Scotia 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 Scotia Wildlife Sanctuary. Metrics from the program are reported in annual Ecohealth Reports and Scorecards. This is the Ecohealth Report for 2020. Values of metrics presented in this report were based on data collected during surveys carried out during 2020. The complete set of metrics and their values are summarised in the accompanying Ecohealth Scorecard.

Across the reporting period, AWC conducted targeted monitoring of reintroduced species, including the Brush-tailed Bettong (*Bettongia penicillata*), Burrowing Bettong (*Bettongia lesueur*), Bridled Nailtail Wallaby (*Onychogalea fraenata*), Greater Bilby (*Macrotis lagotis*) and Numbat (*Myrmecobius fasciatus*). A semi-captive insurance population of Mala (*Lagorchestes hirsutus*) was also monitored. Total survey effort for these reintroduced species was 2,216 cage trap nights (bettongs), 128 Thomas trap nights (Mala), 672 km of spotlighting transects (Bilby and Bridled Nailtail Wallaby) and 504 km of daytime driving transects for Numbat.

Population estimates for reintroduced species were as follows: Brush-tailed Bettong: 15; Burrowing Bettong: 130; Mala: 44; Bridled Nailtail Wallaby: 50; Greater Bilby: 300; and Numbat: 135. The survey methods have poor resolution when population sizes are small: for example, although the trapping survey estimated only 15 Brush-tailed Bettongs, a total of 40 individuals were translocated from Scotia in December 2020, with another 16 individuals translocated to Mallee Cliffs in 2021.

Scotia and the surrounding region experienced the severest drought on record in 2019 (annual rainfall = 48 mm, compared to long-term annual average of 233 mm). Rainfall returned to average in 2020 (231 mm) which initiated a recovery of vegetation. For two species – Bilby and Numbat - the more favourable conditions in 2020 resulted in a recovery in population sizes from the low numbers recorded in 2019. For the remaining species – Burrowing Bettong, Brushtail Bettong and Bridled Nailtail Wallaby – populations continued to decline through 2019 to 2020. In one of these species, the Burrowing Bettong, trapping data showed that the proportion of females carrying pouch young had increased from 20% in 2019 to 84% in 2020, suggesting a likely recovery of the population. For the other two species, given small population sizes recorded in 2020, AWC intervened to limit inbreeding. In the case of the Brush-tailed Bettong, most of the remaining individuals at Scotia were translocated to Yookamurra in December 2020, to pool with the Yookamurra population, which has also experienced a severe drought-driven decline. In the case of the Bridled Nailtail Wallaby, all remaining individuals in Stage 1 and the Homestead Paddock adjacent to Stage 1 were moved into the Stage 2 fenced area, beginning in late 2020.

All remaining Mala from the insurance population at Scotia were translocated to Newhaven Wildlife Sanctuary in August 2020, to complete the reintroduction to that site.

A Standard Bird Survey was undertaken in October 2020. There were an average of 8 species recorded per site. Most indicator species were recorded at slightly higher occupancy than the last survey in 2018.

A total of 63 previously identified Malleefowl (*Leipoa ocellata*) mounds were surveyed for signs of activity, with four identified as being active. This is consistent with the numbers of active mounds identified during previous surveys (2017-2018), and an increase from 2019 when no active mounds were found. Encouragingly, in early 2021, ground-truthing of 67 additional mounds identified by LiDAR resulted in a further eight active mounds being recorded.

A planned burn of 40.6 hectares was undertaken for infrastructure protection within the predator-free exclosure. No unplanned fires occurred on Scotia in 2020.

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Cover photograph: Clockwise left to right: Mulga snakes fighting, multiple bird species using a pond over summer, Splendid Fairywren, Numbat. AWC/Tali Moyle

Introduction

Australian Wildlife Conservancy (AWC) owns, manages, or works in partnerships across 30 properties in Australia, covering almost 6.5 million hectares, to implement our mission: *the effective conservation of Australian wildlife and their habitats*. AWC relies on information provided by an integrated program of monitoring and research to measure progress in meeting its mission and to improve conservation management. AWC's Ecohealth Monitoring Program has been designed to measure and report on the status and trends of species, ecological processes and threats on each of these properties (Kanowski et al. 2018). The program focuses on selected 'indicator' species, guilds, processes and threats, using metrics derived from data collected through a series of purpose-designed surveys.

The structure of the Ecohealth Program on each AWC property is as follows. Based on the guidance provided by AWC's over-arching program framework, above, Ecohealth Monitoring Plans are developed, describing the conservation values or assets of each property, and threats to these assets; and setting out the monitoring program that will be used to track the status and trend of selected indicators of these conservation assets and threats. Annual survey plans and schedules are developed to implement these plans. The outcomes of these surveys are presented in annual Ecohealth Reports and summary Ecohealth Scorecards.

This document is the first in the series of annual Ecohealth Reports for Scotia Wildlife Sanctuary. It draws on survey trip reports to calculate values for metrics that reveal the status and trends of the Ecohealth indicators. The companion Ecohealth Scorecard presents the indicators and their metrics in a summary format.

Scotia Wildlife Sanctuary

Scotia Wildlife Sanctuary (referred to here as Scotia) is situated in the semi-arid Murray-Darling Basin Bioregion in far south-western New South Wales, 150 km south of Broken Hill, adjacent to the South Australian border (Figure 1). The sanctuary is within the traditional lands of the Barkindji people. Scotia is 64,653 ha and falls within the Riverland Biosphere region which extends south to the Murray River in SA. AWC acquired Scotia in 2002.

The Scotia landscape is characterised by consolidated red sand dunes and swales vegetated by *Eucalyptus* mallee communities on the dunes and slopes, and Belah (*Casuarina pauper*) woodlands in the swales, with several other smaller vegetation communities (Westbrooke et al. 1998). The mallee has a spinifex understory on sandier soils and dune tops, and a shrubby understorey on the dune slopes. Scotia supports a total of 244 vertebrate fauna species (see Appendix 1 for a complete species list), including nationally significant populations of threatened species reintroduced into an 8,000 ha fenced feral predator-free exclosure (Stage 1 and 2). Species reintroduced include the Burrowing Bettong (*Bettongia lesueur*), Brush-tailed Bettong (*Bettongia penicillata*), Greater Bilby (*Macrotis lagotis*), Bridled Nailtail Wallaby (*Onychogalea fraenata*) and Numbat (*Myrmecobius fasciatus*). Additionally, a semi-captive insurance population of the endangered Mala (or Rufous Hare-Wallaby, *Lagorchestes hirsutus*) was maintained on site until August 2020.

AWC conducts ecological surveys and research to inform conservation management on its sanctuaries. On Scotia, the science program includes:

- studies of reintroduced mammals and their ecology (Viera et al. 2007; Finlayson et al. 2008; Hayward et al. 2012, 2015; Berry et al. 2019);
- studies of the response of extant mammals, reptiles and birds, and vegetation, to the reintroduction project (Roshier et al. 2020; Kemp et al. 2021);
- research into the ecology of feral cats and foxes outside the fenced area (Carter et al. 2019).

In addition, AWC has hosted and/ or collaborated with a range of external researchers conducting work at Scotia on various aspects of the ecological consequences of reintroductions for plants, invertebrates and ecological processes (e.g., Coggan et al. 2016; Decker et al. 2019).

The purpose of monitoring at Scotia is to focus on the ecological health of the sanctuary using a set of key indicators. Monitoring the Ecohealth of the sanctuary is a long-term undertaking that has been designed to allow AWC to track the trajectorie of key values such that appropriate management activities can be undertaken and to support maintenance and improvement of the overall ecological health of the sanctuary.

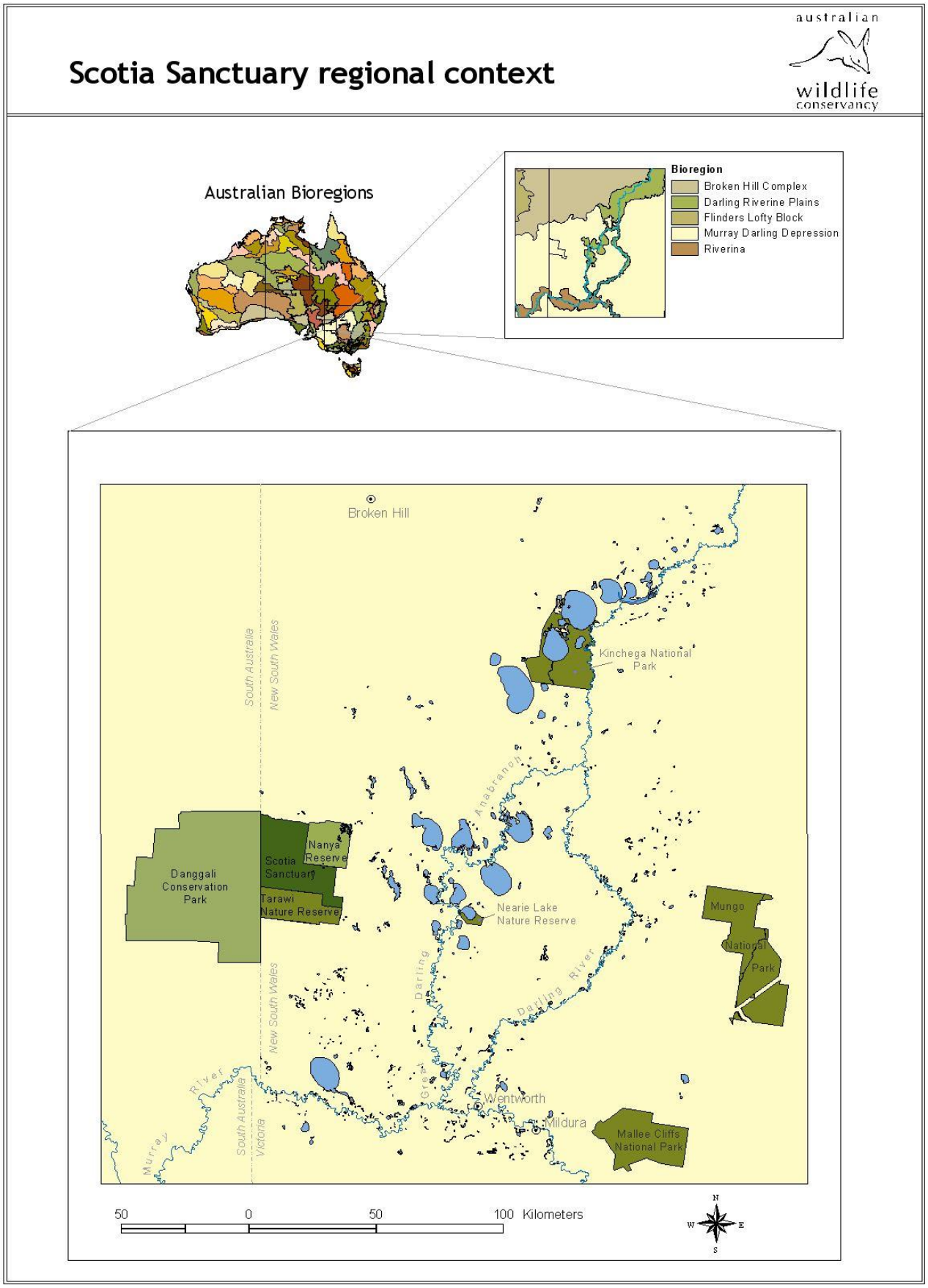

Figure 1. Location of Scotia

Climate and weather summary

The climate at Scotia typically consists of hot summers with the highest long-term mean maximum temperature of 34.5°C in January 2020, and cold winters with a mean minimum of 5.2°C (Figure 2).

Rain is intermittent at Scotia with most rainfall typically occurring over the spring/ summer months; the long-term average rainfall is 229 mm (1995 -2020) (Bureau of Meteorology,'BoM', 2020). Like much of NSW, Scotia has recently experienced a prolonged dry period. In 2019, just 48 mm of rain was received, the lowest total since records began in 1995 (Figure 3 and Figure 4). Average rainfall returned in 2020 (231 mm).

