

# Kalamurina Wildlife Sanctuary Ecohealth Report 2021



## Summary

Australian Wildlife Conservancy (AWC) has implemented an Ecological Health Monitoring Program (Ecohealth) across Kalamurina Wildlife Sanctuary (Kalamurina) to measure the changes in the status and trend of conservation assets, and threats to those assets. Metrics from the program are reported in annual Ecohealth Reports and Scorecards. This is the Ecohealth Report for 2021. Values of metrics derived in this report were based on data collected during surveys carried out between 2009 and 2021. The complete set of metrics and their values are summarised in the accompanying Ecohealth Scorecard.

In implementing the Kalamurina Ecohealth program in 2021, AWC conducted 198 bird surveys, and 63 track and sign surveys. These surveys detected two threatened small mammals and 109 bird species.

Bird surveys were carried out in July at 66 Ecohealth monitoring sites located in the major vegetation communities on Kalamurina. This resulted in a total of 109 species of resident bush birds, nomadic and seasonal visiting bush birds and nomadic water birds being recorded. Diversity is similar to previous surveys but abundance increased for a number of nomadic species. This is thought to be as a result of the significant rainfall experienced several months prior to the survey. There were no new species for the sanctuary list from this survey.

Track and sign surveys were carried out at 63 Ecohealth monitoring sites located in the major vegetation communities on Kalamurina. These surveys detected two threatened mammals, Crest-tailed Mulgara (*Dasycercus cristicauda*) and Dusky Hopping Mouse (*Notomys fuscus*) at 41% and 27% of tracking sites, respectively, with both species being frequently detected at many of those sites. These surveys are also used to detect the distribution of various feral herbivore and feral predator species across the sanctuary. Feral predators and herbivores continue to remain at relatively low occupancy across Kalamurina.

In 2020, following several very dry years, the region around Kalamurina returned to average rainfall, and there was a small flow in the Warburton Creek. This was supplemented by a widespread significant rainfall event in autumn 2021 which caused another creek flow and filling of small lakes and claypans as well as benefitting the dune and swale system. 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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## Introduction

Australian Wildlife Conservancy (AWC) currently owns, manages, or works in partnerships across 31 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 outcomes.

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). Data from the monitoring program are used to address the following broad questions relevant to our mission:

- 'are species persisting on a property?'
- 'are habitats being maintained?'
- 'are threats below ecologically-significant thresholds?'

For threatened and iconic species, including reintroduced species, AWC's monitoring program aims to obtain more detailed information related to their conservation management, for example data on survival, recruitment, condition, distribution and/or population size.

The structure of the Ecohealth Program is as follows. AWC's Monitoring and Evaluation framework provides guidance on the development of the Ecohealth Monitoring Plans for each property managed by AWC: these plans describe the conservation values and assets of each property, the threats to these assets, and the monitoring program that will be used to track their status and trend, and to evaluate outcomes. 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.

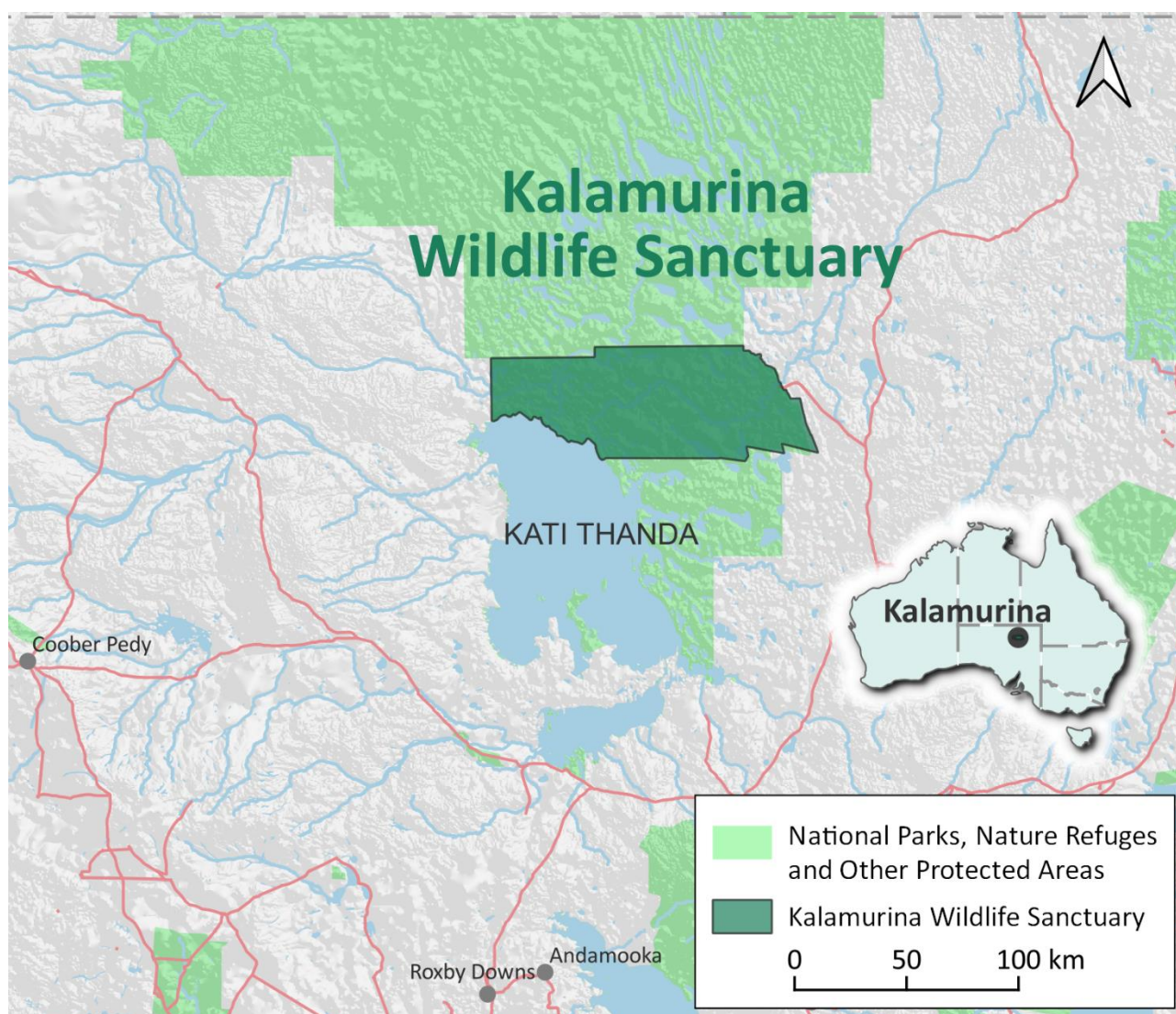
This document is the second in a series of annual Ecohealth Reports for Kalamurina Wildlife Sanctuary (referred to here as Kalamurina). The companion Ecohealth Scorecard presents the indicators and their metrics in a summary format.

