Mt Gibson Wildlife Sanctuary

Ecohealth Report 2021

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Summary

Australian Wildlife Conservancy (AWC) has implemented an Ecological Health Monitoring Program (Ecohealth) across Mt Gibson Wildlife Sanctuary (Mt Gibson), to measure the changes in the status and trends 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 2018 and 2021. The complete set of metrics and their values are summarised in the accompanying Ecohealth Scorecard.

In implementing the Ecohealth program in 2021, AWC conducted 2,998 live trap nights, 11,779 camera trap nights and 148.5 km of transects at Mt Gibson. These surveys detected 17 mammal, 27 reptile and 15 bird species.

Mt Gibson is engaged in an ambitious reintroduction program, with 10 species of regionally-extinct mammals planned for reintroduction by 2023 to a 7,832 ha fenced feral predator-free area and/ or outside the fenced area. Since 2011, nine mammal species have been reintroduced to the fenced area and one species outside of the fenced area. In 2021, translocations of seven of the nine species of locally-extinct mammals reintroduced to Mt Gibson met success criteria relevant to their stage of reintroduction.

In summary, