Plains Wanderer) are the only bird species thought possible to have become extinct in the Simpson Desert Dunefields since European settlement. There are several species of threatened birds potentially extant on Kalamurina including the Grey Grasswren (*Amytornis barbatulus*) and Night Parrot (*Pezoporus occidentalis*).

Early knowledge of reptiles, amphibians and fish is poor in the region with little survey work undertaken until the late 1960s. It is thought that no species from any of these groups have become extinct in the Simpson Desert Dunefields.

AWC began an ecological monitoring program on Kalamurina in 2008. Kalamurina is a very large, remote sanctuary with limited access and what can be extreme climatic conditions. It is also bisected in an east-west

direction by the Warburton Creek which carries flood waters from higher in the catchment through the sanctuary to Kati Thanda – Lake Eyre. All of these factors make it a difficult place to plan and safely conduct surveys regularly. Some surveys have been planned and then cancelled due to rainfall or flooding and others have begun but cancelled before scheduled completion because of adverse weather, usually rain. Bird surveys have been completed most years since 2008, but the terrestrial vertebrate fauna survey has been conducted more erratically.

Climate and weather summary

Kalamurina is located in an arid climate zone with infrequent and erratic rainfall. Long-term annual average rainfall is 164 mm, the highest recorded annual rainfall is 434 mm in 2016 and the lowest recorded annual rainfall is 29 mm in 2018 (Figure 4). Rainfall in the area is extremely variable. Following on from 2016, where the region experienced one of the highest rainfall events in the last ten years, the next few years were very dry (2017 to 2019). In 2020, annual rainfall returned to being aligned with the long-term average. The average evaporation rate is extremely high (over 3,000 mm/ year), far exceeding rainfall.

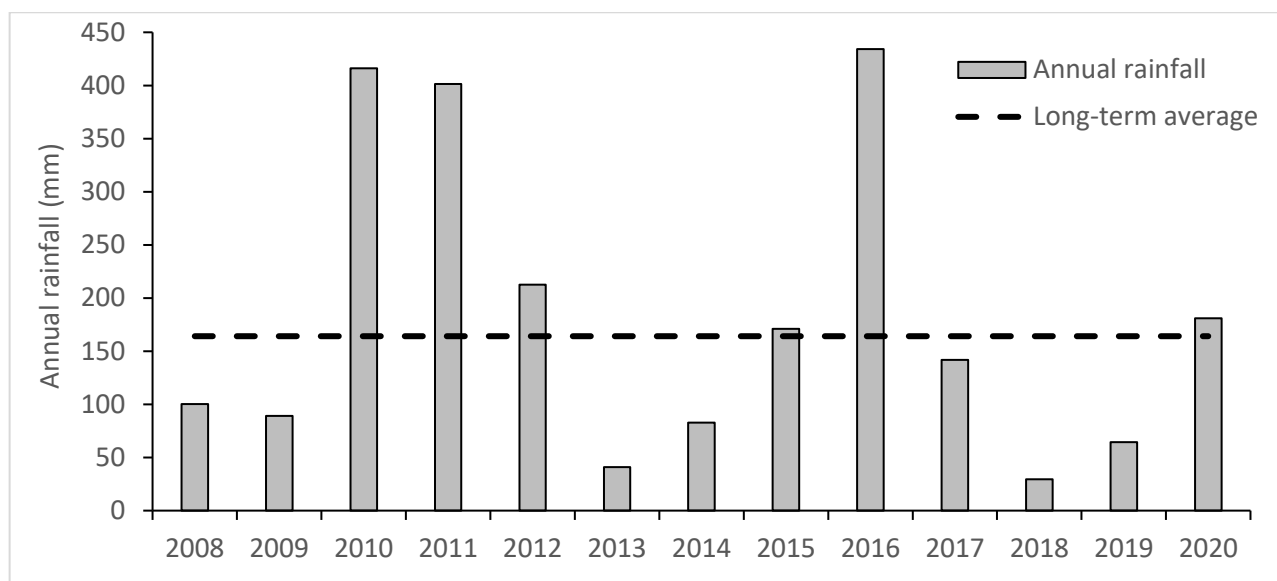


Figure 4. Annual rainfall recorded at Kalamurina Wildlife Sanctuary with long-term average

Continuous temperature records for Kalamurina have not been kept. The closest official BOM weather station for which a long and continuous record is available is at Oodnadatta, 140 km north-west of Kalamurina's western boundary (Figure 5). The highly uncertain nature of rainfall in the Simpson-Strzelecki region drives an erratic pattern of ecosystem processes, which undergo long resting periods interspersed with eruptions of growth and reproduction.

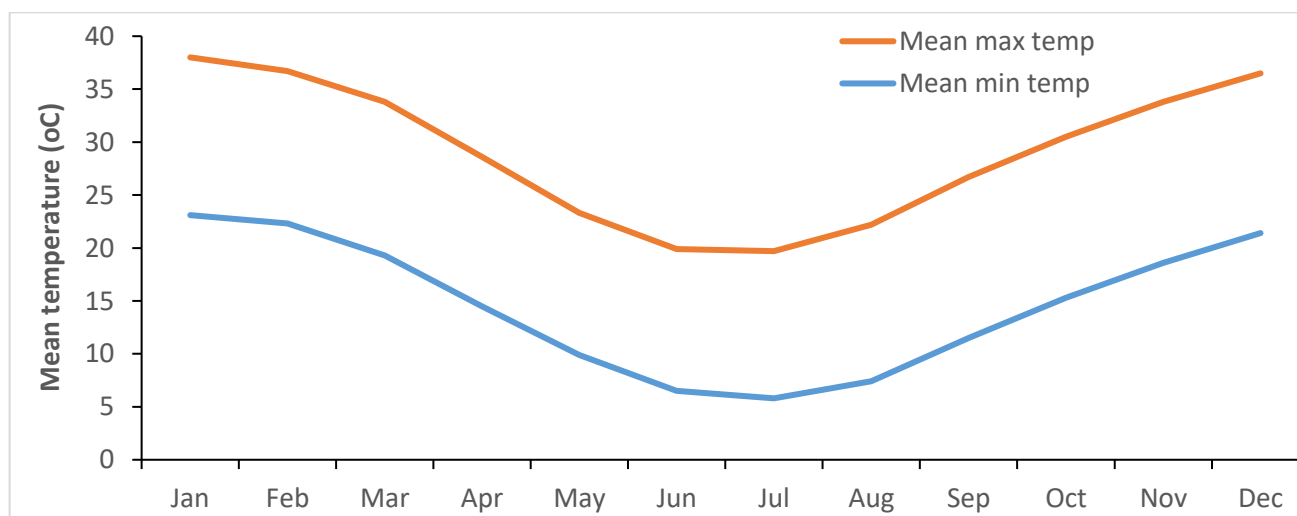


Figure 5. Monthly mean maximum and mean minimum temperatures recorded at Oodnadatta, indicative for Kalamurina

Methods

Indicators and metrics

Biodiversity and threat indicators selected for monitoring Ecohealth on Kalamurina are listed in Tables 1 and 2, along with the rationale for their selection, associated metrics, and survey methods used to obtain the required data.