## Kalamurina Wildlife Sanctuary

### Conservation values

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.

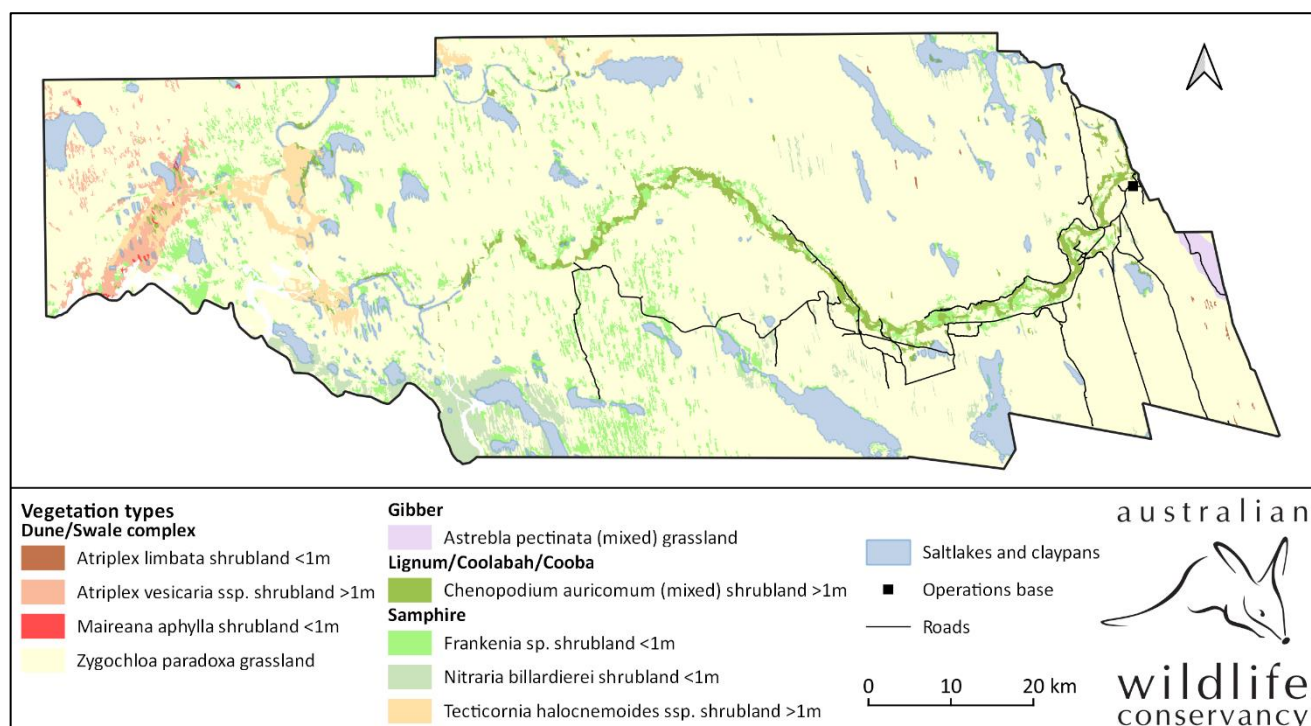
Kalamurina was acquired by AWC from private pastoral interests in late 2007 and comprises two pastoral leases: Crown Lease Pastoral No. 2412 (Kalamurina) and Crown Lease Pastoral No. 2534 (Kallakoopah West). Kalamurina is notable for its contribution to the protection of the ecosystems of the Simpson Strzelecki Dunefields Bioregion (IBRA 7.0; ERIN 2014). In particular, lower reaches of three significant creeks, Warburton, Kallakoopah 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 1).



**Figure 1. Location and regional context of Kalamurina.**

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 Kallakoopah West. With an average annual rainfall around 160 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 Kallakoopah West where there is no permanent 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 Kallakoopah West lease. From stock returns, the 20-year average from 1980–99 was 1,540 cattle equivalents ( $0.22/\text{km}^2$ ). 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 2). The most extensive vegetation community is the Sandhill Canegrass (*Zygochloa paradoxa*) tall hummock grassland  $\pm$  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 2. Extent and distribution of broad vegetation types on Kalamurina.**

Over 265 species of native vertebrates are currently known or considered likely to occur on Kalamurina. These include 22 mammal, 170 bird, 57 reptile, 4 frog and 12 fish species. Twenty of these species are listed as threatened under 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) and 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 are 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 (*Dasymercus cristicauda*) and Dusky Hopping Mouse (*Notomys fuscus*).

The Bush Stone-curlew (*Burhinus grallarius*) (and possibly the Plains Wanderer, *Pedionomus torquatus*) 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 barbatus*) 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.