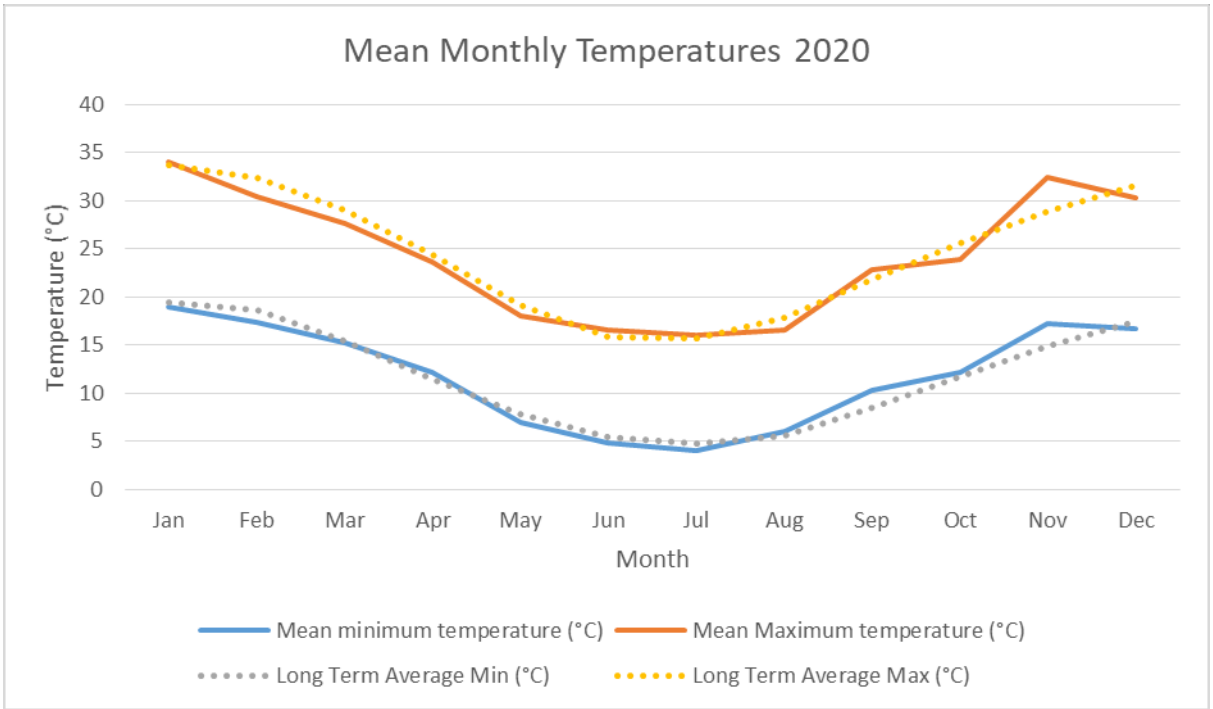

Figure 2. Mean monthly temperatures for Broken Hill and long term averages (1995-2020). Data collected from BoM Broken Hill Airport AWS (BoM weather station 047048, considered representative of Scotia as the closest station to the Sanctuary, 137km N).

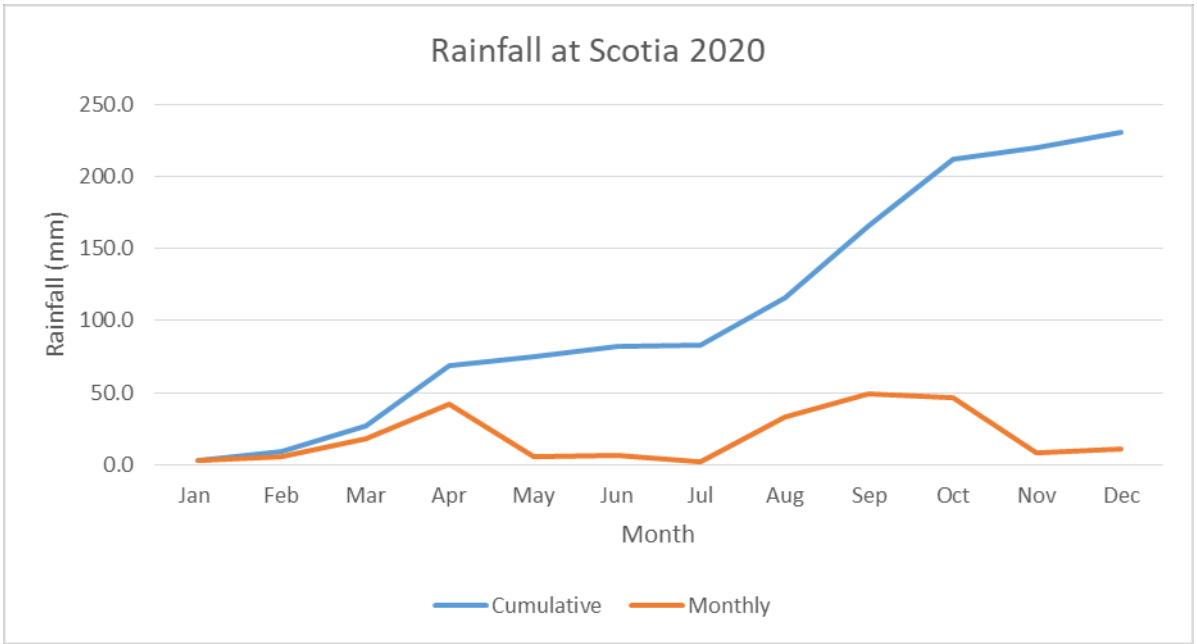

Figure 3. Monthly rainfall for Scotia. Data collected from BoM 47105 Wentworth (Scotia Wildlife Sanctuary).

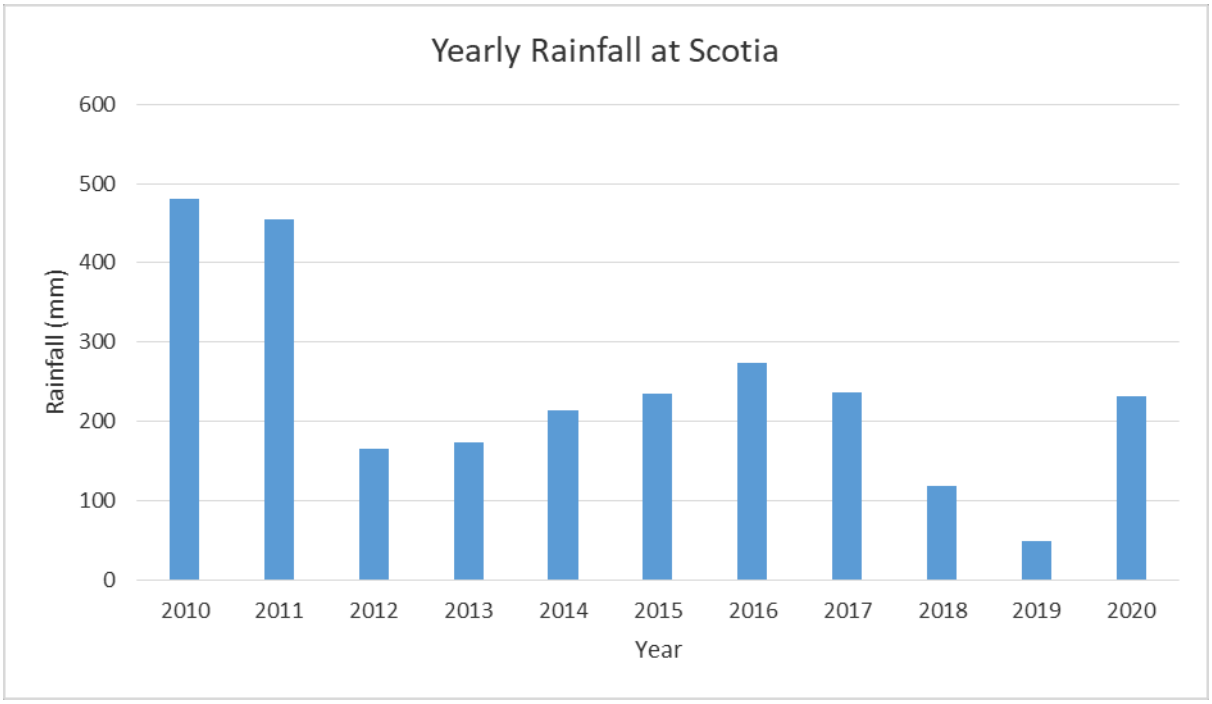

Figure 4. Yearly rainfall for Scotia 2010-2020. Long-term average rainfall is 229mm (1995-2020). Data collected from BoM 47105 Wentworth (Scotia Wildlife Sanctuary).

Methods

Indicators and metrics

Scotia's Ecohealth Monitoring Program has been designed to measure and report on the status and trends of species, ecological processes and threats on the sanctuary. The program focuses on selected biodiversity and threat indicators, using metrics derived from data collected through a series of purpose-designed surveys. A selection of species or guilds were chosen as biodiversity indicators which fit into one or more of the following categories: (1) declining and/or threatened species or guilds, (2) strong drivers of ecosystem function, or (3) are a member of the full range of taxa (to enable ongoing surveillance monitoring of a range of taxonomic groups to provide early warning of any unexpected declines). On Scotia, 47 biodiversity (species and guilds) indictors have been selected for monitoring (Table 1). Seventeen of these indicators were surveyed with the Ecohealth methodology in 2020 and were reported on in this report. Threat metrics are selected to ensure monitoring the status and trends of introduced weeds, predators and herbivores and inappropriate fire regimes. Five threat indicators have been selected for monitoring (Table 2). In 2020, one of these was reported on. In future years, reporting for key weed species will be added.

Table 1. Biodiversity indicators for the Ecohealth Monitoring Program for Scotia. Rationale for selection: R = Reintroduced species; T = threatened or declining; D = strong driver of ecosystem function; S = surveillance monitoring. Metric definitions: Population estimate = estimated population size; occupancy = proportion of sites recorded; richness = average number of species per site; abundance = number of individuals recorded per 100 trap nights (mammals, reptiles, frogs).

Indicator					Survey Method	Metric/s
	T	D	S	R		
Mammals						
Reintroduced mammals						
Numbat (*Myrmecobius fasciatus*)	*			*	Transects (diurnal)	Population estimate
Greater Bilby (*Macrotis lagotis*)	*	*		*	Transects (nocturnal)	Population estimate
Burrowing Bettong (*Bettongia lesueur*)	*	*		*	Mammal Trapping Survey	Population estimate
Brush-tailed Bettong (*Bettongia pencillata*)	*			*	Mammal Trapping Survey	Population estimate
Mala (*Lagorchestes hirsutus*)	*			*	Mammal Trapping Survey	Population estimate
Bridled Nailtail Wallaby (*Onychogalea fraenata*)	*			*	Transects (nocturnal)	Population estimate
Small-medium mammals						
Dasyurids - guild	*	*			Standard Trapping Survey	Abundance, occupancy
Rodents - guild	*	*			Standard Trapping Survey	Abundance, occupancy
Common Dunnart (*Sminthopsis murina*)			*		Standard Trapping Survey	Abundance, occupancy
Fat-tailed Dunnart (*Sminthopsis crassicaudata)*			*		Standard Trapping Survey	Abundance, occupancy
Stripe-faced Dunnart (*Sminthopsis macroura*)	*				Standard Trapping Survey	Abundance, occupancy
Southern Ningaui (*Ningaui yvonneae*)	*	*			Standard Trapping Survey	Abundance, occupancy
Western Pygmy-possum (*Cercartetus concinnus*)	*				Standard Trapping Survey	Abundance, occupancy
Bolam's Mouse (*Pseudomys bolami*)	*				Standard Trapping Survey	Abundance, occupancy
All Small-medium mammals	*		*		Standard Trapping Survey	Abundance, occupancy
Large Herbivores						
Red Kangaroo (*Macropus rufus*)		*			Methods under development	Abundance, occupancy

Indicator					Survey Method	Metric/s
	T	D	S	R		
Western Grey Kangaroo (*Macropus fuliginosus*)		*			Methods under development	Abundance, occupancy
Bats						
Microbat - guild			*		Methods under development	Abundance, occupancy
Reptiles						
Small-medium reptiles						
All small-medium reptiles			*		Standard Trapping Survey	Abundance, occupancy
Reptiles – agamids (guild)			*		Standard Trapping Survey	Abundance, occupancy
Reptiles – pygopodids (guild)			*		Standard Trapping Survey	Abundance, occupancy
Reptiles – skinks (guild)			*		Standard Trapping Survey	Abundance, occupancy
Reptiles – geckos (guild)			*		Standard Trapping Survey	Abundance, occupancy
Barred Wedge-snout Ctenotus (*Ctenotus schomburgkii*)			*		Standard Trapping Survey	Abundance, occupancy
Morethia skink (*Morethia obscura*)			*		Standard Trapping Survey	Abundance, occupancy
Southern Sandslider (*Lerista labialis*)			*		Standard Trapping Survey	Abundance, occupancy
Nobbi Dragon (*Diporiphora nobbi*)			*		Standard Trapping Survey	Abundance, occupancy
Mallee Dragon (*Ctenophorus fordi*)			*		Standard Trapping Survey	Abundance, occupancy
Marbled-faced Delma (*Delma australis*)	*		*		Standard Trapping Survey	Abundance, occupancy
Eastern Tree Dtella (*Geyhra versicolor*)			*		Standard Trapping Survey	Abundance, occupancy
Beaded Gecko (*Lucasium damaeum*)			*		Standard Trapping Survey	Abundance, occupancy
Three-lined Knob-tail Gecko (*Nephrurus levis*)			*		Standard Trapping Survey	Abundance, occupancy
Large reptiles						
Reptiles-large varanids/snakes (guild)		*			Standard Trapping Survey	Abundance, occupancy
Birds						
All birds			*		Standard Bird Survey	Richness
Honeyeaters - guild			*		Standard Bird Survey	Richness
Ground-active birds - guild			*		Standard Bird Survey	Richness
Nocturnal birds - guild			*		Methods under development	Occupancy
Chestnut Quail-thrush (*Cinclosoma castanotum*)	*				Standard Bird Survey	Occupancy
Gilbert's Whistler (*Pachycephala inornate*)	*				Standard Bird Survey	Occupancy
Hooded Robin (*Melanodryas cucullate*)	*				Standard Bird Survey	Occupancy
Major Mitchell's Cockatoo (*Lophochroa leadbeateri*)	*				Standard Bird Survey	Occupancy
Shy Heathwren (*Hylacola cauta*)	*				Standard Bird Survey	Occupancy
Southern Scrub-robin (*Drymodes brunneopygia*)	*				Standard Bird Survey	Occupancy
Striated Grasswren (*Amytornis striatus*)	*				Standard Bird Survey	Occupancy
Malleefowl (*Leipoa ocellata*)	*	*			Malleefowl Mound Survey	Activity (number of active mounds)
Frogs						
Amphibian guild			*		Standard Trapping Survey, Targeted Survey	Abundance, richness

Indicator					Survey Method	Metric/s
	T	D	S	R		
Vegetation						
Vegetation characteristics			*		Methods under development	Per cent cover, species richness

Table 2. Threat indicators for Scotia Ecohealth Monitoring Program.