Table 1. The biodiversity indicators for Ecohealth Monitoring Program on Kalamurina Sanctuary in 2020.

Rationale for selection: T = threatened or declining; D = strong driver of ecosystem function; S = surveillance monitoring. Metric definitions: Abundance = number of individuals/100 trap nights [or site]; occupancy = proportion of sites recorded; richness = mean number of species/site.

Indicator	Rationale			Survey method	Metric/s
	T	D	S		
Mammals					
Small-medium mammals					
Crest-tailed Mulgara (<i>Dasyercus cristicauda</i>)	*		*	Tracking surveys	Occupancy
Dusky Hopping Mouse (<i>Notomys fuscus</i>)	*			Tracking surveys	Occupancy
Desert Mouse (<i>Pseudomys desertor</i>)			*	Box traps, pitfall traps	Abundance, Occupancy
Small-medium mammals – all	*		*	Box traps, pitfall traps	Abundance, Occupancy
Small-med mammals (Dasyurids – guild)	*		*	Box traps, pitfall traps	Abundance, Occupancy
Small-med mammals (Rodents – guild)	*		*	Box traps, pitfall traps	Abundance, Occupancy
Reptiles					
Small-medium-sized reptiles					
Pale-rumped Skink (<i>Ctenotus regius</i>)			*	Pitfall traps, funnel traps	Abundance, Occupancy
Bynoe's Gecko (<i>Heteronotia binoei</i>)			*	Pitfall traps, funnel traps	Abundance, Occupancy
Painted Dragon (<i>Ctenophorus pictus</i>)			*	Pitfall traps, funnel traps	Abundance, Occupancy
Reptiles – all (less large varanids & snakes)			*	Pitfall traps, funnel traps	Abundance, Richness
Reptiles – skinks (guild)			*	Pitfall traps, funnel traps	Abundance, Richness
Reptiles – agamids (guild)			*	Pitfall traps, funnel traps	Abundance, Richness
Reptiles – geckos (guild)			*	Pitfall traps, funnel traps	Abundance, Richness
Birds					

Indicator	Rationale			Survey method	Metric/s
	T	D	S		
All birds			*	Standard bird survey: 20-min counts	Mean abundance, mean richness
Honeyeaters - guild			*	Standard bird survey: 20-min counts	Mean abundance, Occupancy
Woodland birds - guild			*	Standard bird survey: 20-min counts	Mean abundance, Occupancy
Ground active birds - guild			*	Standard bird survey: 20-min counts	Mean abundance, Occupancy

Table 2. Threat indicators for Ecohealth Monitoring Program for Kalamurina Sanctuary.

Indicator	Rationale	Survey method	Metric/s
Feral predators			
Cat (<i>Felis catus</i>)	Major threat to wildlife	Track and Sign	Occupancy
Fox (<i>Vulpes vulpes</i>)	Major threat to wildlife	Track and Sign	Occupancy
Feral herbivores			
Camel (<i>Camelus dromedarius</i>)	Threat to wildlife, vegetation	Track and Sign	Occupancy
Cattle (<i>Bos taurus</i>)	Threat to wildlife, vegetation	Track and Sign	Occupancy
Rabbit (<i>Oryctolagus cuniculus</i>)	Threat to wildlife, vegetation	Track and Sign	Occupancy
Pig (<i>Sus scrofa</i>)	Threat to wildlife, vegetation	Track and Sign	Occupancy
Weeds			
Buffel grass (<i>Cenchrus ciliaris</i>)	(on neighbouring upstream properties)	Vegetation surveys, targeted surveys	Extent of infestation (categorised by density)
'Prickle Bushes' (Prickly Acacia, Mesquite, Parkinsonia, Mimosa)	(on neighbouring upstream properties)	Vegetation surveys, targeted surveys	Extent of infestation (categorised by density)
Athel Pine (<i>Tamarix aphylla</i>)	(on neighbouring upstream properties)	Vegetation surveys, targeted surveys	Extent of infestation (categorised by density)

Survey design

There are 51 terrestrial vertebrate fauna monitoring sites on Kalamurina (Figure 6). Kalamurina is a difficult place to conduct monitoring given the vast size, lack of track access and being bisected east to west by the Warburton Creek. As a result, there is a concentration of sites in the eastern third of the sanctuary and along the tracks (Figure 6). Sites were selected in a range of habitats defined primarily by vegetation type, topography and accessibility. Some survey sites have been located in places with no ground access, requiring the use of a helicopter to access. Thirty-three (33) permanent monitoring sites were initially established, an additional eight survey sites were added to broaden survey effort to remote portions of the sanctuary supporting other vegetation types, with a further 10 sites added in 2020 to broaden geographic spread to help identify potential refuge areas and to re-balance number of sites in each of the broad vegetation types. Replicates in each vegetation type are located at least 500 m apart. At present, terrestrial vertebrate fauna surveys are conducted every third year, or more frequently after extreme weather.

There are 80 bird monitoring sites, primarily overlapping with terrestrial vertebrate fauna sites but also at other locations (Figure 6). To date, bird surveys have been conducted annually, at a minimum, and more frequently in some years.

There are 75 one-ha track and sign survey sites (Figure 6) that are used to monitor Crested -tailed Mulgara, Dusky Hopping Mouse, as well as feral herbivores and predators. These sites primarily overlap with terrestrial vertebrate fauna sites and are stratified by broad vegetation communities (with a suitable substrate). To date, track surveys have been carried out annually when possible.