## Threats

### Feral animals

Kalamurina, like much of southern Australia, has been impacted by a range of feral animals, including camels (*Camelus dromedarius*), donkeys (*Equus asinus*), horses (*Equus caballus*), feral cattle (*Bos taurus*), pigs (*Sus scrofa*), house mice (*Mus musculus*), red foxes (*Vulpes vulpes*), feral cats (*Felis catus*), European rabbits (*Oryctolagus cuniculus*), and a species of bird: house sparrow (*Passer domesticus*). Feral herbivores have been present in the region since European settlement. Some of these species (cattle, camel, horse, donkey) were associated with exploration, pastoral and mining enterprises. The rabbit self-colonised the region as part of its' rapid expansion across the continent once introduced in the late 19<sup>th</sup> century. The pig has self-colonised in more recent times and appears to be expanding its range from upstream following a series of flood events. Feral predators and large feral herbivores are subject to ongoing control and monitoring on the sanctuary. Feral cats and foxes are primarily responsible for the decline of small-medium sized mammals in Australia, some to extinction, and remain an on-going threat. Both cats and foxes are also predators of ground-active birds such as pigeons and doves. Both feral cats and foxes are listed as key threatening processes under the Environment Protection and Biodiversity Conservation Act 1999. Feral herbivores are a threat to vegetation. Heavily grazed areas reduce ground cover and increase exposure of small-medium mammals and ground-active birds to predation.

### Weeds

Kalamurina has a number of introduced plant species but there are no significant introduced weed species currently known. Several significant environmental weeds and Weeds of National Significance (WONS) such as buffel grass (*Cenchrus ciliaris*), prickly acacia (*Vachellia nilotica*), mesquite (*Prosopis* spp.), parkinsonia (*Parkinsonia aculata*), mimosa bush (*Acacia farnesiana*), athel pine (*Tamarix aphylla*) and couch grass (*Cynodon dactylon*) are known to occur on neighbouring properties upstream on the Warburton creek catchment. These present a significant threat to Kalamurina and surveillance of probable entry points is warranted. Several individual plants of buffel grass have been discovered and removed in recent years.

### Changed fire regimes

In most regions of Australia fire is a major driver of the structure and composition of local ecosystems, and hence wildlife habitat. Fire is not currently an ecological driver on Kalamurina. There are no known large wildfires in this landscape in European history.

Aboriginal fire practices in the Simpson Desert region are poorly documented. However, in other landscapes where Aboriginal fire practices have been documented (e.g., central Australia: Bird et al. 2008), the fire regime typically comprised numerous small low intensity fires, distributed patchily in time and space in areas supporting relatively permanent populations, grading to less frequent, but larger fires elsewhere. In arid Australia, permanent Aboriginal occupation was dependent upon the availability of water. There is limited permanent natural water sources in the Simpson Desert but it can be assumed to have been subject to some level of Aboriginal fire management, but the particular regimes applied to these non-Triodia dominated ecosystems are unknown.

Lightning strike may have been another source of fire particularly after favourable seasons produced flushes of growth of annual and perennial grasses and forbs.

Fire frequency and intensity at Kalamurina may change if buffel grass were to become established.

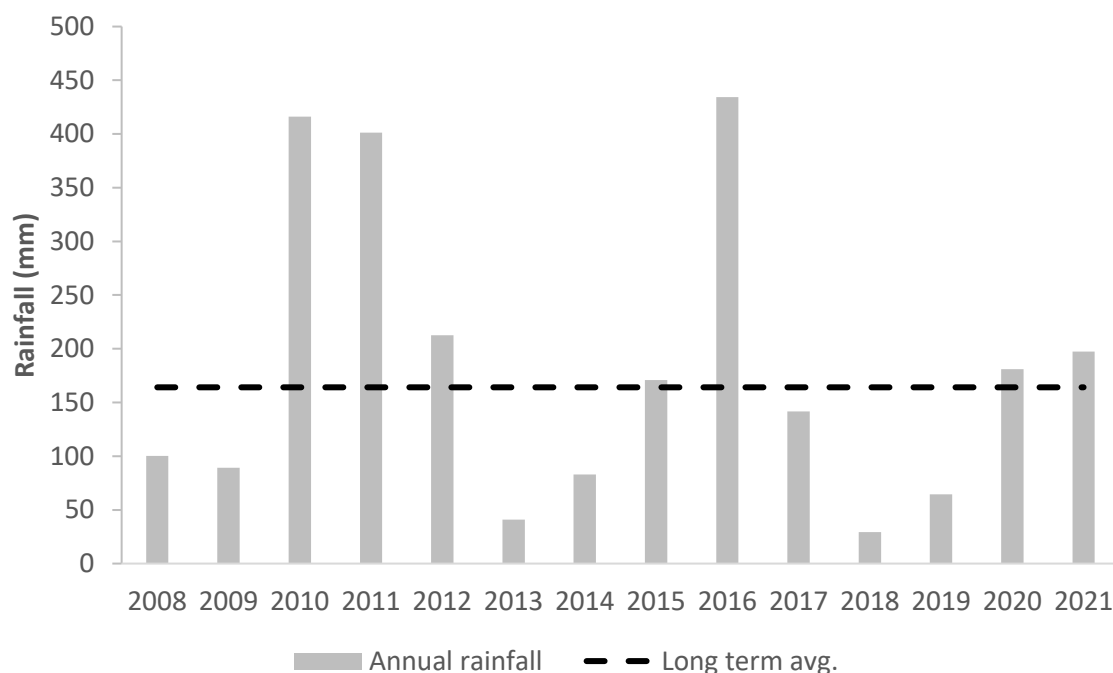
There are no management burns planned for Kalamurina and there have been no planned or unplanned fire events on Kalamurina in more than 10 years.