Indicator	Rationale	Survey method	Metric/s
Feral predators			
Cat (*Felis catus*)	Major threat to wildlife	Camera Trap Grid	Abundance, occupancy
Fox (*Vulpes vulpes*)	Major threat to wildlife	Camera Trap Grid	Abundance, occupancy
Feral herbivores			
Goats (*Capra hircus*)	Threat to native species (flora & fauna)	Camera Trap Grid	Abundance, occupancy
Rabbits (*Oryctolagus cuniculus*)	Threat to native species (flora & fauna)	Camera Trap Grid	Abundance, occupancy
Fire			
Fire	Key driver of vegetation dynamics, structure and composition, habitat attributes	Fire Scar Analysis	Area burnt in planned fire (% of property; ha) Area burnt in unplanned fire (% of property; ha)

Survey types and history

To report on the Biodiversity and Threat Indicators, AWC survey teams conduct a variety of surveys repeated on a schedule of 1-5 years. These include:

- Standard Trapping Survey
- Mammal Trapping Surveys
- Transects (nocturnal and diurnal)
- Standard Bird Survey
- Malleefowl Mound Surveys
- Camera Trap Grid
- A range of Targeted Surveys (e.g. species-specific cage trapping and strip plot transects, frog surveys)

In addition to surveys, computations of sanctuary-wide fire scar data were conducted for:

- Fire Scar Analysis

Seven ecological ground-based surveys were completed at Scotia in 2020: a Standard Bird Survey, three Cage Trapping surveys (Brush-tailed Bettong; Burrowing Bettong; and Mala), two Strip Plot Transect surveys (Greater Bilby and Bridled Nailtail Wallaby; Numbats) and a Malleefowl Mound Survey (Table 3). The Standard Trapping Survey was not undertaken in 2020. The methodology is described and results of these surveys and computations are reported on in this document.

Table 3. Survey effort for Ecohealth Monitoring Program surveys on Scotia in 2020.

Survey name	Effort in 2020	Description/comment	Survey history
Standard Trapping Survey (pitfall trapping)	0 trap nights	63 trapping sites surveyed with pitfall traps. Stratified to cover a range of geography and major vegetation types	2019 – 1,584 Trap nights 2018 – 2,079 Trap nights 2017 – 1,584 Trap nights 2016 – 1,584 Trap nights 2015 – 1,584 Trap nights 2014 – 1,584 Trap nights 2013 – 1,584 Trap nights 2012 – 1,584 Trap nights 2011 – 1,584 Trap nights 2010 – 1,584 Trap nights
Standard Trapping Survey (funnel trapping)	0 trap nights	63 trapping sites surveyed with funnel traps. Stratified to cover a range of geography and major vegetation types	2019 – 1,728 Trap nights 2018 – 2,268 Trap nights 2017 – 1,728 Trap nights 2016 – 1,728 Trap nights 2015 – 1,728 Trap nights 2014 – 1,728 Trap nights 2013 – 1,728 Trap nights 2012 – 1,728 Trap nights 2011 – 1,728 Trap nights 2010 – 1,728 Trap nights
Mammal Trapping Survey (Brush-tailed Bettong)	848 trap nights	106 trapping sites with two cage traps, repeated across four days. In 2015-2020 surveys were conducted annually, 2010-2014 surveys were conducted bi-annually	2020 – 848 Trap nights 2019 – 848 Trap nights 2018 – 848 Trap nights 2017 – 848 Trap nights 2016 – 848 Trap nights 2015 – 848 Trap nights 2014 – 848 Trap nights 2013 – 636 Trap nights 2012 – 636 Trap nights 2011 – 345 Trap nights 2010 – 345 Trap nights

Survey name	Effort in 2020	Description/comment	Survey history
Mammal Trapping Survey (Burrowing Bettong)	1,368 trap nights	114 trapping sites surveyed with three cage traps, repeated over four days. In 2015-2020 surveys were conducted annually, 2010-2014 surveys were conducted bi-annually	2020 – 1,368 Trap nights 2019 – 1,368 Trap nights 2018 – 1,368 Trap nights 2017 – 1,368 Trap nights 2016 – 1,368 Trap nights 2015 – 1,368 Trap nights 2014 – 1,368 Trap nights 2013 – 1,026 Trap nights 2012 – 1,026 Trap nights 2011 – 1,026 Trap nights 2010 – 1,026 Trap nights
Mammal Trapping Survey (Mala)	192 trap nights	24 trapping sites surveyed with two Thomas traps, four nights. 4 nights 2016-2020, 3 nights 2012-2015, five nights 2011, six nights 2010 (2010-2011 slightly different survey setup to current survey).	2020 – 192 Trap nights 2019 – 192 Trap nights 2018 – 192 Trap nights 2017 – 192 Trap nights 2016 – 192 Trap nights
Transects (nocturnal: Greater Bilby and Bridled Nailtail Wallaby)	May - 420 km June – 420 km	Spotlighting transects. Spotlighting surveys from 2010-2014 were conducted bi-annually with a different transect setup to the current surveys. 2015-2019, set transects and fixed methodology, 2015 conducted twice a year. 2020 twice a year.	2020 – 840 km 2019 – 420 km 2018 – 420 km 2017 – 420 km 2016 – 420 km 2015 – 420 km
Transects (diurnal: Numbat)	630 km	Spotlighting road transects. Numbat road transects from 2010-2014 were at random transects through Stage 1, 2015-2020 saw set transects and methodology through stage 1 and 2.	2020 – 630 km 2019 – 630 km 2018 – 392 km 2017 – 630 km 2016 – 630 km 2015 – 630 km 2014 – 497 km 2012 – 822 km 2011 – 669 km 2010 – 695 km
Standard Bird Survey	144 surveys	20 minute - 2 ha survey shortly after dawn with a single observer. These were done at all 48 standard trapping sites across three mornings.	2020 – 48 sites 2018 – 63 sites 2017 – 48 sites 2015 – 48 Sites 2013 – 84 sites
Malleefowl Mound Survey	63 sites/ Plus 67 new mounds were identified through LiDAR	Visit and survey 63 known mound sites	2020 – 63 sites 2019 – 63 sites 2018 – 26 sites 2017 – 62 sites 2016 – 54 sites 2014 – 45 sites 2013 – 27 sites 2012 – 31 sites 2011 – 29 sites 2010 – 27 sites

Survey design and methods

Standard Trapping Survey

From 2010 to 2019, an annual live trapping survey targeting small mammals and reptiles was conducted across four survey mornings and afternoons. A total of 63 sites were stratified across three vegetation communities: Mallee/Trioda, Mallee shrub and Belah woodland, and four management treatments were surveyed (Stages 1-4) (Figure 5).

Survey sites were 1 ha in area and comprised a total of 11 pitfall traps. Inset from each corner of the 1 ha site, two 20L buckets were positioned 25 m apart and connected by a 30 m drift fence. In the centre of the site a central 'cross' contained a third bucket halfway along the fence where two short drift fences (7.5 m) ran at a 90° to the main fence. Each drift fence also had two funnel traps (apart from the middle array which has four; two along each short fence), with a total of 12 funnel traps per site (Figure 6).

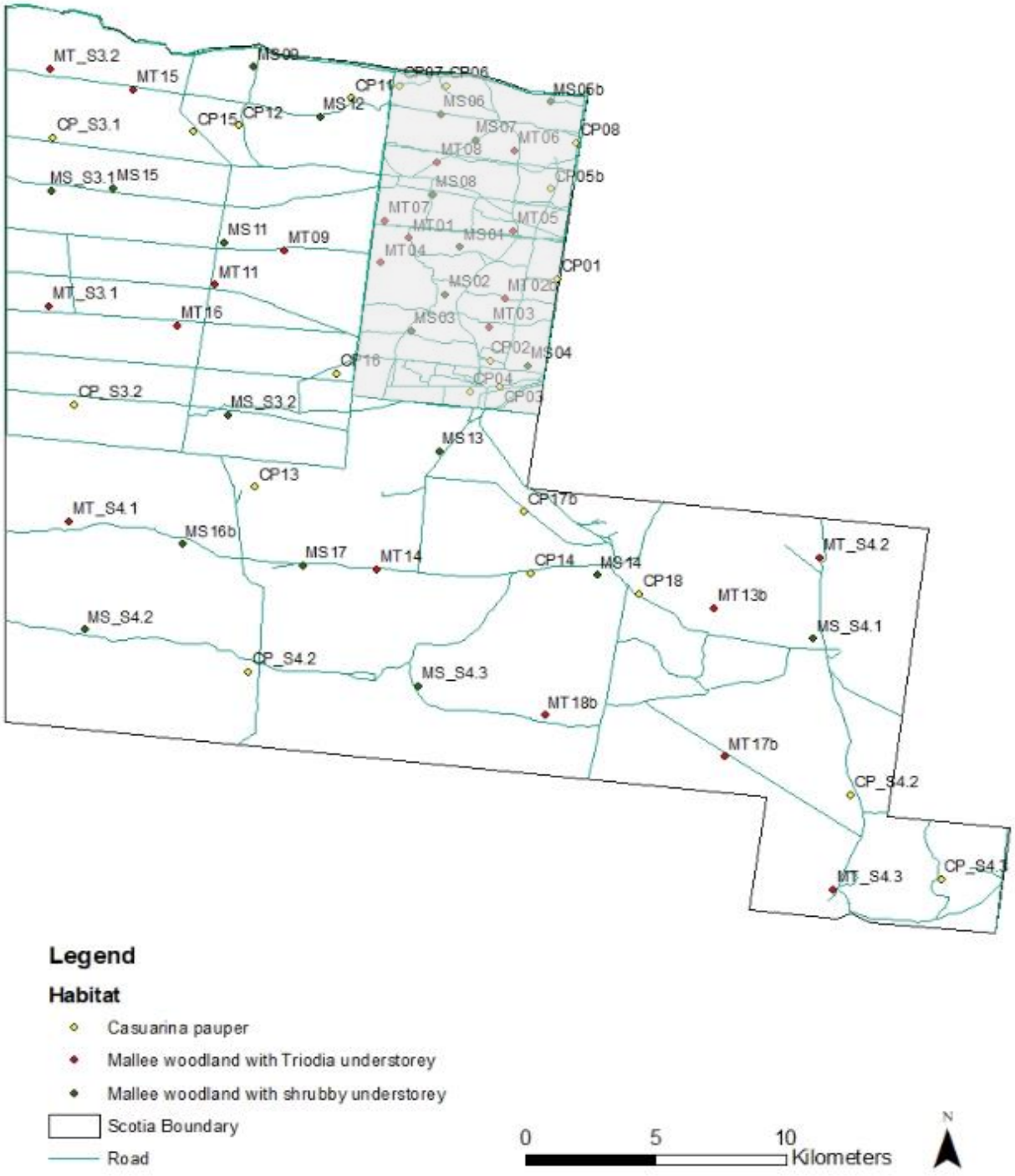

Figure 5. Location of permanent live-trapping monitoring sites across Scotia. Shading = fenced area.

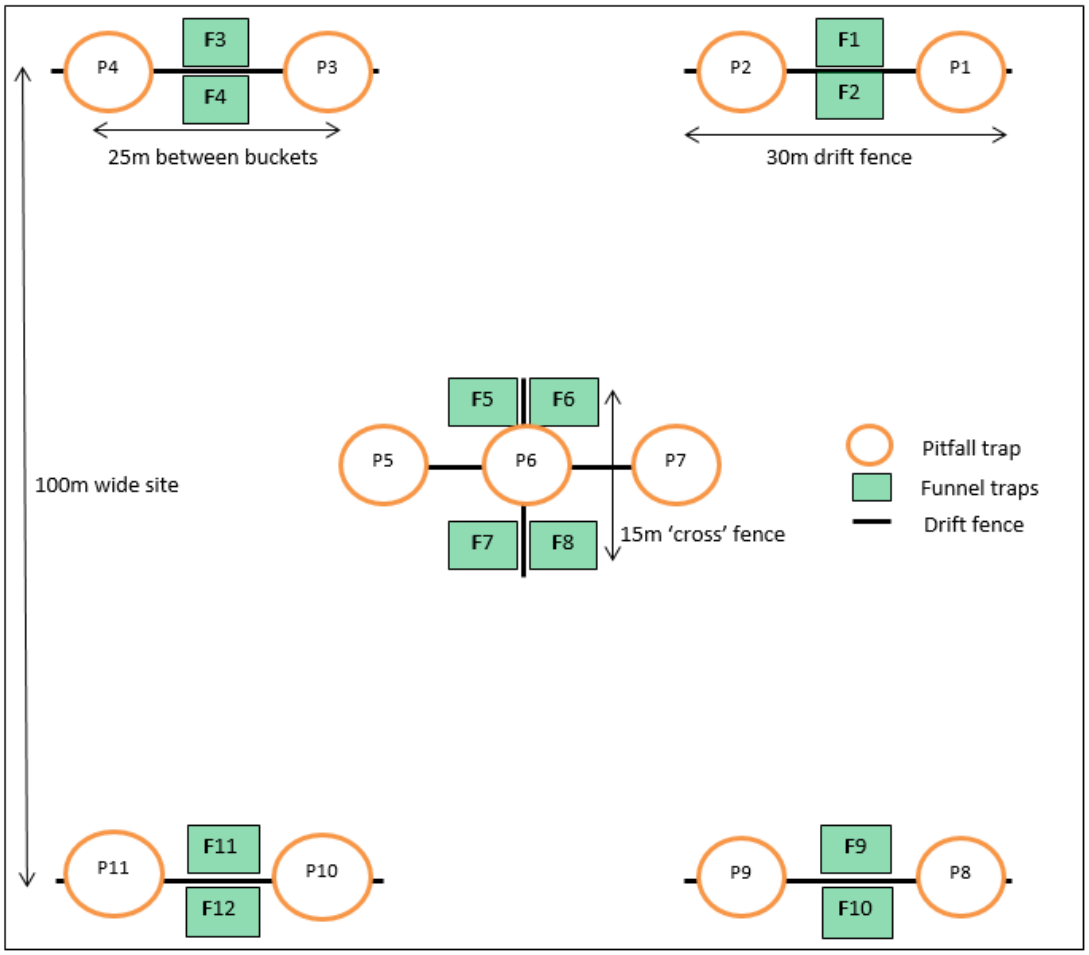

Figure 6. Site layout for live trapping survey of mammals and reptiles at Scotia

Mammal Trapping

Brush-tailed Bettong and Burrowing Bettong

To obtain population estimates for the Brush-tailed Bettong and Burrowing Bettong, a four-night mark-recapture survey was undertaken utilising cage traps throughout Stage 1 and Stage 2 of the feral predator-free exclosure (Kemp et al. 2016). Trap sites were located approximately 500 m apart along Scotia's existing road network. There were 114 sites in Stage 1 (three traps at each site, 342 total cage traps) targeting the Burrowing Bettong and 106 sites in Stage 2 (two traps at each site, 212 total cage traps) targeting the Brush-tailed Bettong (Figure 7). The survey takes place on an annual basis.