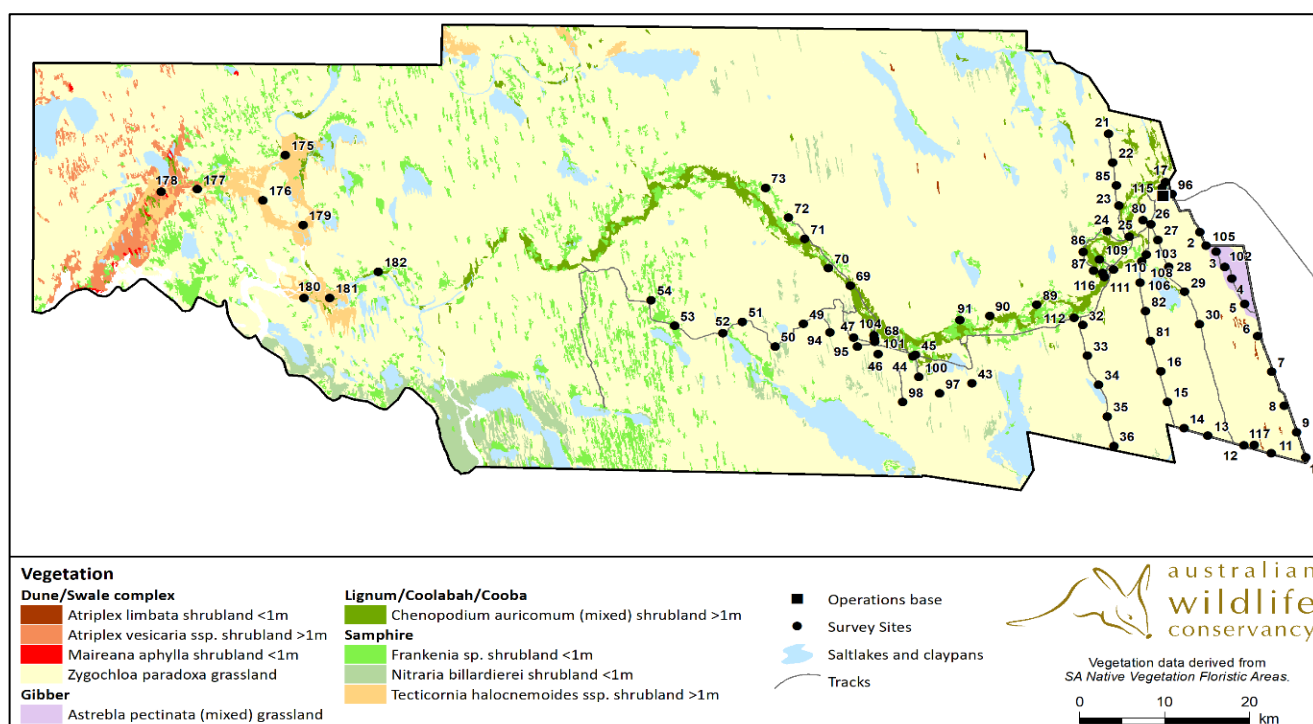


Figure 6. Location of fauna, bird, sign and vegetation monitoring sites on Kalamurina

Survey methods

Small terrestrial vertebrate fauna

The small terrestrial vertebrate fauna surveys use a combination of live-trapping techniques (i.e. Elliott box traps, pitfall traps and funnel traps) were centred at each of the 51 permanently established sites. Each fauna survey site consists of two back-to-back 'Y' shapes (each with three 10 m 'wings', joined at the middle) separated by about 10 m (Figure 7) which includes eight pitfall, 12 funnel, and 20 Elliott traps at each site. Each pair of funnel traps is covered with a sheet of air-cell insulation and nesting material is placed in the bottom of each pitfall to provide protection for trapped animals. Elliot traps are baited with a mixture of rolled oats and peanut paste.

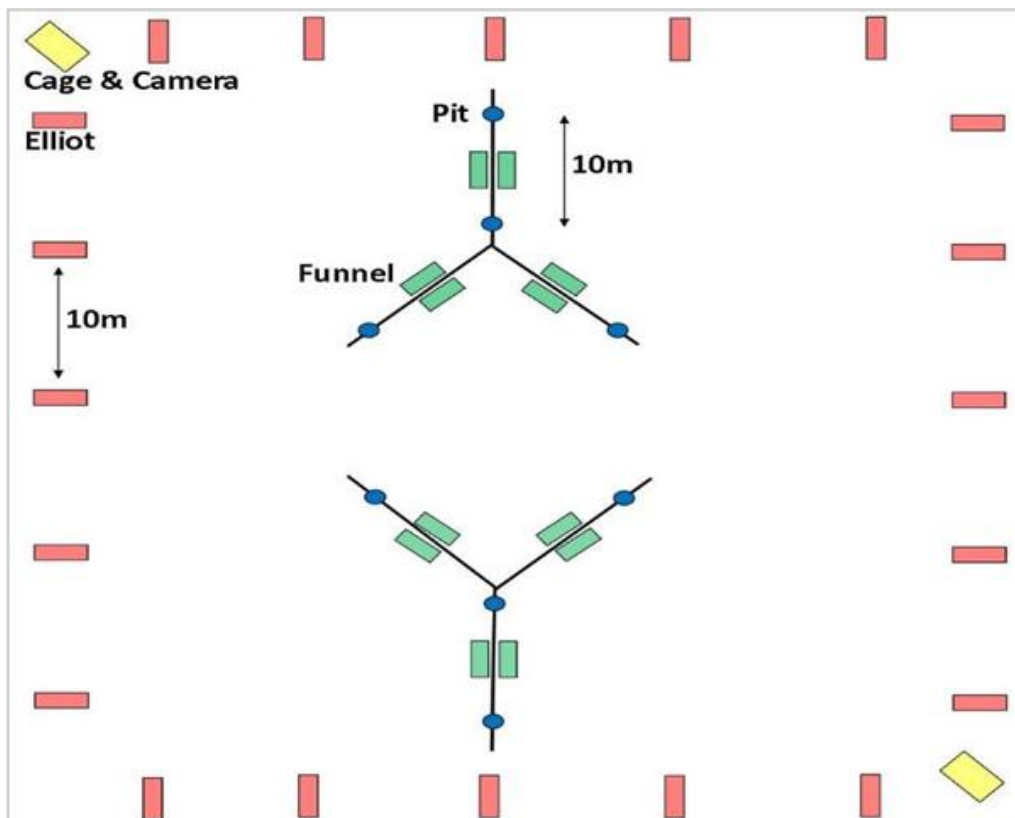


Figure 7. Schematic layout of Standard Trapping survey site indicating trap type and placement.