## Climate and weather summary

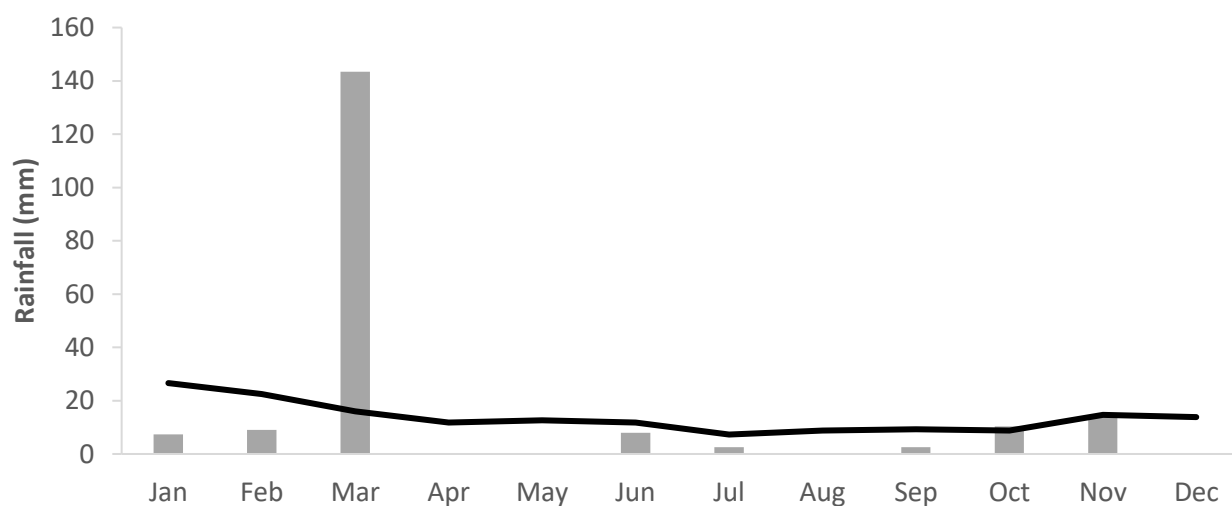
Kalamurina is located in an arid climate zone with infrequent and erratic rainfall. Long-term annual average rainfall (from incomplete records spread over 160 years) is 164 mm, the highest recorded annual rainfall is 434 mm in 2016 and the lowest recorded annual rainfall is 29 mm in 2018 (Figure 3). 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 and 2021, annual rainfall returned to being aligned with the long-term average (BOM 2021). 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). The average evaporation rate is extremely high (over 3,000 mm/ year), far exceeding rainfall.

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 Airport (BOM station 017043), 140 km north-west of Kalamurina's western boundary (Figure 5).

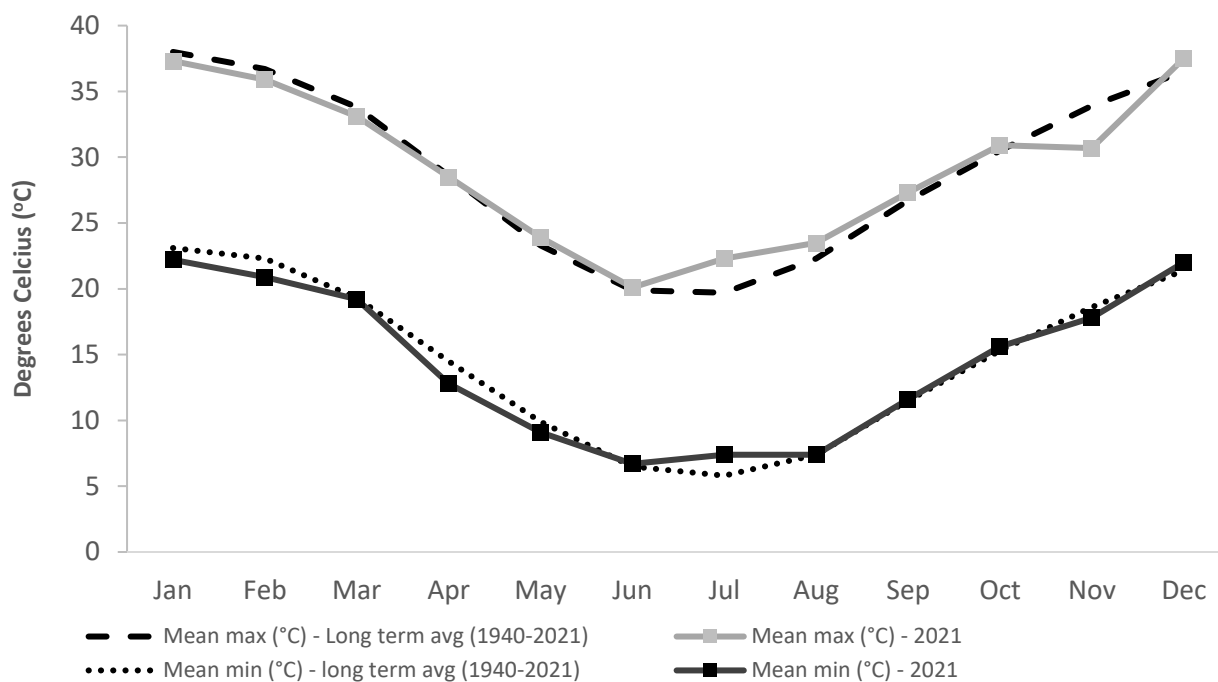


**Figure 3. Annual rainfall at Kalamurina, 2008–2021.** Dashed line = average 2008–2021.



**Figure 4. Monthly rainfall Kalamurina 2021.** Solid line is long term average monthly rainfall Kalamurina.





**Figure 5. Average annual temperatures for Oodnadatta weather station (ID 017043) for 2021 and since 1940. Used as indicative of Kalamurina.**

## Methods

### Indicators and metrics

On Kalamurina, 15 biodiversity (species and guilds) indicators have been selected for monitoring (Table 1). Six of these indicators are reported on in this 2021 Ecohealth report, including two related to threatened and iconic species, and the remainder to surveillance monitoring of faunal assemblages.

Threat metrics are selected to monitor the status and trends of introduced weeds, predators and herbivores, and fire regimes. Nine threat indicators have been selected for monitoring (Table 2), all are reported upon in this report.