Mala

A four-night mark-recapture survey was employed in April 2020 to gain population estimates for the captive/insurance population of Mala. Trap sites were placed in a grid throughout the Mala enclosure approximately 200 m apart. There was a total of 24 sites with two Thomas traps at each site (48 traps total; Figure 8). Mala were again trapped in August to be translocated to Newhaven.

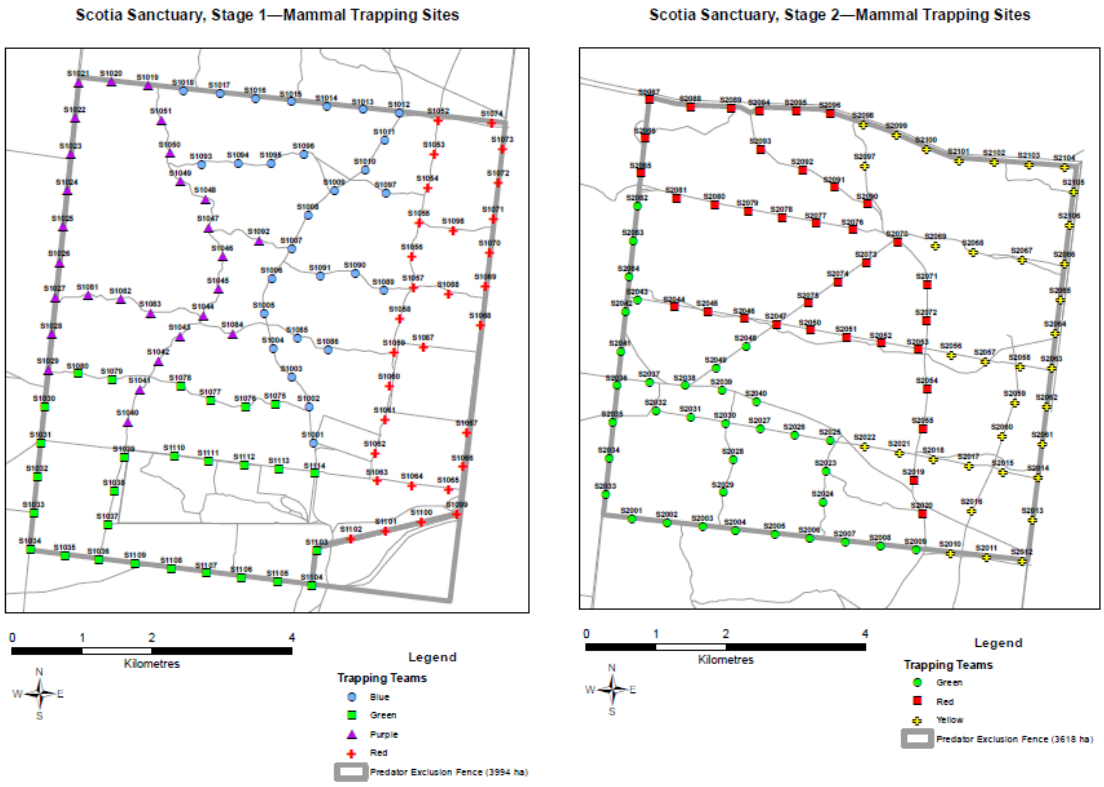

Figure 7. Trap site locations in Stage 1 (left) and Stage 2 (right) used during the mark-recapture surveys of Scotia's bettong populations

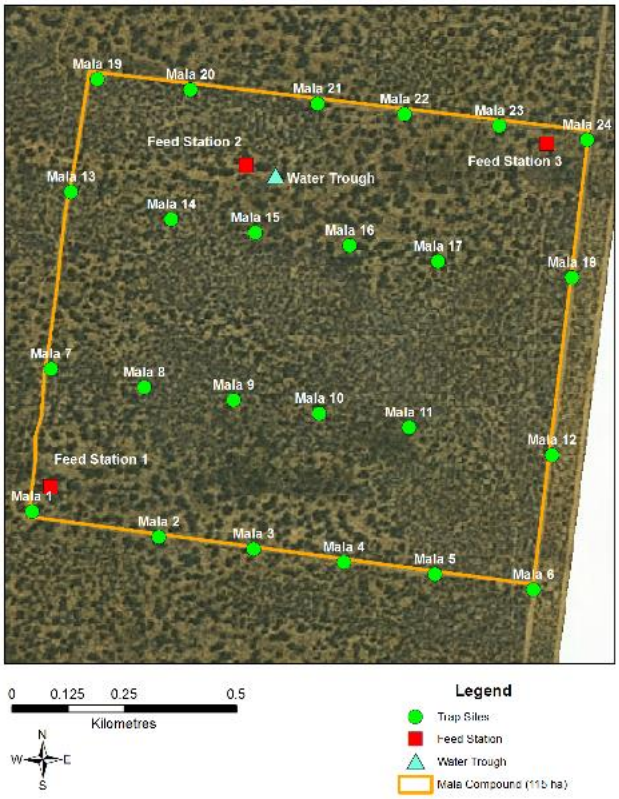

Figure 8. Trap site locations in the Mala enclosure used during the mark-recapture surveys

Transects

Nocturnal

Nocturnal driving transects using spotlights were undertaken for the Bridled Nailtail Wallaby and Greater Bilby over six nights. These surveys were each conducted twice in 2020 (March and July). Transects were 1 km in length unless situated along a fence line, in which case they were 2 km long and only observed on one side. In total there were 28 transects in Stage 1 (36 km) and 28 in Stage 2 (34 km; Figure 9; L'Hotellier et al. 2016a, 2016b).

Diurnal

Diurnal driving transects were undertaken for the Numbat over nine days, half in the morning and half in the afternoon. For diurnal surveys, the same transects were driven in Stage 1 and Stage 2 as for nocturnal surveys (Figure 9).

Figure 9. Driving transect locations in Stage 1 (left) and Stage 2 (right) used for surveys of Bridled Nailtail Wallabies and Greater Bilbies (nocturnal/spotlight survey), and Numbats (diurnal survey)

Standard Bird Survey

The Standard Bird Survey was conducted at 48 sites in 2020, stratified across the three main vegetation communities: (i) Mallee Triodia, (ii) Mallee shrub and (iii) Belah woodland, within the four management treatments (i.e. Stages 1–4) on the sanctuary. Each treatment type (i.e. Stages 1–4) has different management histories. Of the 48 sites, 16 sites were located in each vegetation community, divided equally between the fenced (feral free; Stages 1 and 2) and unfenced treatments (Stages 3 and 4; Figure 5). Each site encompassed a 2-ha search area that was sampled by a single observer. The observer spent 20 minutes actively searching the area by wandering slowly across the entirety of the site, identifying and recording any sightings or vocalisations within the 2-ha area. This is the preferred survey technique used by BirdLife Australia.

On an annual basis in spring, each site was surveyed three times with no two replicates occurring on the same day, and all three preferably on consecutive days. Where possible, each replicate was completed by a different observer and effort was made to ensure that each replicate per site occurred at a different time post-sunrise.

Malleefowl Mound Survey

Sixty-three known Malleefowl mounds across the property were each surveyed once between October 2020 and February 2021. This survey followed the standards, protocols and monitoring procedures set out by the Malleefowl Recovery Team. The diameter, depth, height and shape of each mound was recorded, and whether it was currently active.

In addition to the original 63 known mounds, LiDAR imagery was captured across the entirety of the property in 2019. Suspected mound locations were ground-truthed in February 2021. From the 136 LiDAR points ground-truthed, 67 new Malleefowl mounds were located and surveyed as described above.

Analysis methods

Standard Trapping Survey

The Standard Trapping Survey data were used to determine the presence, relative abundance and diversity of small mammals, reptiles and amphibians on Scotia. An index of abundance, catch per unit effort, was calculated by: (total number of individuals of each species or guild, captured across the survey period/total trap effort)*100 trap nights. Occupancy was calculated as the percent of sites surveyed that a species or guild is detected. Species richness was calculated as the average total number of species per site.

Mammal Trapping

Mark-recapture was used to estimate total population size of bettongs and Mala based on cage trapping surveys. This approach is used when counting all individuals in a population is not practical. In mark-recapture analyses, a portion of the population is captured and marked, prior to release. During subsequent sampling event(s), another portion is captured, and the number of previously marked animals is counted. Assuming the number of previously marked animals is proportional to the total number of marked animals in the population, an equation is used to estimate total population size using the software program MARK (White and Burnham 1999).

Transects

Population estimates for the Bilby, Bridled Nailtail Wallaby and Numbat were generated from survey records using a strip-plot methodology, given characteristics of the sighting records that precluded a distance sampling approach (as per Kanowski et al. 2001). Where multiple surveys were carried out in a year, the latest (i.e. most recent) survey estimate is presented in the Ecohealth Scorecard.

Standard Bird Survey

For bird guilds and individual species, occupancy was calculated as the percent of sites surveyed that a species or guild was detected. Richness was calculated as the average number of species per site (total across three mornings at each site, averaged across sites).

Malleefowl Mound Survey

The proportion of active mounds out of all mounds surveyed was reported.

Fire Scar Analysis

Fire scar data for 2020 fires were gathered by on-ground mapping using a handheld GPS. The area of the scar in hectares was calculated using ArcMap 10 with Spatial Analyst (Environmental System Research Institute Inc., Redlands, CA, USA).

Results

Biodiversity indicators

Reintroduced mammals

Numbat

The 2020 Numbat population estimate was 135 individuals (± 36 s.e.; Stage 1 = 79, Stage 2 = 56). This estimate is considered conservative: grass growth as a result of recent rains made spotting Numbats difficult. The long-term population trend for Numbats at Scotia suggests that numbers declined in response to drought conditions in 2018/19 (Figure 10). Although surveys in 2018/19 were affected by adverse weather, it is still clear there was a reduced population size during the drought compared to previous years. Numbats reached a peak at Scotia in 2017 when a population estimate of 629 individuals was obtained.

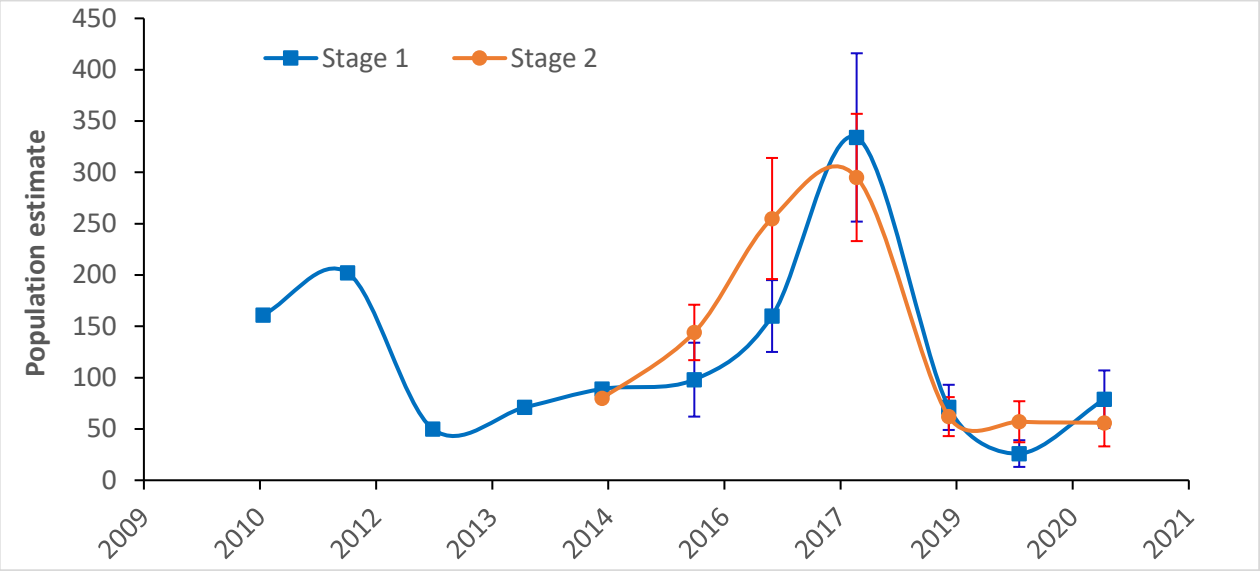

Figure 10. Population estimates for Numbats at Scotia from strip plot-analysis.