Each trap site is operated for three nights. All traps are checked in the morning (and the Elliott traps are closed) and the evening (the Elliott traps are opened and baited). With 8-10 people on survey, up to 10 sites can comfortably be established and checked each day. Small mammals are identified and weighed, the sex and breeding condition is determined and native species are measured and given an individual mark before release. Reptiles and amphibians are identified, snout-vent length is measured, sex is determined if possible and given an individual mark (not amphibians) before release.

Crest-tailed Mulgara and Dusky Hopping Mouse

Crest-tailed Mulgara and Dusky Hopping-mouse populations fluctuate responding to prevailing environmental conditions and predator population densities, and they are often difficult to detect using live traps. Track surveys (the detection of Mulgara and Hopping-mouse sign such as characteristic foot-prints, burrows and scats) are the most effective way to determine occupancy of these species (Molyneux et al. 2017) and are used in addition to live traps associated with small terrestrial vertebrate fauna monitoring. Track survey sites are monitored by searching the site for 20 minutes recording occupancy of either species where signs of presence are observed. To date, this survey has been conducted annually to assess trends in occupancy against a variety of environmental conditions and predator management strategies (Bellchambers 2019).

Diurnal Birds

Surveys are carried out using the BirdLife Australia Atlas (Blakers et al. 1984) methodology. The observer spends 20 minutes actively searching two hectares centred on the survey site (Figure 6) identifying and recording any sightings or vocalisations. When more than one individual of the same species is noted, it is recorded only if the observer is certain that it is not an individual recorded previously. Surveys are repeated on each of three mornings. The time of year these were conducted has changed due to logistical reasons, moving forward surveys will be conducted in July.

Feral herbivores

The density of large feral herbivores can usually best be estimated over extensive areas using aerial survey. To date, Kalamurina has participated in infrequent region-wide monitoring and/or culling programs; AWC has also conducted aerial monitoring/culls of large feral herbivores (McLaren et al. 2015, 2017). The results of these surveys indicated that large feral herbivores are generally present in low abundance and very low

densities. As such, the expense of aerial survey is not warranted for monitoring; instead, signs of feral herbivores are recorded during the track monitoring survey noted above and data from this survey have been used to compute a metric of occupancy.

Predators

At present, signs of feral predators are recorded during the track monitoring survey noted above and used to calculate occupancy.

Weeds

Kalamurina is largely free of weeds due to its isolation, aridity, lack of long-term intensive cattle grazing and saline soils. None of the several nationally significant weeds identified from the Simpson Strzelecki bioregion are known to be present on Kalamurina, although they do occur upstream along the Warburton Creek. As such, the potential for weed invasion at Kalamurina is high, particularly along the floodplains of the creek system, and so continued vigilance and preparedness to implement eradication programmes is applied. Concentrated monitoring for the presence of these weeds occurs by on-ground searches from ATV or by foot along creeklines following flood events or where cattle breach boundary fencing (Bellchambers 2019).

Analysis methods

Small terrestrial vertebrate fauna

The metrics derived from the small terrestrial vertebrate survey are abundance of indicator species and species guilds per survey site. These metrics are calculated using total captures of each species and guild from all traps and expressing it as per unit effort (per 100TN). Occupancy for small mammal indicator species and guilds are reported as percent of sites where the species or guild was detected. Species richness or diversity per site of several indicator reptile species and species guilds are recorded as number of species per site.

Threatened mammals

Track survey methods are used to estimate occupancy of Crest-tailed Mulgara and Dusky Hopping Mice. Occupancy is calculated as the percent of sites surveyed that the species is detected.

Diurnal Birds

The Kalamurina bird survey provides data on the presence, diversity and relative abundance of birds (indicator species and guilds) on the sanctuary. An index of abundance, average count per site, is calculated by firstly, averaging the total (raw) bird counts across three survey mornings for each site to obtain a 'site average'; secondly, summing all 'site averages', then dividing this by the number of sites to get an 'average abundance per 2 ha plot'. Species richness is calculated using the same methodology.

Large herbivores

Occupancy is estimated as the percent of track survey sites monitored within a year that the species is detected.

Feral predators

Occupancy is calculated as the percent of track survey sites monitored within a year that the species is detected.

Survey effort

Small terrestrial vertebrate fauna surveys were planned in 2020, following an extraordinary flood event in 2019 and some good, widespread rainfall in early autumn 2020. However, only eight sites were able to be surveyed with the remainder of survey sites cancelled early due to adverse weather. No survey of these sites has been conducted since 2017.

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

Survey name	2020 Effort	Description/Comment	Previous Surveys
Small terrestrial vertebrate fauna survey	960 trap-nights	8 of 51 sites surveyed with pitfall, Elliot, and funnel traps. Stratified to cover a range of geography and major vegetation types. Weather affected.	2017: 24 of 41 sites, 2880 trap nights 2016: 38 of 41 sites, 4560 trap nights 2013: 33 of 33 sites, 3960 trap nights 2012: 33 of 33 sites, 3960 trap nights 2011: 29 of 33 sites, 3480 trap nights 2009: 20 of 33 sites, 2400 trap nights
Track and sign surveys	65 surveys	20 minute - 2 ha survey, single observer. Completed 65 of 75 sites.	2019: 45 surveys 2017: 61 surveys 2016: 25 surveys 2015: 42 surveys 2013: 33 surveys 2012: 34 surveys 2011: 40 surveys 2010: 82 surveys 2009: 53 surveys 2008: 100 surveys
Bird survey	219 surveys	20 minute - 2 ha survey on 3 consecutive mornings shortly after dawn with a single observer. These were done at 72 of 80 survey sites.	2019: 135 surveys 2017: 168 surveys 2016: 153 surveys 2014: 189 surveys 2013: 159 surveys 2012: 138 surveys 2011: 183 surveys 2010: 156 surveys 2009: 96 surveys 2008: 144 surveys

Results

Biodiversity indicators

Small-medium mammals

The results presented in this report and accompanying scorecard describe the status and trends of the indicators surveyed during the 2020 surveys or earlier surveys where surveys were not conducted in 2020. The results from the 2020 surveys reflect a limited effort due to logistical constraints, however they do include some new sites from the remote western section of the sanctuary. Four of the eight sites surveyed in 2020 were these new western sections sites.