**Table 1. Biodiversity indicators and metrics for Kalamurina.**

#### Key threatened and iconic vertebrates

Indicator	Survey name	Survey method	Metric/s
<b>Mammals</b>			
Crest-tailed Mulgara ( <i>Dasyurus cristicauda</i> )	Tracking Survey	20-min counts	Occupancy
Dusky Hopping Mouse ( <i>Notomys fuscus</i> )	Tracking Survey	20-min counts	Occupancy

#### Vertebrate assemblages and surveillance species

Indicator	Survey name	Survey method	Metric/s
<b>Mammals</b>			
Assemblage richness	All surveys listed for mammals, incidental observations	All survey methods listed for mammals	Number of species
All small-medium mammals (trappable)	Standard Trapping Survey	Box traps, pitfall traps	Abundance
Dasyurids - guild	Standard Trapping Survey	Box traps, pitfall traps	Abundance
Rodents - guild	Standard Trapping Survey	Box traps, pitfall traps	Abundance
<b>Reptiles</b>			
Assemblage richness	Standard Trapping Survey, incidental observations	All survey methods listed for reptiles	Number of species
All reptiles (excl. varanids and snakes)	Standard Trapping Survey	Pitfall traps, funnel traps	Abundance, richness
Skinks - guild	Standard Trapping Survey	Pitfall traps, funnel traps	Abundance, richness
Geckos - guild	Standard Trapping Survey	Pitfall traps, funnel traps	Abundance, richness
Agamids - guild	Standard Trapping Survey	Pitfall traps, funnel traps	Abundance, richness
<b>Birds</b>			
Assemblage richness	Standard Bird Survey, incidental observations	All survey methods listed for birds	Number of species
All birds	Standard Bird Survey	20-min counts	Abundance, richness

Indicator	Survey name	Survey method	Metric/s
Honeyeaters - guild	Standard Bird Survey	20-min counts	Abundance, richness
Ground active birds - guild	Standard Bird Survey	20-min counts	Abundance, richness

Table 2. Threat indicators and metrics for Kalamurina in 2021

Indicator	Survey Name/ methods	Metric/s	Performance criteria
<b>Pest animals</b>			
Feral cat ( <i>Felis catus</i> )	Tracking Survey	Occupancy	TBD
Fox ( <i>Vulpes vulpes</i> )	Tracking Survey	Occupancy	TBD
<b>Feral herbivores</b>			
Camel ( <i>Camelus dromedarius</i> )	Tracking Survey	Occupancy	TBD
Feral Cattle ( <i>Bos taurus</i> )	Tracking Survey	Occupancy	TBD
Pig ( <i>Sus scrofa</i> )	Tracking Survey	Occupancy	TBD
Rabbit ( <i>Oryctolagus cuniculus</i> )	Tracking Survey	Occupancy	TBD
<b>Weeds</b>			
Buffel grass ( <i>Cenchrus ciliaris</i> )	Weed survey	Extent of infestation	TBD
'Prickle Bushes' (prickly acacia, mesquite, parkinsonia, mimosa)	Weed survey	Extent of infestation	TBD

## Monitoring and evaluation framework

Kalamurina's Ecohealth Monitoring Program has been designed to measure and report on the status and trends of selected biodiversity and threat indicators on the property, using metrics derived from data collected through a series of purpose-designed surveys. Where possible, outcomes will be evaluated against performance criteria relevant to each species, guild or assemblage.

### Key threatened and iconic species

The Ecohealth program is focused on species of high conservation value, including threatened and 'iconic' species (e.g., regional endemics, species with high public profile and other species of conservation importance because of the role they play in an ecosystem, etc). Where relevant, reintroduced species are also in this category.

Monitoring programs for reintroduced species in the establishment phase (i.e., within 5-10 years of establishment) are typically set out in a *Translocation Proposal*, along with success criteria to evaluate outcomes around survival, recruitment, population size, etc.

AWC will develop *Population Management Plans* to underpin management of long-established populations of reintroduced species, to ensure early detection of any serious issues that arise, and to trigger timely responses. These plans will specify a monitoring and evaluation program (e.g., Berry et al. 2021).

AWC will aim to develop *Conservation Plans* for the remaining (extant) threatened and iconic species, with similar objectives to Population Management Plans. These plans will specify metrics to monitor outcomes for target species against nominated performance criteria.

### Vertebrate assemblages and surveillance species

AWC's mission involves the conservation of all wildlife, not only threatened or reintroduced species. For this reason, AWC's monitoring program extends to surveillance monitoring of faunal assemblages (mammals, birds, reptiles, frogs). The monitoring program aims to address questions relevant to the conservation of assemblages.

At the most basic level, the program seeks to establish whether all species that are known to occur on the property are still persisting on the property (i.e., 'are all species present?').

With increasing information, the monitoring program can address more detailed questions relating to conservation of assemblages, such as ‘have species maintained their distributions or abundance?’ However, the boom/ bust conditions of most Australian environments can lead to large variations in the numbers of individuals in a population and the habitats or sites occupied by a species – these variations may not necessarily be informative in relation to the conservation of a species at a property over the long term.

AWC is currently working on developing an evaluation framework for surveillance monitoring of faunal assemblages. At present, we will continue to present data on a range of metrics relating to indicator species and guilds.

## Survey types and history

To report on the Biodiversity and Threat Indicators, our survey teams conduct a variety of surveys repeated on a schedule of 1-5 years, as required to obtain timely information on each indicator. The period between surveys is primarily influenced by rainfall and / or flooding events. The surveys include:

- Standard Trapping Survey
- Standard Bird Survey
- Tracking Survey

To monitor threats, a range of surveys are used, including:

- Tracking Survey
- Vegetation Survey
- Weed survey

Two of the ecological surveys were conducted at Kalamurina in 2021. Below is a list of surveys reported upon in this Ecohealth Report (Table 3).

**Table 3. Survey history and effort for Ecohealth surveys on Kalamurina reported on in this Report.**

Survey name	Effort (2021)	Description/comment	Previous surveys
Standard Bird Survey	198 bird surveys (66 sites)	80 sites searched (20 minute - 2 ha survey) on 3 consecutive mornings shortly after dawn with a single observer. In 2021, only 66 sites were surveyed.	2020: 219 surveys 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
Tracking Survey	63 surveys	75 one-ha track and sign survey sites. 20 minute - 2 ha survey, single observer. In 2021, only 63 sites were surveyed.	2020: 65 surveys 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

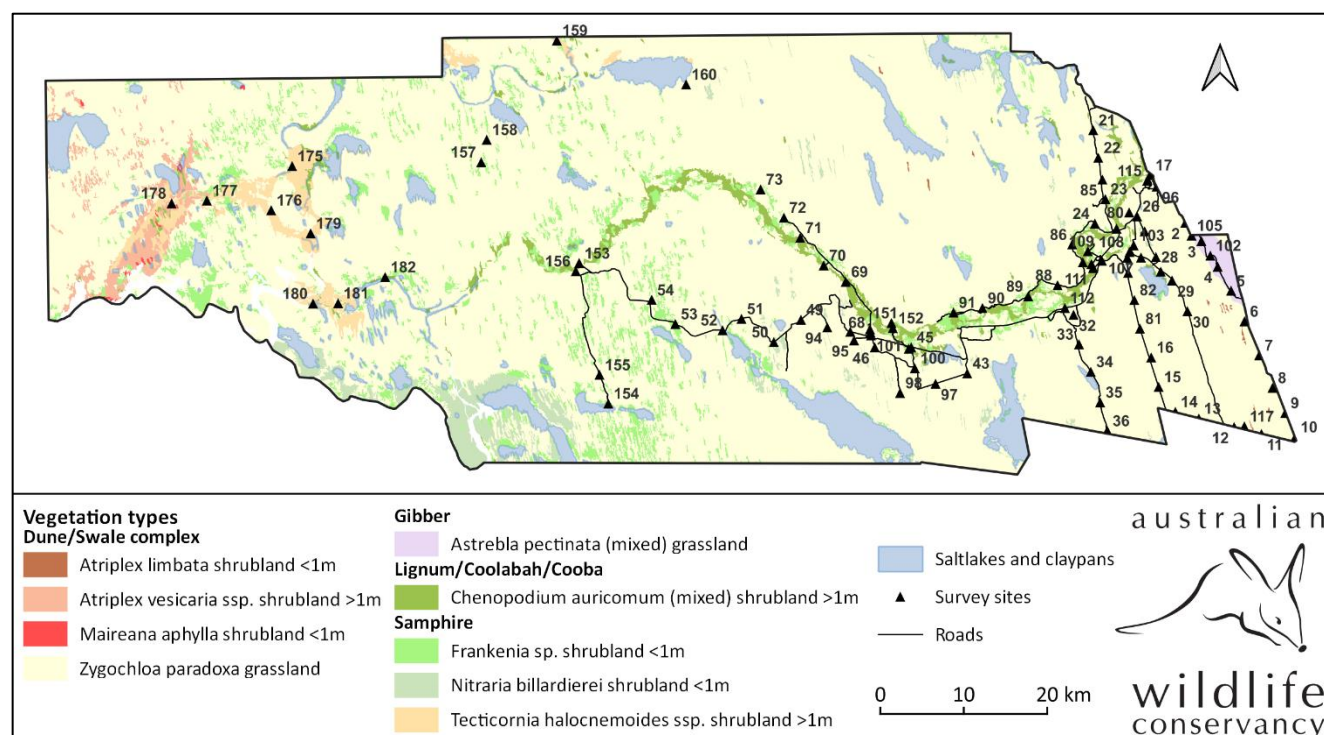
## Survey design and methods

### Standard Bird Survey

There are 80 bird monitoring sites (Figure 6). To date, bird surveys have been conducted annually, at a minimum, and more frequently in some years. Surveys are carried out using the BirdLife Australia Atlas methodology (Blakers et al. 1984). 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.



**Figure 6. Location of bird and tracking monitoring sites on Kalamurina**

## Tracking Survey

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 Standard Trapping Survey sites and are stratified by broad vegetation communities (with a suitable substrate). To date, track surveys have been carried out annually when possible.

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.

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

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.

## Weed surveys

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. Extent of weed species is recorded.

## Analysis methods

Most Ecohealth metrics are common across the indicator species for Kalamurina. Unless noted otherwise, the metrics are calculated as set out in Table 4 below. On Kalamurina, species are assigned to one or more guild. The full lists of the species that have been assigned to particular guilds for the purposes of metrics calculations are listed in Appendix 1.

**Table 4. Metrics and associated calculations for Kalamurina.**

Indicator	Metric	Survey data sources	Description	Analysis summary / calculation
Assemblage richness	Number of species	All surveys and incidental records	A measure of intactness for the whole sanctuary	The number of species detected on the sanctuary within the last 1-5 years is compared to the number of species listed as 'confirmed', 'very likely' or 'likely' on the sanctuary species list.
Various	Abundance	Standard Trapping Survey Standard Bird Survey	A measure of activity; number of detections per 100 trap nights or average number individuals per site/survey	<p><b>Per 100TN:</b></p> <p>For individuals (Total number of individuals recorded within the guild/total number of trap nights) * 100 trap nights.</p> <p>For guilds number of individuals recorded within the relevant guild / total number of trap nights) * 100</p> <p><b>Per site:</b></p> <p>For individuals average number of individuals recorded across surveys at each site, averaged across all sites</p> <p>For guilds average number of individuals recorded across surveys at each site, averaged across all sites</p>
Various	Occupancy	Tracking Survey, Standard Trapping Survey Standard Bird Survey	A measure of distribution; the proportion of sites where the species was recorded	(Number of sites at which a species was recorded / number of sites surveyed) * 100

Indicator	Metric	Survey data sources	Description	Analysis summary / calculation
Various	Richness	Standard Trapping Survey Standard Bird Survey	A measure of diversity; average number of species per site	Total number of species recorded within the relevant guild / total number of sites or surveys

## Results

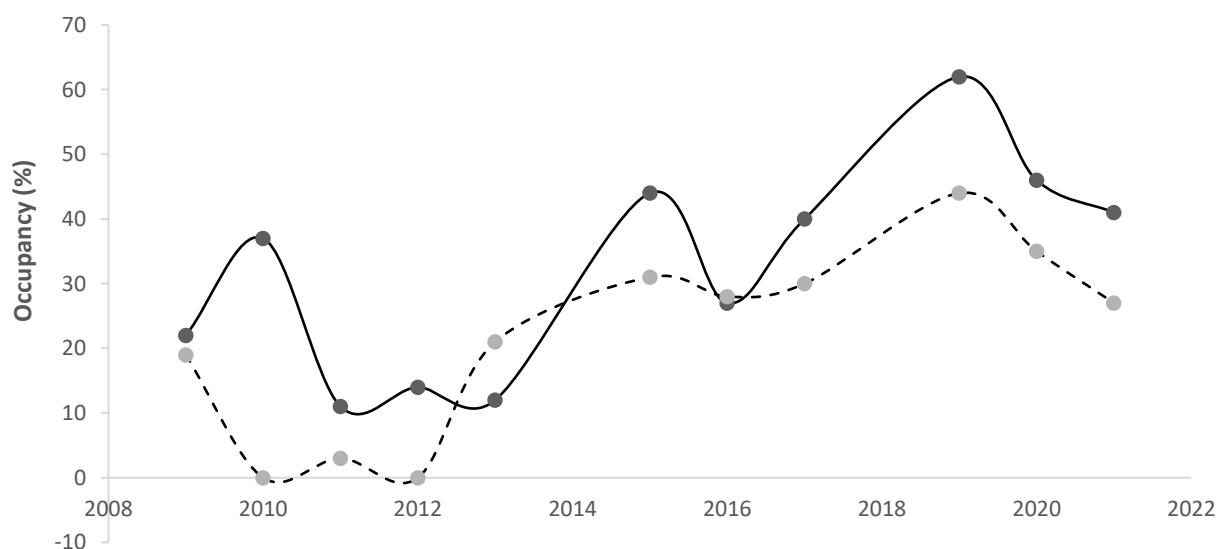
### Key threatened and iconic vertebrates

#### Crest-tailed Mulgara

Track surveys indicate that, while there has been recent small decrease in occupancy over the past few years, there has been long-term increase since surveys began. In 2021, 41% of sites recorded fresh evidence of Crest-tailed Mulgara (Figure 7), above the longer-term average occupancy of 32% (2009-2021).

#### Dusky Hopping-mouse

Track surveys indicate that, while there has been a recent small decrease in occupancy over the past few years, there has been a long-term increase since surveys began. In 2021, 27% of sites recording evidence of Dusky Hopping Mice (Figure 7), above the longer-term average occupancy of 22% (2009-2021)



**Figure 7. Proportion of sites that Crest-tailed Mulgara (solid lines) and Dusky Hopping-mouse (dashed lines) were detected on Kalamurina, 2008-2020 (no data available from 2014 and 2018).**

### Vertebrate assemblages and surveillance species

#### Birds

There are 172 native bird species confirmed to occur on Kalamurina, and a further 1 that is likely to occur based on known species ranges. Of these, 109 species (63%) were detected in 2021 and 110 species (64%) were detected in 2020. In both 2020 and 2021, 58 of the species were recorded on the Standard Bird Survey sites and the remainder were opportunistic observations. In 2021, 7 of 7 confirmed or likely honeyeater species (6 of 7 in 2020), and 24 of 41 confirmed ground-active bird species (24 of 41 in 2020) were observed. Missing species were likely due to preceding dry conditions, and many species being irregular or seasonal visitors to Kalamurina.

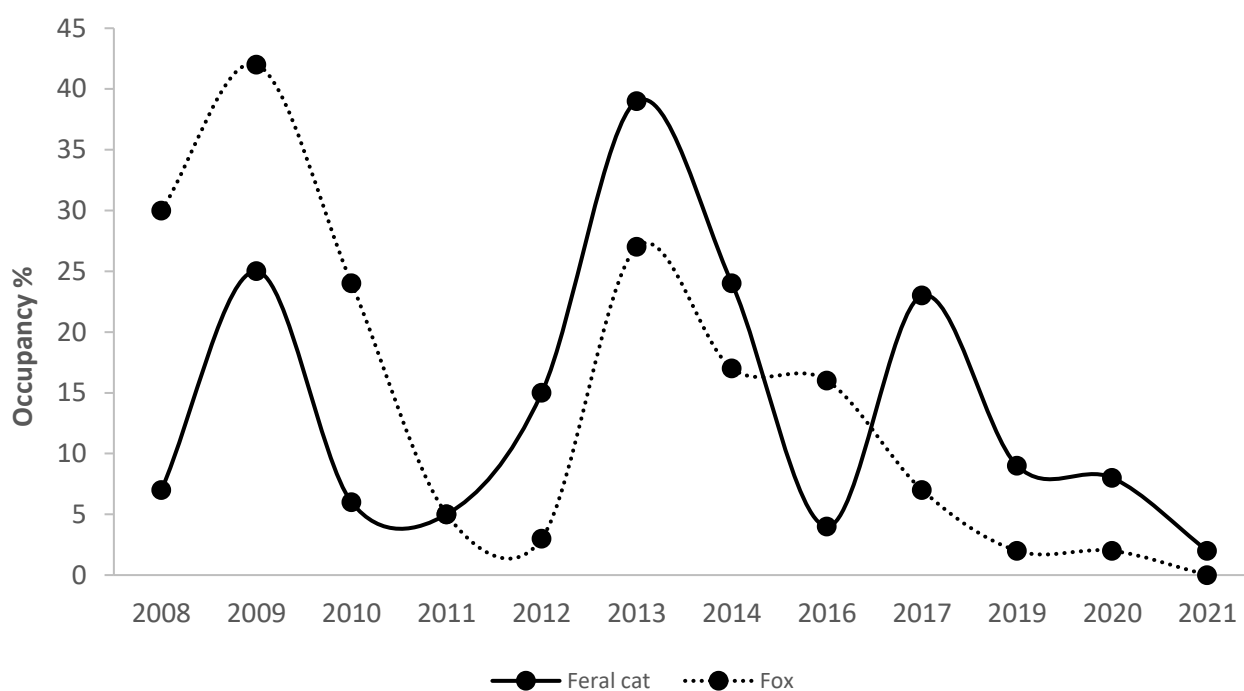
In 2021, a total of 58 species (65 species 2020) were recorded during the formal 20 minute surveys at the 2 ha survey sites, with a total of 109 species recorded throughout the survey period (110 species 2020), including opportunistic observations. No new species for Kalamurina were observed. A number of species were observed breeding or juveniles were observed indicating recent breeding. Abundance and richness increased in 2021 to an average of 74 individuals and 9.4 species per site (27 individuals and 7 species per site in 2020). This was due to the presence of large flocks of several species of Woodswallow (*Artamus spp.*), Budgerigars (*Melopsittacus undulatus*) and Crimson Chats (*Epthianura tricolor*) all of which were taking advantage of the seasonal conditions.

Ground active birds were the most common guild occurring at 97% of sites (2020: 91%) with an average of 5 species being recorded at each site and 21 individuals per site. Honeyeaters were also widespread occurring at 45% of sites (2020: 58%) with an average of 1 species per site and 4 individuals per site. Many species observed opportunistically this year were water-dependent species, but increased numbers and occupancy of some nomadic species such as Pied Honeyeater (*Certhionyx variegatus*) were observed utilising fresh vegetation. Appendix 2 lists all bird species recorded at Kalamurina during 2021 survey.

## Threat indicators

### Feral predators

In 2021, cat was detected at one track survey site and the fox was not detected at all. Several sites had old signs of feral predator activity that were not included in these numbers. Over the last 14 years, both species tend to be detected at a low to moderate percentage of sites (Figure 8).



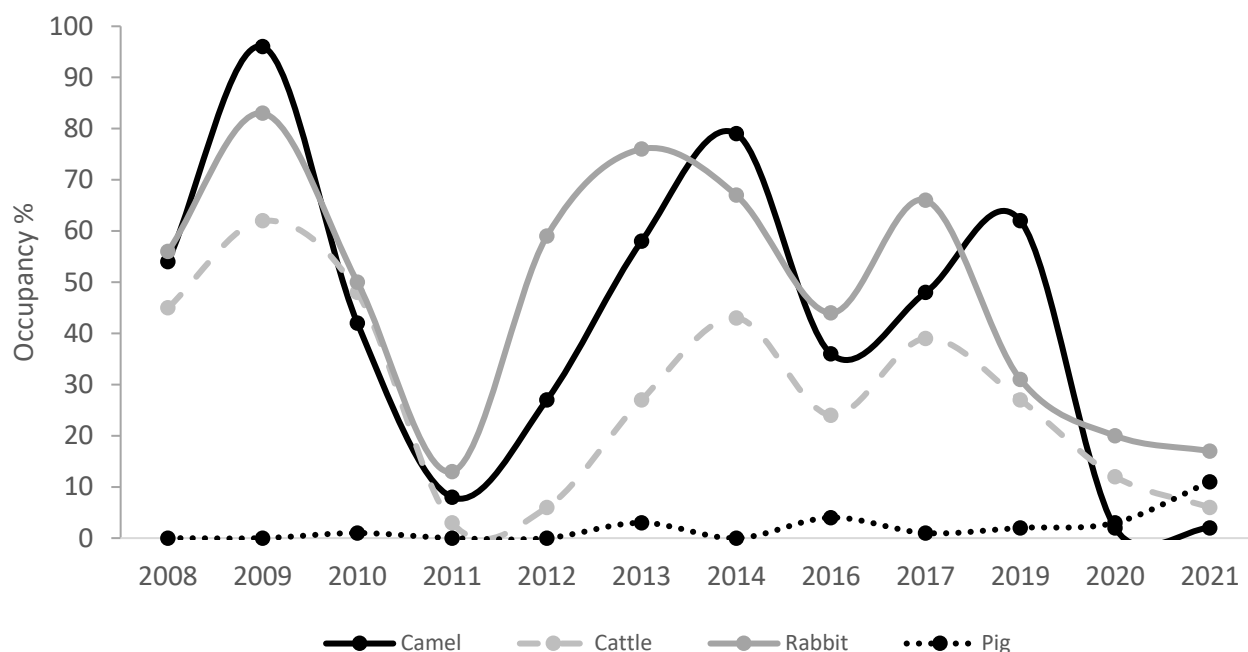
	2008	2009	2010	2011	2012	2013	2014	2016	2017	2019	2020	2021
Number of sites monitored	100	53	82	40	34	33	42	25	61	45	65	63

**Figure 8. Occupancy estimates of feral predators on Kalamurina between 2008 and 2021.** Occupancy is the percent of track monitoring sites where the species was detected.



## Feral herbivores

In 2021, four species of introduced herbivores: camel, cattle, pig and rabbit were recorded on track surveys. Occupancy estimates for camel varies markedly over time, ranging from 1.5% – 96.2%, with 2021 being the equal lowest rate of detection between 2008 – 2021 (Figure 9). Similarly, cattle occupancy varies ranging from 2.5%– 62% with a relative low estimate of 6% in 2021 (Figure 9). Pigs have tended to occur at a low occupancy over the duration of this survey and, in 2021, have a relatively high level of activity and range following a couple of wetter years. Rabbits are typically moderately distributed occupying 12.5% – 83% of sites, with a relatively low estimate of 17% in 2021 (Figure 9). They are not widespread but are numerous where found.



	2008	2009	2010	2011	2012	2013	2014	2016	2017	2019	2020	2021
Number of sites monitored	100	53	82	40	34	33	42	25	61	45	65	63

**Figure 9. Occupancy estimates of feral herbivores on Kalamurina between 2008 and 2021. Occupancy is the percent of track monitoring sites where the species was detected.**

## Weeds

Kalamurina is fortunate to be relatively weed free. 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 upstream in the drainage systems flowing into Kalamurina, so every effort is made to survey creek-lines following flood events.

In 2021, several individuals of buffel grass were detected and removed. These have likely arrived by vehicle. The extent of buffel grass on Kalamurina is 0.1 ha.

## 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. This was followed in early 2021 by significant 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.

The higher rainfall likely had a positive influence on Crest-tailed Mulgara and Dusky Hopping Mouse. The occupancy of these two threatened mammals was above long-term averages and both species were frequently detected at many of the survey sites

Bird surveys were conducted in 2021 following the rainfall events. The widespread rainfall in the dune and swale system meant the bird survey results showed the local bushbirds were abundant and diverse in the dry country and sites in riparian areas and flood-outs recording high diversity and abundance.

Following a couple of wetter years, the only feral animal found to be increasing in occupancy and activity was the feral pig. Overall, feral predators and feral herbivore estimated occupancy continues to remain relatively low on Kalamurina, despite improved rainfall and associated changes in available resources.

## 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.

For their assistance in conducting Ecohealth surveys at Kalamurina in 2021, we particularly thank AWC volunteers, Bernie Haase, Joss and Trish Haiblen.

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