Greater Bilby

Transects conducted in 2020 resulted in a Greater Bilby population estimate of 300 individuals (Stage 1 = 179, Stage 2 = 121). The 2020 estimate is similar to that obtained in February 2019 (386), but substantially higher than an estimate obtained in May 2019 (148). Seasonal differences in population estimates are also observed for Bilbies at AWC's Yookamurra Wildlife Sanctuary. The 2018 estimate was substantially higher (1,031; Figure 11). Greater Bilby numbers at Scotia declined during the drought conditions in 2019 but appear to have recovered slightly with the return of average rainfall in 2020 (Figure 11).

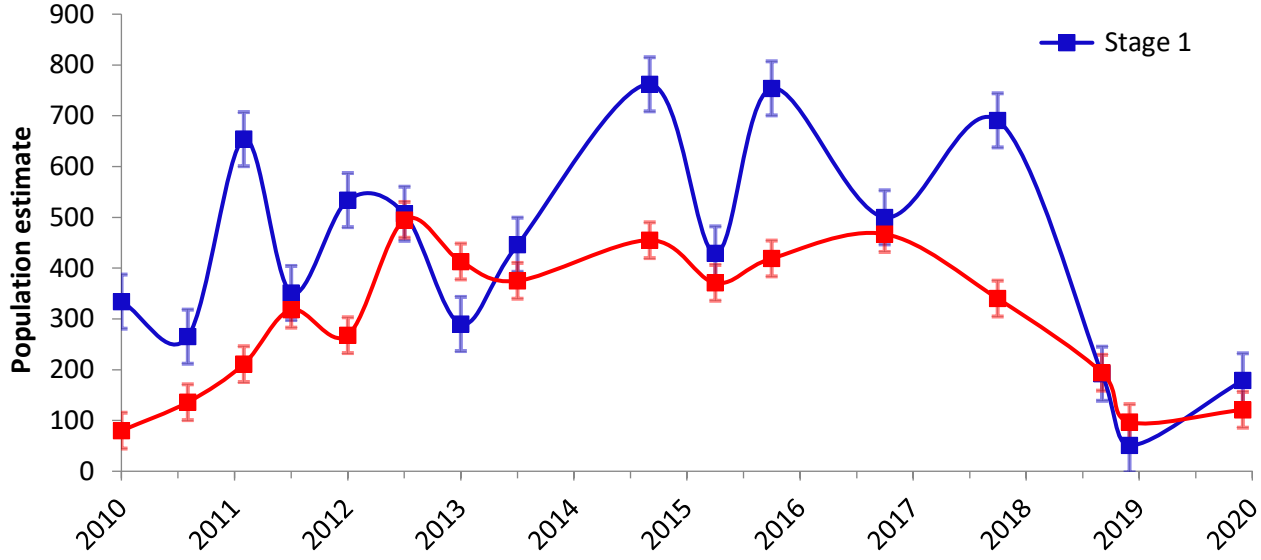

Figure 11. Population estimates for Greater Bilbies at Scotia between 2010 and 2020

Brush-tailed Bettong

The Brush-tailed Bettong population estimate, derived from trapping, was 15 individuals. This is a known underestimate, given that a total of 40 Brush-tailed Bettongs were translocated from Scotia in December 2020, and additional individuals remained on site. Nevertheless, the population declined from 2019 (estimate = 54) and 2018 (estimate = 127; Figure 12). Despite the decline in population size, Brush-tailed Bettongs were in good body condition, and 61% of females were carrying pouch young.

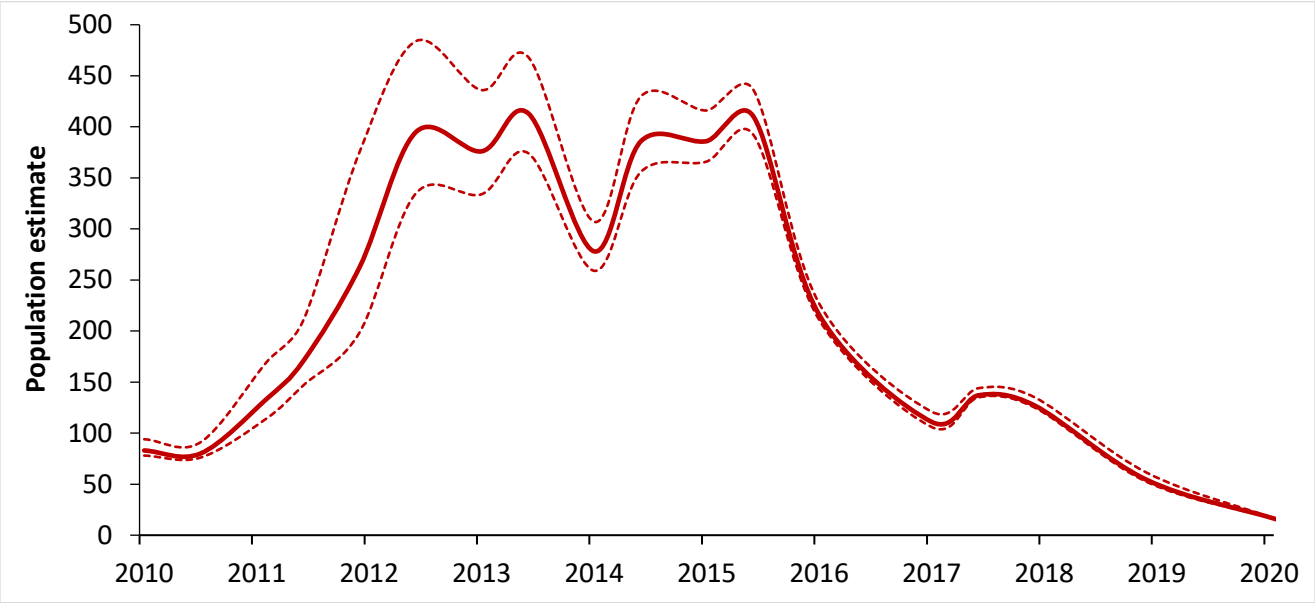

Figure 12. Population estimates for Brush-tailed Bettongs at Scotia between 2010 and 2020. Dotted lines represent upper and lower 95% confidence limits.

Brush-tailed Bettongs also declined at AWC's Yookamurra Wildlife Sanctuary in SA in the 2019 drought. To manage the risk of inbreeding in these populations, a decision was taken to pool remaining individuals from both populations at Yookamurra. To give effect to this decision, in late 2020, a total of 40 Brush-tailed Bettongs were translocated from Scotia to Yookamurra. Not all individuals could be captured for translocation: the remaining Brush-tailed Bettongs at Scotia were ultimately translocated to Mallee Cliffs in 2021 (total of 16 individuals).

AWC's intention is to re-establish the population of Brush-tailed Bettongs at Scotia in coming years, using a genetically diverse set of founders.

Burrowing Bettong

The Burrowing Bettong population estimate for 2020 was 130 individuals, down from 447 in 2019 and 733 in 2018 (Figure 13). This is the lowest population estimate for this species at Scotia in over 10 years, again presumably driven by the extreme drought conditions in 2018/19.

Nevertheless, 84% of females captured carried pouch young, an increase from 2019 (20% of females). The high incidence of breeding is likely a response to increased rainfall in the first part of 2020.

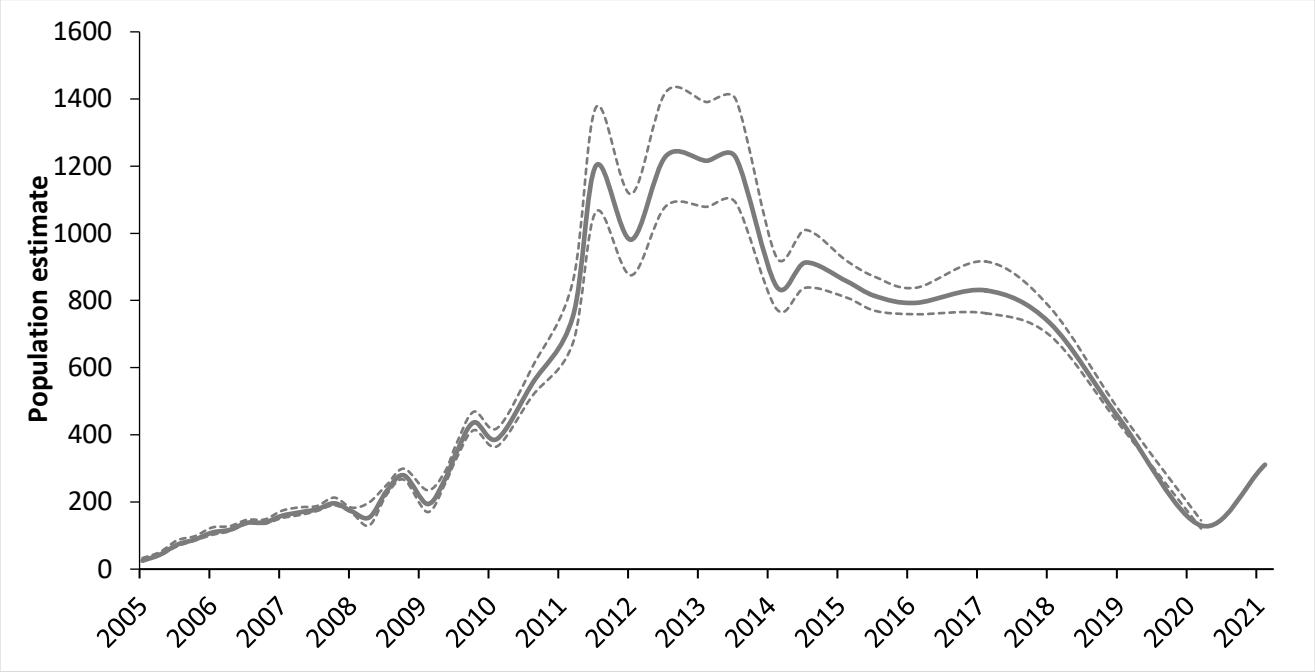

Figure 13. Population estimates (solid line) for Burrowing Bettongs in Scotia (Stage 1) between 2010 and 2020. Dotted lines represent upper and lower 95% confidence limits.

Mala

The 2020 population estimate for Mala at Scotia was 44 (95% CI: lower 41, upper 55). This is similar to 2019 (estimate = 43) but lower than 2018 (estimate = 71), not surprising given that 30 Mala were translocated to Newhaven from Scotia in June 2018 (Figure 14). Seven of the 24 (29%) females captured were carrying pouch young, the lowest in 5 years. Average weight was lower than previous years. This population, located within a special-purpose 115 ha compound, is supplied with a proportion of their food and water. Despite this, drought conditions appear to have had some impact.

All remaining Mala (n = 45) were translocated to Newhaven in August 2020.

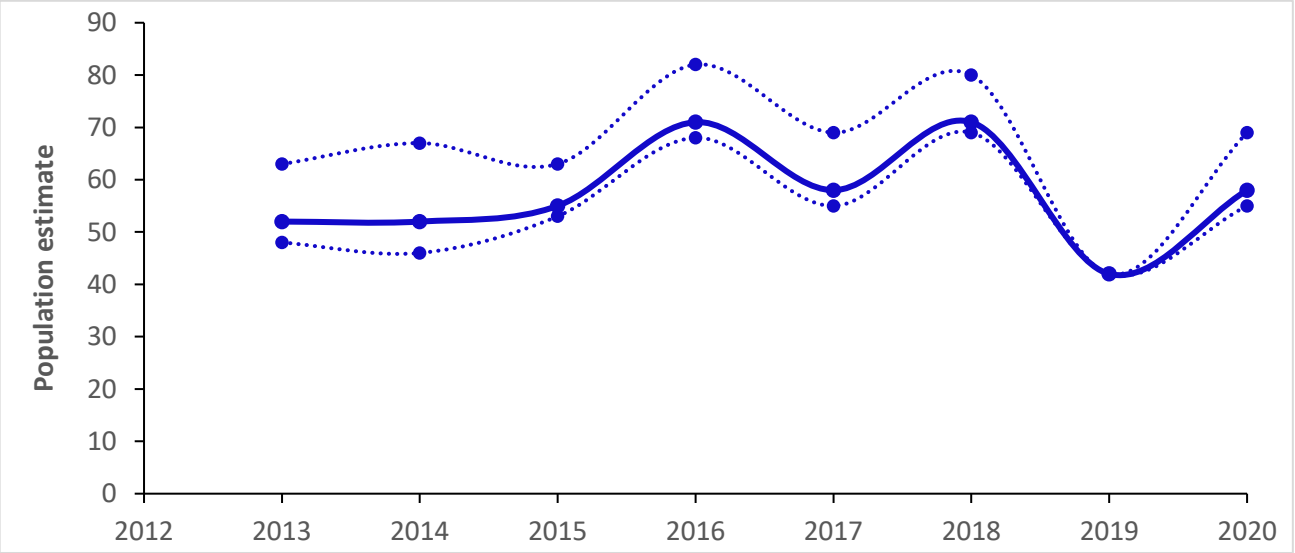

Figure 14. Population estimates (solid line) for Mala at Scotia between 2013 and 2020. Dotted lines represent upper and lower confidence limits.

Bridled Nailtail Wallaby

Surveys for Bridled Nailtail Wallabies were conducted in May 2020. Only two individuals were observed, given a population estimate of 25. Unfortunately, the survey method is imprecise when the population is small, and a decision was made to repeat the survey in June 2020. This survey detected four individuals, resulting in an estimate of 50 (± 29 s.e.) individuals, a marked decrease in population size from previous years (Figure 15).

Like most fauna in semi-arid regions, Bridled Nailtail Wallabies are strongly influenced by prevailing climatic conditions. The extreme drought conditions at Scotia across 2018/19 presumably led to the population decline observed in 2020.

In response to the observed population decline, AWC developed a Population Management Plan for the Bridled Nailtail Wallaby (Berry et al. 2021), identifying key risks to the population, and outlining how those risks will be mitigated. The plan stipulated the pooling of all remaining animals on Scotia in Stage 2, to limit the potential for inbreeding amongst remaining animals and related problems associated with small population size. Between October 2020 and March 2021, 47 wallabies were captured from the 'house paddock' adjacent to Stage 1 and translocated to Stage 2, the combined population estimated at over 70 individuals. Animals will be closely monitored in Stage 2 to track future changes in population size.

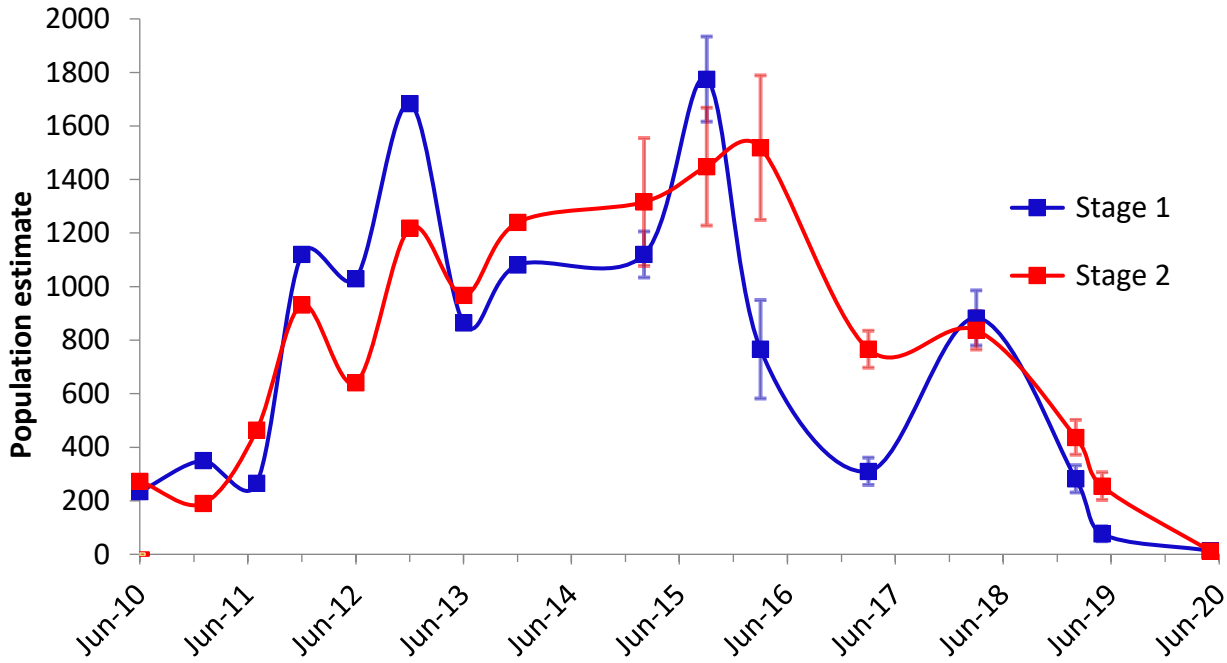

Figure 15. Population estimates for Bridled Nailtail Wallabies at Scotia between 2009 and 2020.

Small-medium mammals (extant)

Extant small mammals were not surveyed in 2020. Captures of small mammals from 2019 surveys are summarised in Appendix 2.

Reptiles and amphibians

Reptiles and amphibians were not surveyed in 2020. Captures of reptiles from 2019 surveys are summarised in Appendix 2.

Birds

A total of 62 bird species was recorded during the Standard Bird Survey in 2020. This comprised a total of 4,128 individual birds recorded across the entire survey, at an average richness of 8 species per site. The most abundant species were the Budgerigar (*Melopsittacus undulates*) and Masked Woodswallow (*Artamus personatus*), accounting for 76.2% and 6.3% of total individuals, respectively. Budgerigars were observed at 46 of the 48 survey sites. The Honeyeater guild had a mean richness of 1.3 species per site, and the ground active bird guild a similar mean richness of 1.2 species per site.

Indicator species occupancy results are shown in Table 4. Occupancy of the Striated Grasswren was higher in 2020 than in previous surveys. Occupancy of the Chestnut Quail-thrush was also high relative to previous surveys. Neither the Shy Heathwren nor Hooded Robin were recorded in 2020; these species are generally only recorded sporadically.

One notable observation recorded as an opportunistic record (observed whilst travelling between survey sites) was the Scarlet-chested Parrot, observed in a fire scar at the southern end of Stage 3 (outside the

fenced area). This species has been previously recorded in the same area on only 2 other occasions in the last 4 years.

Table 4. Occupancy of Ecohealth indicator bird species (number of sites surveyed in brackets)

Species	2020 (n=48)	2018 (n=63)	2017 (n=48)	2015 (n=48)	2013 (n=84)
Chestnut Quail-thrush	18.8%	4.8%	16.7%	12.5%	10.7%
Gilbert's Whistler	6.3%	11.1%	8.3%	10.4%	8.3%
Hooded Robin	0.0%	0.0%	4.2%	2.1%	1.2%
Major Mitchell's (Pink Cockatoo)	2.1%	0.0%	0.0%	2.1%	0.0%
Shy Heathwren	0.0%	9.5%	0.0%	2.1%	1.2%
Southern Scrub-robin	10.4%	6.3%	16.7%	8.3%	1.2%
Striated Grasswren	12.5%	7.9%	8.3%	10.4%	1.2%

Malleefowl

Of the original 63 monitored Malleefowl mounds surveyed, 4 were recorded as active in surveys conducted in late 2020 – early 2021. Of the 67 new mounds identified through LiDAR, and surveyed in 2021, 8 were identified as active. Therefore, in total for this reporting period, there were 12 active Malleefowl mounds. Eight of these mound were located inside the fenced area and 4 outside. The 67 new LiDAR mounds will be assessed and prioritised to determine which mounds will be actively monitored during future reporting periods, using a repeatable methodology.

Previously only a small percentage of mounds surveyed have been found active (Figure 16). In 2012 AWC recorded the most active mounds, with 9 active from 31 surveyed. No mounds were recorded as active in 2019 from the 63 monitored.

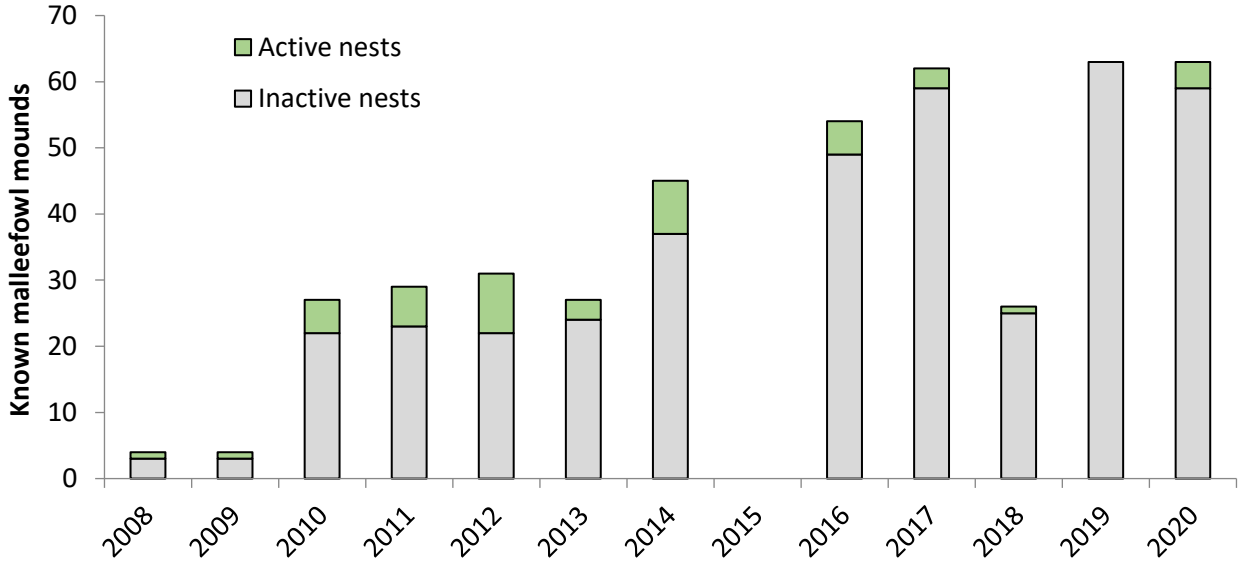

Figure 16. Known Mallefowl mounds surveyed from 2008-2020, categorised by activity. Note does not include mounds identified by LiDAR and surveyed for the first time in late 2020.

Threat indicators

Fire

In 2020, 40.6 ha (0.06% of the property) was strategically burnt within the feral predator-free fenced area for infrastructure protection. No areas were burnt outside the fenced area in 2020.

No unplanned fires occurred in 2020.

Discussion

The extreme drought experienced in 2018/19 had a dramatic impact on reintroduced populations of mammals at Scotia, with severe declines in most species. In 2020, rainfall returned to average. Encouragingly, Greater Bilby and Numbat population estimates increased in 2020 from the low numbers recorded in 2019. While the population of Burrowing Bettongs was low in 2020, the great majority of females were carrying pouch young.

In response to these results, AWC intervened to manage populations of two species, the Bridled Nailtail Wallaby (populations pooled in Stage 2) and Brush-tailed Bettong (most individuals relocated to Yookamurra to pool with that population). As a result of improved environmental conditions, populations of remaining species are expected to increase in numbers through 2021.

Acknowledgements

AWC acknowledges the Barkindji people as the Traditional Custodians of the country on which Scotia resides. We also acknowledge their continuing connection to land, culture and community. We pay our respects to Barkindji Elders past present and emerging.

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Appendix 1. List of native species

Table 5. Amphibians, reptiles, small mammals and birds confirmed or considered likely to occur on Scotia

Amphibians	Common Name	EPBC	State	Likelihood
HYLIDAE				
Cyclorana verrucosa	Rough Frog	Not listed	Not listed	Possible
LIMNODYNASTIDAE				
Limnodynastes fletcheri	Long-thumbed Frog	Not listed	Not listed	Possible
Limnodynastes tasmaniensis	Spotted Grass Frog	Not listed	Not listed	Confirmed
Neobatrachus centralis	Desert Trilling Frog	Not listed	Not listed	Possible
Neobatrachus sudelli	Sudell's Frog	Not listed	Not listed	Confirmed
Reptiles	Common Name	EPBC	State	Likelihood
AGAMIDAE				
Ctenophorus fordi	Mallee Military Dragon	Not listed	Not listed	Confirmed
Cteonphorus nuchalis	Central Netted Dragon	Not listed	Not listed	Possible
Ctenophorus pictus	Painted Dragon	Not listed	Not listed	Confirmed
Diporiphora nobbi coggeri	Nobbi Dragon	Not listed	Not listed	Confirmed
Pogona vitticeps	Central Bearded Dragon	Not listed	Not listed	Confirmed
Typmanocryptis lineata	Lined Earless Dragon	Not listed	Not listed	Likely
Tympanocryptis tetraporophora	Eyrean Earless Dragon	Not listed	Not listed	Likely
CARPHODACTYLIDAE				
Nephrurus levis	Smooth Knob-tailed Gecko	Not listed	Not listed	Confirmed
DIPLODACTYLIDAE				
Diplodactylus vittatus	Wood Gecko	Not listed	Not listed	Confirmed
Oedura cincta	Marbled Velvet Gecko	Not listed	Not listed	Confirmed
Strophurus elderi	Jewelled Gecko	Not listed	Vulnerable	Confirmed
Strophurus intermedius	Southern Spiny-tailed Gecko	Not listed	Not listed	Confirmed
Strophurus williamsi	Eastern Spiny-tailed Gecko	Not listed	Not listed	Confirmed
ELAPIDAE				
Brachyurophis australis	Coral Snake	Not listed	Not listed	Confirmed
Demansia psammophis	Yellow-faced Whip Snake	Not listed	Not listed	Confirmed
Eciopsis curta	Bardick	Not listed	Endangered	Possible
Furina diadema	Red-naped Snake	Not listed	Not listed	Confirmed
Parasuta nigriceps	Mitchell's Short-tailed Snake	Not listed	Not listed	Confirmed
Parasuta spectabilis	Mallee Black-headed Snake	Not listed	Not listed	Possible
Pseudechis australis	Mulga Snake	Not listed	Not listed	Confirmed
Pseudonaja aspidorhyncha	Strap-snouted Brown Snake	Not listed	Not listed	Possible
Pseudonaja mengdeni	Mengden's Brown Snake	Not listed	Not listed	Confirmed
Pseudonaja modesta	Ringed Brown Snake	Not listed	Endangered	Confirmed
Pseudonaja nuchalis	Western Brown Snake	Not listed	Not listed	Confirmed
Pseudonaja textilis	Eastern Brown Snake	Not listed	Not listed	Possible
Suta suta	Curl Snake	Not listed	Not listed	Confirmed
Vermicella annulata	Bandy-bandy	Not listed	Not listed	Confirmed
GEKKONIDAE				
Gehyra versicolor	Tree Dtella	Not listed	Not listed	Confirmed
Heteronotia binoei	Bynoe's Gecko	Not listed	Not listed	Confirmed
Lucasium damaeum	Beaded Gecko	Not listed	Not listed	Confirmed
Reptiles	Common Name	EPBC	State	Likelihood
Lucasium stenodactylum	Crowned Gecko	Not listed	Vulnerable	Possible
Rhynchoedura angusta	Border beaked Gecko	Not listed	Not listed	Very likely
Rhynchoedura eyrensis	Eyre Basin beaked Gecko	Not listed	Not listed	Possible
Rhynchoedura ormsbyi	Eastern beaked Gecko	Not listed	Not listed	Possible
Underwoodisaurus milii	Barking Gecko	Not listed	Not listed	Possible
PYGOPODIDAE				

Aprasia inaurita	Mallee Worm-lizard	Not listed	Endangered	Confirmed
Delma australis	Marble-faced Delma	Not listed	Endangered	Confirmed
Delma butleri	Unbanded Delma	Not listed	Not listed	Confirmed
Lialis burtonis	Burton's Snake-lizard	Not listed	Not listed	Confirmed
Pygopus lepidopodus	Common Scaly-foot	Not listed	Not listed	Confirmed
Pygopus nigriceps	Western Hooded Scaly-foot	Not listed	Not listed	Possible
Pygopus schraderi	Eastern Hooded Scaly-foot	Not listed	Not listed	Confirmed
PYTHONIDAE				
Morelia spilota metcalfei	Murray Darling Carpet Python	Not listed	Not listed	Confirmed
SCINCIDAE				
Cryptoblepharus australis	Inland Snake-eyed Skink	Not listed	Not listed	Confirmed
Cryptoblepharus pannosus	Ragged Snake-eyed Skink	Not listed	Not listed	Confirmed
Ctenotus atlas	Southern Mallee Ctenotus	Not listed	Not listed	Confirmed
Ctenotus inornatus	Yellow-bellied Ctenotus	Not listed	Not listed	Confirmed
Ctenotus orientalis	Nullarbor Spotted Ctenotus	Not listed	Not listed	Likely
Ctenotus regius	Pale-rumped Ctenotus	Not listed	Not listed	Confirmed
Ctenotus robustus	Robust Ctenotus	Not listed	Not listed	Confirmed
Ctenotus schomburgkii	Barred Wedgesnout Ctenotus	Not listed	Not listed	Confirmed
Ctenotus strauchii		Not listed	Not listed	Confirmed
Ctenotus taeniatus	Sandridge Ctenotus	Not listed	Not listed	Confirmed
Cyclodomorphus melanops elongatus	Eastern Slender Blue-tongue	Not listed	Endangered	Confirmed
Egernia striolata	Tree Skink	Not listed	Not listed	Confirmed
Eremiascincus fasciolatus	Narrow-banded Sand-swimmer	Not listed	Not listed	Likely
Eremiascincus richardsonii	Broad-banded Sand-swimmer	Not listed	Not listed	Confirmed
Lerista aericeps	Desert Plain Slider	Not listed	Not listed	Confirmed
Lerista labialis	Southern Sandslider	Not listed	Not listed	Confirmed
Lerista muelleri	Wood Mulch-slider	Not listed	Not listed	Confirmed
Lerista punctatovittata	Eastern Robust Slider	Not listed	Not listed	Confirmed
Lerista timida	Timid Slider	Not listed	Not listed	Confirmed
Liopholis inornata	Desert Skink	Not listed	Not listed	Confirmed
Menetia greyii	Common Dwarf Skink	Not listed	Not listed	Confirmed
Morethia boulengeri	South-eastern Morethia Skink	Not listed	Not listed	Confirmed
Morethia obscura	Shrubland Morethia Skink	Not listed	Not listed	Confirmed
Tiliqua occipitalis	Western Blue-tongue	Not listed	Vulnerable	Confirmed
Tiliqua rugosa aspera	Shingleback	Not listed	Not listed	Confirmed
TYPHLOPIDAE				
Anilios bicolor	Two-toned Blind Snake	Not listed	Not listed	Confirmed
Anilios bituberculatus	Prong-snouted Blind Snake	Not listed	Not listed	Confirmed
VARANIDAE				
Varanus gouldii	Bungarra	Not listed	Not listed	Confirmed
Varanus varius	Lace Monitor	Not listed	Not listed	Confirmed
Small Mammals (excluding bats)	Common Name	EPBC	State	Likelihood
MURIDAE				
Leporillus conditor	Greater Stick-nest Rat	Vulnerable		Reintroduced
Mus musculus	House Mouse	Not listed	Not listed	Confirmed
Pseudomys bolami	Bolam's Mouse	Not listed	Endangered	Confirmed
Pseudomys desertor	Desert Mouse	Not listed		Very Likely
Small Mammals (excluding bats)	Common Name	EPBC	State	Likelihood
Pseudomys hermannsburgensis	Sandy Inland Mouse	Not listed	Vulnerable	Possible
Rattus rattus	Black Rat	Not listed	Not listed	Confirmed

DASYURIDAE				
Ningaui yvonneae	Southern Ningaui	Not listed	Vulnerable	Confirmed
Sminthopsis crassicaudata	Fat-tailed Dunnart	Not listed	Not listed	Confirmed
Sminthopsis macroura	Stripe-faced Dunnart	Not listed	Vulnerable	Confirmed
Sminthopsis murina	Common Dunnart	Not listed	Not listed	Confirmed
BURRAMYIDAE				
Cercartetus concinnus	Western Pygmy-possum	Not listed	Endangered	Confirmed
Birds	Common Name	EPBC	State	Likelihood
ACANTHIZIDAE				
Acanthiza apicalis	Inland Thornbill	Not listed	Not listed	Confirmed
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	Not listed	Not listed	Confirmed
Acanthiza nana	Yellow Thornbill	Not listed	Not listed	Confirmed
Acanthiza uropygialis	Chestnut-rumped Thornbill	Not listed	Not listed	Confirmed
Aphelocephala leucopsis	Southern Whiteface	Not listed	Not listed	Confirmed
Aphelocephala nigricincta	Banded Whiteface	Not listed	Not listed	Confirmed
Calamanthus campestris	Rufous Fieldwren	Not listed	Vulnerable	Possible
Calamanthus cautus	Shy Heathwren	Not listed	Vulnerable	Confirmed
Gerygone fusca	Western Gerygone	Not listed	Not listed	Confirmed
Pyrrholaemus brunneus	Redthroat	Not listed	Vulnerable	Confirmed
Smicrornis brevirostris	Weebill	Not listed	Not listed	Confirmed
ACCIPITRIDAE				
Accipiter cirrocephalus	Collared Sparrowhawk	Not listed	Not listed	Confirmed
Accipiter fasciatus	Brown Goshawk	Not listed	Not listed	Confirmed
Aquila audax	Wedge-tailed Eagle	Not listed	Not listed	Confirmed
Circus approximans	Swamp Harrier	Not listed	Not listed	Confirmed
Circus assimilis	Spotted Harrier	Not listed	Vulnerable	Possible
Elanus axillaris	Black-shouldered Kite	Not listed	Not listed	Confirmed
Elanus scriptus	Letter-winged Kite	Not listed	Not listed	Possible
Haliastur sphenurus	Whistling Kite	Not listed	Not listed	Confirmed
Hieraaetus morphnoides	Little Eagle	Not listed	Vulnerable	Confirmed
Lophoictinia isura	Square-tailed Kite	Not listed	Vulnerable	Confirmed
Milvus migrans	Black Kite	Not listed	Not listed	Confirmed
AEGOTHELIDAE				
Aegotheles cristatus	Australian Owlet-nightjar	Not listed	Not listed	Confirmed
ALAUDIDAE				
Mirafra javanica	Horsfield's Bushlark	Not listed	Not listed	Possible
ANATIDAE				
Anas castanea	Chestnut Teal	Not listed	Not listed	Likely
Anas gracilis	Grey Teal	Not listed	Not listed	Confirmed
Anas superciliosa	Pacific Black Duck	Not listed	Not listed	Confirmed
Aythya australis	Hardhead	Not listed	Not listed	Confirmed
Biziura lobata	Musk Duck	Not listed	Not listed	Possible
Chenonetta jubata	Australian Wood Duck	Not listed	Not listed	Confirmed
Cygnus atratus	Black Swan	Not listed	Not listed	Confirmed
Malacorhynchus membranaceus	Pink-eared Duck	Not listed	Not listed	Confirmed
Oxyura australis	Blue-billed Duck	Not listed	Vulnerable	Possible
Spatula rhynchotis	Australasian Shoveler	Not listed	Not listed	Confirmed
Stictonetta naevosa	Freckled Duck	Not listed	Vulnerable	Possible
Tadorna tadornoides	Australian Shelduck	Not listed	Not listed	Confirmed
ANHINGIDAE				
Anhinga novaehollandiae	Australasian Darter	Not listed	Not listed	Confirmed
APODIDAE				
Apus pacificus pacificus	Pacific (Fork-tailed) Swift	Not listed	Not listed	Confirmed
ARDEIDAE				
Ardea intermedia	Intermediate Egret	Not listed	Not listed	Possible

Ardea alba	Great Egret	Not listed	Not listed	Confirmed
Ardea pacifica	White-necked Heron	Not listed	Not listed	Confirmed
Egretta garzetta	Little Egret	Not listed	Not listed	Possible
Egretta novaehollandiae	White-faced Heron	Not listed	Not listed	Confirmed
Nycticorax caledonicus	Nankeen Night Heron	Not listed	Not listed	Confirmed
ARTAMIDAE				
Artamus cinereus	Black-faced Woodswallow	Not listed	Not listed	Confirmed
Artamus cyanopterus cyanopterus	(Eastern) Dusky Woodswallow	Not listed	Vulnerable	Confirmed
Artamus minor	Little Woodswallow	Not listed	Not listed	Confirmed
Artamus personatus	Masked Woodswallow	Not listed	Not listed	Confirmed
Artamus superciliosus	White-browed Woodswallow	Not listed	Not listed	Confirmed
Gymnorhina tibicen	Australian Magpie	Not listed	Not listed	Confirmed
Cracticus nigrogularis	Pied Butcherbird	Not listed	Not listed	Confirmed
Cracticus torquatus	Grey Butcherbird	Not listed	Not listed	Confirmed
Strepera versicolor melanoptera	Grey Currawong	Not listed	Not listed	Confirmed
CACATUIDAE				
Cacatua sanguinea	Little Corella	Not listed	Not listed	Confirmed
Eolophus roseicapillus	Galah	Not listed	Not listed	Confirmed
Lophochroa leadbeateri leadbeateri	(Eastern) Major Mitchell's Cockatoo	Not listed	Vulnerable	Confirmed
Nymphicus hollandicus	Cockatiel	Not listed	Not listed	Confirmed
CAMPEPHAGIDAE				
Coracina maxima	Ground Cuckooshrike	Not listed	Not listed	Possible
Coracina novaehollandiae	Black-faced Cuckooshrike	Not listed	Not listed	Confirmed
Coracina papuensis	White-bellied Cuckooshrike	Not listed	Not listed	Confirmed
Lalage tricolor	White-winged Triller	Not listed	Not listed	Confirmed
CASUARIIDAE				
Dromaius novaehollandiae	Emu	Not listed	Not listed	Confirmed
CHARADRIIDAE				
Vanellus miles	Masked Lapwing	Not listed	Not listed	Confirmed
Vanellus tricolor	Banded Lapwing	Not listed	Not listed	Confirmed
Erythrogonys cinctus	Red-kneed Dotterel	Not listed	Not listed	Confirmed
Charadrius australis	Inland Dotterel	Not listed	Not listed	Confirmed
Charadrius ruficapillus	Red-capped Plover	Not listed	Not listed	Confirmed
Elseyornis melanops	Black-fronted Dotterel	Not listed	Not listed	Confirmed
CLIMACTERIDAE				
Climacteris affinis	White-browed Treecreeper	Not listed	Not listed	Confirmed
Climacteris picumnus	Brown Treecreeper	Not listed	Not listed	Confirmed
COLUMBIDAE				
Columba livia	Rock Dove	Not listed	Not listed	Confirmed
Phaps chalcoptera	Common Bronzewing	Not listed	Not listed	Confirmed
Ocyphaps lophotes	Crested Pigeon	Not listed	Not listed	Confirmed
Geopelia cuneata	Diamond Dove	Not listed	Not listed	Confirmed
Geopelia striata	Peaceful Dove	Not listed	Not listed	Confirmed
CORCORACIDAE				
Corcorax melanorhamphos	White-winged Chough	Not listed	Not listed	Confirmed
Struthidea cinerea	Apostlebird	Not listed	Not listed	Confirmed
CORVIDAE				
Corvus bennetti	Little Crow	Not listed	Not listed	Confirmed
Corvus coronoides	Australian Raven	Not listed	Not listed	Confirmed
Corvus mellori	Little Raven	Not listed	Not listed	Confirmed
CUCULIDAE				
Cacomantis flabelliformis	Fan-tailed Cuckoo	Not listed	Not listed	Confirmed

Cacomantis pallidus	Pallid Cuckoo	Not listed	Not listed	Confirmed
Chrysococcyx basalis	Horsfield's Bronze-Cuckoo	Not listed	Not listed	Confirmed
Chrysococcyx osculans	Black-eared Cuckoo	Not listed	Not listed	Confirmed
ESTRILDIDAE				
Taeniopygia guttata	Zebra Finch	Not listed	Not listed	Confirmed
EUROSTOPODIDAE				
Eurostopodus argus	Spotted Nightjar	Not listed	Not listed	Confirmed
FALCONIDAE				
Falco cenchroides	Nankeen Kestrel	Not listed	Not listed	Confirmed
Falco longipennis	Australian Hobby	Not listed	Not listed	Confirmed
Falco berigora	Brown Falcon	Not listed	Not listed	Confirmed
Falco hypoleucos	Grey Falcon	Not listed	Endangered	Confirmed
Falco subniger	Black Falcon	Not listed	Vulnerable	Confirmed
Falco peregrinus	Peregrine Falcon	Not listed	Not listed	Confirmed
HALCYONIDAE				
Dacelo novaeguineae	Laughing Kookaburra	Not listed	Not listed	Confirmed
Todiramphus pyrrhopygius	Red-backed Kingfisher	Not listed	Not listed	Confirmed
Todiramphus sanctus	Sacred Kingfisher	Not listed	Not listed	Confirmed
HIRUNDINIDAE				
Cheramoeca leucosterna	White-backed Swallow	Not listed	Not listed	Confirmed
Hirundo neoxena	Welcome Swallow	Not listed	Not listed	Confirmed
Petrochelidon ariel	Fairy Martin	Not listed	Not listed	Confirmed
Petrochelidon nigricans	Tree Martin	Not listed	Not listed	Confirmed
LARIDAE				
Chlidonias hybrida	Whiskered Tern	Not listed	Not listed	Confirmed
Chroicocephalus novaehollandiae	Silver Gull	Not listed	Not listed	Confirmed
LOCUSTELLIDAE				
Megalurus cruralis	Brown Songlark	Not listed	Not listed	Confirmed
Megalurus mathewsi	Rufous Songlark	Not listed	Not listed	Very Likely
Megalurus gramineus	Little Grassbird	Not listed	Not listed	Confirmed
MALURIDAE				
Malurus assimilis	Purple-backed Fairywren	Not listed	Not listed	Confirmed
Malurus cyaneus	Superb Fairywren	Not listed	Not listed	Possible
Malurus splendens	Splendid Fairywren	Not listed	Not listed	Confirmed
Malurus leucopterus leuconotus	White-winged Fairywren	Not listed	Not listed	Confirmed
Amytornis striatus striatus	(Sandplain) Striated Grasswren	Not listed	Vulnerable	Confirmed
MEGAPODIIDAE				
Leipoa ocellata	Malleefowl	Vulnerable	Endangered	Confirmed
MELIPHAGIDAE				
Acanthagenys rufogularis	Spiny-cheeked Honeyeater	Not listed	Not listed	Confirmed
Anthochaera carunculata	Red Wattlebird	Not listed	Not listed	Confirmed
Certhionyx variegatus	Pied Honeyeater	Not listed	Vulnerable	Confirmed
Epthianura albifrons	White-fronted Chat	Not listed	Vulnerable	Confirmed
Epthianura aurifrons	Orange Chat	Not listed	Not listed	Confirmed
Epthianura tricolor	Crimson Chat	Not listed	Not listed	Confirmed
Gavicalis virescens	Singing Honeyeater	Not listed	Not listed	Confirmed
Lichenostomus cratitius	Purple-gaped Honeyeater	Not listed	Vulnerable	Possible
Manorina flavigula	Yellow-throated Miner	Not listed	Not listed	Confirmed
Manorina melanotis	Black-eared Miner	Endangered	Critically Endangered	Confirmed
Melithreptus brevirostris	Brown-headed Honeyeater	Not listed	Not listed	Confirmed
Nesoptilotis leucotis	White-eared Honeyeater	Not listed	Not listed	Confirmed
Philemon citreogularis	Little Friarbird	Not listed	Not listed	Confirmed
Plectorhyncha lanceolata	Striped Honeyeater	Not listed	Not listed	Confirmed

Ptilotula ornatus	Yellow-plumed Honeyeater	Not listed	Not listed	Confirmed
Ptilotula penicillatus	White-plumed Honeyeater	Not listed	Not listed	Confirmed
Ptilotula plumulus	Grey-fronted Honeyeater	Not listed	Not listed	Confirmed
Purnella albifrons	White-fronted Honeyeater	Not listed	Not listed	Confirmed
Sugomel niger	Black Honeyeater	Not listed	Not listed	Confirmed
MEROPIDAE				
Merops ornatus	Rainbow Bee-eater	Not listed	Not listed	Confirmed
MONARCHIDAE				
Grallina cyanoleuca	Magpie-lark	Not listed	Not listed	Confirmed
Myiagra inquieta	Restless Flycatcher	Not listed	Not listed	Confirmed
MOTACILLIDAE				
Anthus novaeseelandiae	Australasian Pipit	Not listed	Not listed	Confirmed
NECTARINIIDAE				
Dicaeum hirundinaceum	Mistletoebird	Not listed	Not listed	Confirmed
NEOSITTIDAE				
Daphoenositta chrysoptera	Varied Sittella	Not listed	Vulnerable	Confirmed
OREOICIDAE				
Oreoica gutturalis	Crested Bellbird	Not listed	Not listed	Confirmed
OTIDIDAE				
Ardeotis australis	Australian Bustard	Not listed	Endangered	Confirmed
PACHYCEPHALIDAE				
Colluricincla harmonica	Grey Shrikethrush	Not listed	Not listed	Confirmed
Pachycephala inornata	Gilbert's Whistler	Not listed	Vulnerable	Confirmed
Pachycephala pectoralis	Australian Golden Whistler	Not listed	Not listed	Confirmed
Pachycephala rufiventris	Rufous Whistler	Not listed	Not listed	Confirmed
Pachycephala rufogularis	Red-lored Whistler	Vulnerable	Critically Endangered	Possible
PARDALOTIDAE				
Pardalotus punctatus xanthopyge	(Yellow-rumped) Spotted Pardalote	Not listed	Not listed	Confirmed
Pardalotus rubricatus	Red-browed Pardalote	Not listed	Not listed	Confirmed
Pardalotus striatus	Striated Pardalote	Not listed	Not listed	Confirmed
PELECANIDAE				
Pelecanus conspicillatus	Australian Pelican	Not listed	Not listed	Confirmed
PETROICIDAE				
Melanodryas cucullata cucullata	(South-eastern) Hooded Robin	Not listed	Vulnerable	Confirmed
Microeca fascinans assimilis	Jacky Winter	Not listed	Not listed	Confirmed
Petroica boodang	Scarlet Robin	Not listed	Vulnerable	Confirmed
Petroica goodenovii	Red-capped Robin	Not listed	Not listed	Confirmed
Drymodes brunneopygia	Southern Scrub-robin	Not listed	Vulnerable	Confirmed
PHASIANIDAE				
Coturnix pectoralis	Stubble Quail	Not listed	Not listed	Confirmed
Coturnix ypsilophora	Brown Quail	Not listed	Not listed	Confirmed
PHALACROCORACIDAE				
Microcarbo melanoleucos	Little Pied Cormorant	Not listed	Not listed	Confirmed
Phalacrocorax carbo	Great Cormorant	Not listed	Not listed	Confirmed
Phalacrocorax sulcirostris	Little Black Cormorant	Not listed	Not listed	Confirmed
Phalacrocorax varius	Pied Cormorant	Not listed	Not listed	Confirmed
PODARGIDAE				
Podargus strigoides	Tawny Frogmouth	Not listed	Not listed	Confirmed
PODICIPEDIDAE				
Podiceps cristatus	Great Crested Grebe	Not listed	Not listed	Possible
Poliocephalus poliocephalus	Hoary-headed Grebe	Not listed	Not listed	Confirmed
Tachybaptus novaehollandiae	Australasian Grebe	Not listed	Not listed	Confirmed

POMATOSTOMIDAE				
Pomatostomus ruficeps	Chestnut-crowned Babbler	Not listed	Not listed	Confirmed
Pomatostomus superciliosus	White-browed Babbler	Not listed	Not listed	Confirmed
PSITTACIDAE				
Barnardius zonarius barnardi	Australian Ringneck	Not listed	Not listed	Confirmed
Glossopsitta porphyrocephala	Purple-crowned Lorikeet	Not listed	Vulnerable	Confirmed
Melopsittacus undulatus	Budgerigar	Not listed	Not listed	Confirmed
Neophema chrysostoma	Blue-winged Parrot	Not listed	Not listed	Confirmed
Neophema elegans	Elegant Parrot	Not listed	Not listed	Confirmed
Neophema splendida	Scarlet-chested Parrot	Not listed	Vulnerable	Confirmed
Northiella haematogaster	Eastern Bluebonnet	Not listed	Not listed	Confirmed
Polytelis anthopeplus monarchoides	(Eastern) Regent Parrot	Vulnerable	Endangered	Confirmed
Psephotellus varius	Mulga Parrot	Not listed	Not listed	Confirmed
Psephotus haematonotus	Red-rumped Parrot	Not listed	Not listed	Confirmed
PSOPHODIDAE				
Cinclosoma castanotum	Chestnut Quail-thrush	Not listed	Vulnerable	Confirmed
Psophodes cristatus	Chirruping Wedgebill	Not listed	Not listed	Confirmed
RALLIDAE				
Fulica atra	Eurasian Coot	Not listed	Not listed	Confirmed
Gallirallus philippensis	Buff-banded Rail	Not listed	Not listed	Confirmed
Porzana fluminea	Australian (Spotted) Crake	Not listed	Not listed	Possible
Porzana pusilla	Baillon's Crake	Not listed	Not listed	Confirmed
Tribonyx ventralis	Black-tailed Native-hen	Not listed	Not listed	Confirmed
RECURVIROSTRIDAE				
Himantopus himantopus	Pied Stilt	Not listed	Not listed	Confirmed
Recurvirostra novaehollandiae	Red-necked Avocet	Not listed	Not listed	Confirmed
RHIPIDURIDAE				
Rhipidura albiscapa	Grey Fantail	Not listed	Not listed	Confirmed
Rhipidura leucophrys	Willie Wagtail	Not listed	Not listed	Confirmed
STRIGIDAE				
Ninox connivens connivens	(Southern) Barking Owl	Not listed	Vulnerable	Possible
Ninox boobook	Southern Boobook	Not listed	Not listed	Confirmed
STURNIDAE				
Sturnus vulgaris	Common Starling	Not listed	Not listed	Confirmed
THRESKIORNITHIDAE				
Platalea flavipes	Yellow-billed Spoonbill	Not listed	Not listed	Confirmed
Platalea regia	Royal Spoonbill	Not listed	Not listed	Possible
Plegadis falcinellus	Glossy Ibis	Not listed	Not listed	Possible
Threskiornis molucca	Australian White Ibis	Not listed	Not listed	Possible
Threskiornis spinicollis	Straw-necked Ibis	Not listed	Not listed	Confirmed
TURNICIDAE				
Turnix pyrrhothorax	Red-chested Button-quail	Not listed	Not listed	Possible
Turnix varius	Painted Button-quail	Not listed	Not listed	Confirmed
Turnix velox	Little Button-quail	Not listed	Not listed	Confirmed
TYTONIDAE				
Tyto javanica	Eastern Barn Owl	Not listed	Not listed	Confirmed
ZOSTEROPIDAE				
Zosterops lateralis	Silvereye	Not listed	Not listed	Confirmed

Appendix 2. Native small mammals and reptiles

Reptile species observed during the Standard Trapping Survey in 2019. Occupancy = number of sites where each reptile species was recorded (n = 48).

Scientific Name	No. Records	Occupancy (n = 48 Sites)
Anilios bituberculatus	6	4
Brachyurophis australis	1	1
Cryptoblepharus australis	2	2
Cryptoblepharus pannosus	3	3
Ctenophorus fordi	13	10
Ctenotus atlas	9	6
Ctenotus inornatus	13	10
Ctenotus regius	15	11
Ctenotus schomburgkii	45	24
Delma butleri	1	1
Diporiphora nobbi	3	3
Egernia striolata	2	2
Eremiascincus richardsonii	34	16
Gehyra versicolor	24	20
Heteronotia binoei	14	12
Lerista aericeps	5	1
Lerista labialis	108	30
Lerista punctatovittata	14	12
Lialis burtonis	1	1
Liopholis inornata	1	1
Lucasium damaeum	8	8
Menetia greyii	20	14
Morethia boulengeri	13	10
Morethia obscura	1	1
Nephrurus levis	15	12
Oedura cincta	2	2
Pogona vitticeps	3	3
Pseudonaja modesta	1	1
Pygopus schraderi	1	1
Rhynchoedura angusta	17	13
Strophurus intermedius	2	2
Varanus gouldii	3	3

Native mammals recorded during trapping, camera and/ or nocturnal spotlight in 2019. Sites occupied = total number of sites where each mammal species was observed during surveys.

Common Name	Scientific Name	Numbers captured	Sites occupied	Survey Method
Southern Ningaui	*Ningaui yvonneae*	16	11	Trapping
Fat-tailed Dunnart	*Sminthopsis crassicaudata*	1	1	Trapping
Strip-faced Dunnart	*Sminthopsis macroura*	1	1	Trapping
Common Dunnart	*Sminthopsis murina*	18	14	Trapping

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