The abundance of small mammals has varied by two orders of magnitude between 2009 – 2020, with a high of 31 individuals/ 100TN in 2011, and a low of 0.08 individuals/ 100 TN in 2008. The 2020 result (0.42 per 100TN) was at the lower end of the abundances recorded since 2009 (Table 4). In 2020, small mammals were relatively widespread, occupying 50% of sites. The mammals detected were strongly dominated by the Dasyurids guild which were found at 38% of the sites and accounted for 86% of the captures. Rodents only occurred at 13% of sites and accounted for 14% of captures. The extremely high abundance of small mammals in 2011 and 2012 was because of very high capture rates of Long-haired Rats (*Rattus villosissimus*) that were irrupting throughout arid Australia following several years of well above average rainfall.

Appendix 1 lists all small native mammals captured during this 2020 survey.

Table 4. Summary of trapping results of mammal captures in the small vertebrate surveys conducted at Kalamurina between 2009 and 2017. Abundance is number of captures per 100 trap nights.

Metric	2009	2011	2012	2013	2016	2017	2020
No. sites monitored	20	29	33	33	38	24	8
No. trap nights	2400	3480	3960	3960	4560	2360	960
Small mammal abundance	0.13	31.3	24.0	0.08	1.12	0.68	0.42

Threatened mammals

Crest-tailed Mulgara

Track surveys indicate a general increase in occupancy across sites since 2011, with 46% of sites recording evidence of Crest-tailed Mulgara in 2020 (Figure 8).

Dusky Hopping-mouse

Track surveys indicate a general increase in occupancy across sites between 2008-2020, with 35% of sites recording evidence of Dusky Mice in 2020 (Figure 8).

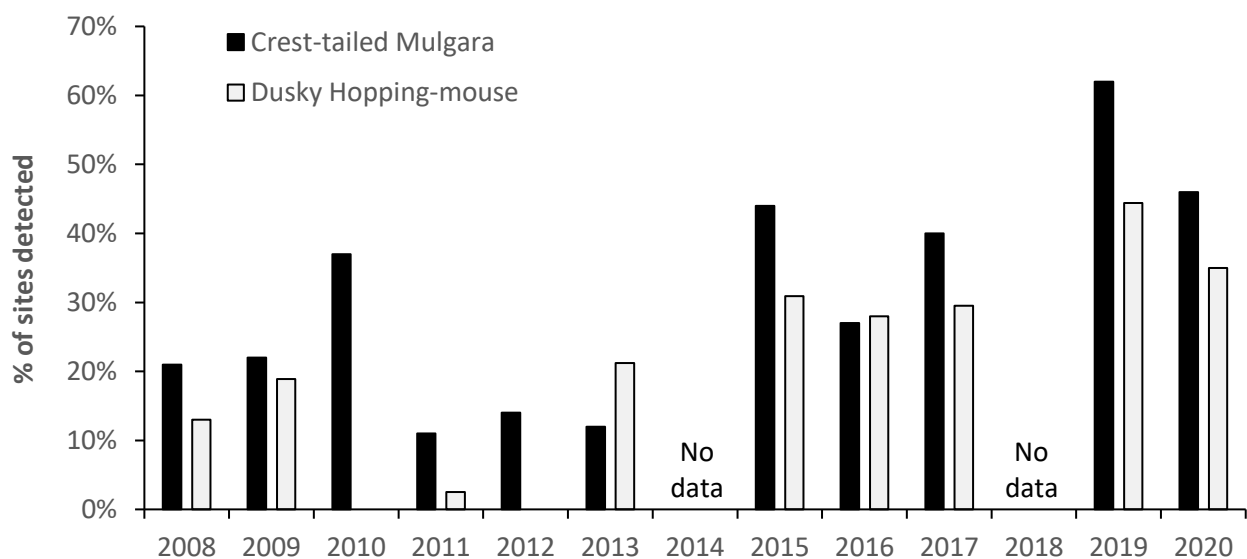


Figure 8. Proportion of sites that Crest-tailed Mulgara and Dusky Hopping-mouse were detected on Kalamurina, 2008-2020.

Other small-medium mammals

Desert Mouse

No Desert Mouse were detected during 2020 surveys. The species was last captured during 2017 surveys in low abundance (0.3) and occupancy (17.6%) across 24 trapping sites.

Small reptiles

Between 2009 and 2020, small reptile mean species richness ranged from 2.2-9.8 species detected/ site, with 2020 recording the second lowest species richness during this time (Table 5). Skinks were the most common guild, representing 86% of captures, followed by geckos (11%) and agamids (1%). The Pale-rumped Skink declined in abundance and occupancy, but was still widespread across the sanctuary (75% site occupancy) and was moderately abundant with 3 captures per 100 trap nights (2017: A = 4.1; O=87.5%). Bynoe's Gecko was stable between 2017 – 2020 and was detected at 25% of sites (2017: A=0.6, O=37.5%). The Painted Dragon experienced a decline in abundance and occupancy compared with 2017 surveys, with only 0.1 captures per 100 trap nights and 12.5% of sites recording the species (2017: A=0.6, O=33.3%).

Appendix 1 lists all small reptiles captured during this 2020 survey.

Table 5. Summary of trapping results of reptile captures in the small vertebrate surveys conducted at Kalamurina between 2009 and 2017. Species richness is the mean number of species detected across all sites within a year.

Metric	2009	2011	2012	2013	2016	2017	2020
No. sites monitored	20	29	33	33	38	24	8
No. trap nights	2400	3480	3960	3960	4560	2360	960
Small reptile – mean richness	4.1	9.8	6.7	4.4	4.3	2.2	3

Diurnal Birds

Bird surveys were conducted in 2020 following some widespread rainfall across Kalamurina in early autumn, resulting in annual and perennial plant growth and flowering. There was also a small flood event down the creeks to Kati Thanda-Lake Eyre following moderate rainfall events in south-west Queensland. Despite rainfall in the dune and swale system, it was quite patchy with the bird survey results showing many sites recording no species in the dry country and sites in riparian areas and flood-outs recording high diversity and abundance.

A total of 65 species were recorded during the formal 20 minute surveys at the 2 ha survey sites, with a total of 110 species recorded throughout the survey period, including opportunistic observations. No new species for Kalamurina were observed. Abundance and richness increased in 2020 to an average of 27 individuals and 7 species per site. Ground active birds were the most common guild occurring at 91% of sites and accounting for 56% of records. Honeyeaters were also widespread occurring at 58% of sites and accounting for 15% of records. Many species observed opportunistically this year were water-dependent species, but increased numbers and occupancy of some nomadic species such as Pied Honeyeater were observed utilising fresh vegetation. Appendix 2 lists all bird species recorded at Kalamurina during 2020 survey.

Threat indicators

Feral herbivores

In 2020, five species of introduced herbivores: camel, donkey, cattle, pig and rabbit were recorded on track surveys. Occupancy estimates for camel varies markedly over time, ranging from 1.5 – 96.2%, with 2020 being the lowest rate of detection between 2008-2020 (Table 6). Similarly, cattle occupancy varies ranging from 2.5-62.3% with a relative low estimate of 12.3% in 2020 (Table 6). Horse/donkey and pigs tend to occur at a low percentage of sites, 0-41.5% and 0-9.8% respectively, with 1.5% and 3% respectively in 2020 (Table 6). Rabbits are typically moderately distributed occupying 12.5 – 83% of sites, with a relatively low estimate of 20% in 2020 (Table 6).

Feral predators

In 2020, both cat and fox were recorded at relatively few track survey sites, 7.7% and 1.5% respectively. Both species tend to be detected at a low to moderate percentage of sites (Table 6).

No predator transects were conducted on Kalamurina during 2020. Feral predator species may be culled as encountered during daily operations on sanctuary. The encounter rate for each is so low that calculating density estimates is not possible using a transect methodology.

Table 6. Occupancy estimates of feral herbivores predators on Kalamurina between 2008 and 2020.

Occupancy is the percent of track monitoring sites where the species was detected.

Metric	2008	2009	2010	2011	2012	2013	2014	2016	2017	2019	2020
Number of sites monitored	100	53	82	40	34	33	42	25	61	45	65
Camel	54%	96%	42%	8%	27%	58%	79%	36%	48%	62%	2%
Cattle	45%	62%	48%	3%	6%	27%	43%	24%	39%	27%	12%
Horse/donkey	20%	42%	9%	0%	3%	3%	10%	0%	0%	13%	2%
Pig	0%	0%	1%	0%	0%	3%	0%	4%	10%	2%	3%
Rabbit	56%	83%	50%	13%	59%	76%	67%	44%	66%	31%	20%
Fox	30%	42%	24%	5%	3%	27%	17%	16%	7%	2%	2%
Cat	7%	25%	6%	5%	15%	39%	24%	4%	23%	9%	8%

*donkey rather than horse

Weeds

Kalamurina is fortunate to be relatively weed free and control efforts to date have involved spot-removal of particular environmental weed species around key infrastructure and environmental assets. There are a number of significant weed species that are known to occur further up the drainage systems coming in to Kalamurina so every effort is made to survey creek-lines following flood events.

In 2020, approximately 100 km of creekline and channels were surveyed for the presence of Buffel Grass, Parkinsonia and other “prickle bushes”, with none detected.

Discussion

AWC has been conducting ecological surveys on Kalamurina since 2008. The results of these surveys show that, generally, the abundance and species richness of small mammals and reptiles on Kalamurina is highly correlated with rainfall.

In 2020, following several very dry years, the region around Kalamurina returned to average rainfall, and there was a small flow in Warburton Creek. The higher rainfall likely had a positive influence on some of the survey results, such that some nomadic bird species were recorded, and resident birds and some small mammals and reptiles were more active.

Nevertheless, numbers recorded in 2020 were at the lower end of the cycle, an unsurprising outcome given the preceding years of severe drought. Nevertheless, two threatened mammals, Crest-tailed Mulgara and Dusky Hopping Mouse were detected at 46% and 35% of tracking sites, respectively, with both species being frequently detected at many of those sites. The number of bird species was higher in 2020 than recorded previously, with consistent survey effort between survey periods.

Acknowledgments

AWC acknowledges the Traditional Owners of the country on which Kalamurina Wildlife Sanctuary resides. We also acknowledge their continuing connection to land, culture and community. We pay our respects to Traditional Owner Elders past present and emerging.

AWC's Ecohealth Program is only possible because of the generosity of AWC's supporters. The Ecohealth surveys at Kalamurina would not be completed without input from amazing volunteers.

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Appendices

Appendix 1: Native mammals and reptiles recorded during Kalamurina biodiversity survey 2020.

Class	Family	Scientific Name	Common Name	Status
Mammalia	Canidae	<i>Canis lupus dingo</i>	Dingo	Confirmed
Mammalia	Dasyuridae	<i>Dasycercus cristicauda</i>	Crest-tailed Mulgara	Confirmed
Mammalia	Dasyuridae	<i>Sminthopsis macroura</i>	Stripe-faced Dunnart	Confirmed
Mammalia	Macropodidae	<i>Macropus rufus</i>	Red Kangaroo	Confirmed
Mammalia	Muridae	<i>Pseudomys hermannsburgensis</i>	Sandy Inland Mouse	Confirmed
Reptilia	Agamidae	<i>Ctenophorus pictus</i>	Painted Dragon	Confirmed
Reptilia	Carphodactylidae	<i>Nephrurus levis</i>	Three-lined Knob-tail	Confirmed
Reptilia	Diplodactylidae	<i>Lucasium damaeum</i>	Beaded Gecko	Confirmed
Reptilia	Diplodactylidae	<i>Rhynchoedura eyrensi</i>	Eyre Basin Beaked Gecko	Confirmed
Reptilia	Elapidae	<i>Pseudechis australis</i>	Mulga Snake	Confirmed
Reptilia	Elapidae	<i>Pseudonaja aspidorhyncha</i>	Strap-snouted Brown Snake	Confirmed
Reptilia	Gekkonidae	<i>Heteronotia binoei</i>	Bynoe's Prickly Gecko	Confirmed
Reptilia	Scincidae	<i>Ctenotus regius</i>	Pale-rumped Ctenotus	Confirmed
Reptilia	Scincidae	<i>Ctenotus taeniatus</i>	Ribbon Ctenotus	Confirmed
Reptilia	Scincidae	<i>Eremiascincus phantasmus</i>	Ghost Skink	Confirmed
Reptilia	Scincidae	<i>Lerista labialis</i>	Southern Sand Slider	Confirmed
Reptilia	Scincidae	<i>Menetia greyii</i>	Common Dwarf Skink	Confirmed
Reptilia	Scincidae	<i>Morethia boulengeri</i>	South-east Morethia Skink	Confirmed

Appendix 2: Bird species recorded during Kalamurina bird survey 2020.

Class	Family	Scientific Name	Common Name	Status
Aves	Accipitridae	<i>Aquila audax</i>	Wedge-tailed Eagle	Confirmed
Aves	Accipitridae	<i>Elanus axillaris</i>	Black-shouldered Kite	Confirmed
Aves	Accipitridae	<i>Haliastur sphenurus</i>	Whistling Kite	Confirmed
Aves	Accipitridae	<i>Hamirostra melanosternon</i>	Black-breasted Buzzard	Confirmed
Aves	Accipitridae	<i>Hieraaetus morphnoides</i>	Little Eagle	Confirmed
Aves	Accipitridae	<i>Milvus migrans</i>	Black Kite	Confirmed
Aves	Anatidae	<i>Anas gracilis</i>	Grey Teal	Confirmed
Aves	Anatidae	<i>Anas superciliosus</i>	Pacific Black Duck	Confirmed
Aves	Anatidae	<i>Aythya australis</i>	Hardhead	Confirmed
Aves	Anatidae	<i>Chenonetta jubata</i>	Maned Duck	Confirmed
Aves	Anatidae	<i>Cygnus atratus</i>	Black Swan	Confirmed
Aves	Anatidae	<i>Malacorhynchus membranaceus</i>	Pink-eared Duck	Confirmed
Aves	Anatidae	<i>Spatula rhyncosa</i>	Australasian Shoveller	Confirmed
Aves	Anatidae	<i>Tadorna tadornoides</i>	Australian Shelduck	Confirmed
Aves	Aegothelidae	<i>Aegotheles cristatus</i>	Australian Owlet-nightjar	Confirmed
Aves	Eurostopodidae	<i>Eurostopodus argus</i>	Spotted Nightjar	Confirmed
Aves	Podargidae	<i>Podargus strigoides</i>	Tawny Frogmouth	Confirmed
Aves	Casuariidae	<i>Dromaius novaehollandiae</i>	Emu	Confirmed
Aves	Charadriidae	<i>Charadrius ruficapillus</i>	Red-capped Plover	Confirmed
Aves	Charadriidae	<i>Elseyornis melanops</i>	Black-fronted Dotterel	Confirmed
Aves	Charadriidae	<i>Peltohyas australis</i>	Inland Dotterel	Confirmed
Aves	Charadriidae	<i>Vanellus miles</i>	Masked Lapwing	Confirmed
Aves	Charadriidae	<i>Vanellus tricolor</i>	Banded Lapwing	Confirmed
Aves	Laridae	<i>Chroicocephala novaehollandiae</i>	Silver Gull	Confirmed

Class	Family	Scientific Name	Common Name	Status
Aves	Laridae	<i>Hydroprogne caspia</i>	Caspian Tern	Confirmed
Aves	Recurvirostridae	<i>Himantopus leucocephalus</i>	White-headed Stilt	Confirmed
Aves	Recurvirostridae	<i>Recurvirostra novaehollandiae</i>	Red-necked Avocet	Confirmed
Aves	Scolopacidae	<i>Tringa nebularia</i>	Common Greenshank	Confirmed
Aves	Columbidae	<i>Geopelia cuneata</i>	Diamond Dove	Confirmed
Aves	Columbidae	<i>Geopelia placida</i>	Peaceful Dove	Confirmed
Aves	Columbidae	<i>Ocyphaps lophotes</i>	Crested Pigeon	Confirmed
Aves	Columbidae	<i>Phaps chalcoptera</i>	Common Bronzewing	Confirmed
Aves	Columbidae	<i>Phaps histrionica</i>	Flock Bronzewing	Confirmed
Aves	Halcyonidae	<i>Todiramphus pyrrhopygius</i>	Red-backed Kingfisher	Confirmed
Aves	Cuculidae	<i>Cacomantis pallidus</i>	Pallid Cuckoo	Confirmed
Aves	Cuculidae	<i>Chalcites basalis</i>	Horsfield's Bronze-Cuckoo	Confirmed
Aves	Falconidae	<i>Falco berigora</i>	Brown Falcon	Confirmed
Aves	Falconidae	<i>Falco cenchroides</i>	Nankeen Kestrel	Confirmed
Aves	Falconidae	<i>Falco hypoleucos</i>	Grey Falcon	Confirmed
Aves	Falconidae	<i>Falco longipennis</i>	Australian Hobby	Confirmed
Aves	Falconidae	<i>Falco subniger</i>	Black Falcon	Confirmed
Aves	Phasianidae	<i>Coturnix pectoralis</i>	Stubble Quail	Confirmed
Aves	Gruidae	<i>Antigone rubicunda</i>	Brolga	Confirmed
Aves	Rallidae	<i>Fulica atra</i>	Eurasian Coot	Confirmed
Aves	Rallidae	<i>Porphyrio melanotus</i>	Australasian Swamphen	Confirmed
Aves	Otididae	<i>Ardeotis australis</i>	Australian Bustard	Confirmed
Aves	Acanthizidae	<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill	Confirmed
Aves	Acanthizidae	<i>Acanthiza uropygialis</i>	Chestnut-rumped Thornbill	Confirmed
Aves	Acanthizidae	<i>Aphelocephalus nigricincta</i>	Banded Whiteface	Confirmed
Aves	Acrocephalidae	<i>Acrocephalus australis</i>	Australian Reed Warbler	Confirmed
Aves	Artamidae	<i>Artamus cinereus</i>	Black-faced Woodswallow	Confirmed
Aves	Artamidae	<i>Artamus cyanopterus</i>	Dusky Woodswallow	Confirmed
Aves	Artamidae	<i>Artamus leucorhynchus</i>	White-breasted Woodswallow	Confirmed
Aves	Artamidae	<i>Artamus personatus</i>	Masked Woodswallow	Confirmed
Aves	Artamidae	<i>Artamus superciliosus</i>	White-browed Woodswallow	Confirmed
Aves	Artamidae	<i>Gymnorhina tibicen</i>	Australian Magpie	Confirmed
Aves	Campephagidae	<i>Coracina maxima</i>	Ground Cuckoo-shrike	Confirmed
Aves	Campephagidae	<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike	Confirmed
Aves	Campephagidae	<i>Lalage tricolor</i>	White-winged Triller	Confirmed
Aves	Corvidae	<i>Corvus bennetti</i>	Little Crow	Confirmed
Aves	Corvidae	<i>Corvus coronoides</i>	Australian Raven	Confirmed
Aves	Estrildidae	<i>Taeniopygia guttata</i>	Zebra Finch	Confirmed
Aves	Hirundinidae	<i>Cheramoeca leucosterna</i>	White-backed Swallow	Confirmed
Aves	Hirundinidae	<i>Hirundo neoxena</i>	Welcome Swallow	Confirmed
Aves	Hirundinidae	<i>Petrochelidon aerial</i>	Fairy Martin	Confirmed
Aves	Hirundinidae	<i>Petrochelidon nigricans</i>	Tree Martin	Confirmed
Aves	Locustellidae	<i>Megalurus cruralis</i>	Brown Songlark	Confirmed
Aves	Locustellidae	<i>Megalurus gramineus</i>	Little Grassbird	Confirmed
Aves	Locustellidae	<i>Megalurus mathewsi</i>	Rufous Songlark	Confirmed
Aves	Maluridae	<i>Amytornis goideri</i>	Eyrean Grasswren	Confirmed
Aves	Maluridae	<i>Malurus assimilis</i>	Purple-backed Fairy-wren	Confirmed
Aves	Maluridae	<i>Malurus leucopterus</i>	White-winged Fairy-wren	Confirmed
Aves	Meliphagidae	<i>Acanthagenys rufogularis</i>	Spiny-cheeked Honeyeater	Confirmed
Aves	Meliphagidae	<i>Certhionyx variegatus</i>	Pied Honeyeater	Confirmed
Aves	Meliphagidae	<i>Epthianura aurifrons</i>	Orange Chat	Confirmed

Class	Family	Scientific Name	Common Name	Status
Aves	Meliphagidae	<i>Epthianura tricolor</i>	Crimson Chat	Confirmed
Aves	Meliphagidae	<i>Gavicalis virescens</i>	Singing Honeyeater	Confirmed
Aves	Meliphagidae	<i>Manorina flavigula</i>	Yellow-throated Miner	Confirmed
Aves	Meliphagidae	<i>Ptilotula penicillata</i>	White-plumed Honeyeater	Confirmed
Aves	Meliphagidae	<i>Ptilotula plumula</i>	Grey-fronted Honeyeater	Confirmed
Aves	Meliphagidae	<i>Purnella albifrons</i>	White-fronted Honeyeater	Confirmed
Aves	Monarchidae	<i>Grallina cyanoleuca</i>	Magpie-lark	Confirmed
Aves	Motacillidae	<i>Anthus australis</i>	Australian Pipit	Confirmed
Aves	Pachycephalidae	<i>Oreoica gutturalis</i>	Crested Bellbird	Confirmed
Aves	Pachycephalidae	<i>Pachycephala rufiventris</i>	Rufous Whistler	Confirmed
Aves	Petroicidae	<i>Petroica goodenovii</i>	Red-capped Robin	Confirmed
Aves	Pomatostomidae	<i>Pomatostomus ruficeps</i>	Chestnut-crowned Babbler	Confirmed
Aves	Psophodidae	<i>Cinclosoma cinnamomeum</i>	Cinnamon Quail-thrush	Confirmed
Aves	Psophodidae	<i>Psophodes cristatus</i>	Chirruping Wedgebill	Confirmed
Aves	Rhipiduridae	<i>Rhipidura leucophrys</i>	Willie Wagtail	Confirmed
Aves	Ardeidae	<i>Ardea alba</i>	Great Egret	Confirmed
Aves	Ardeidae	<i>Ardea pacifica</i>	White-necked Heron	Confirmed
Aves	Ardeidae	<i>Egretta novaehollandiae</i>	White-faced Heron	Confirmed
Aves	Pelicanidae	<i>Pelecanus conspicillatus</i>	Australian Pelican	Confirmed
Aves	Threskiornithidae	<i>Platalea flavipes</i>	Yellow-billed Spoonbill	Confirmed
Aves	Threskiornithidae	<i>Platalea regia</i>	Royal Spoonbill	Confirmed
Aves	Threskiornithidae	<i>Threskiornis molucca</i>	Australian White Ibis	Confirmed
Aves	Threskiornithidae	<i>Threskiornis spinicollis</i>	Straw-necked Ibis	Confirmed
Aves	Podicipididae	<i>Poliocephalus poliocephalus</i>	Hoary-headed Grebe	Confirmed
Aves	Podicipididae	<i>Tachybaptus novaehollandiae</i>	Australasian Grebe	Confirmed
Aves	Cacatuidae	<i>Cacatua sanguinea</i>	Little Corella	Confirmed
Aves	Cacatuidae	<i>Eolophus roseicapillus</i>	Galah	Confirmed
Aves	Cacatuidae	<i>Nymphicus hollandicus</i>	Cockatiel	Confirmed
Aves	Psittaculidae	<i>Melopsittacus undulatus</i>	Budgerigar	Confirmed
Aves	Psittaculidae	<i>Northiella haematogaster</i>	Eastern Blue Bonnet	Confirmed
Aves	Strigidae	<i>Ninox boobook</i>	Southern Boobook	Confirmed
Aves	Tytonidae	<i>Tyto javanica</i>	Eastern Barn Owl	Confirmed
Aves	Phalacrocoracidae	<i>Microcarbo melanoleucos</i>	Little Pied Cormorant	Confirmed
Aves	Phalacrocoracidae	<i>Phalacrocorax sulcirostris</i>	Little Black Cormorant	Confirmed
Aves	Phalacrocoracidae	<i>Phalacrocorax varius</i>	Pied Cormorant	Confirmed

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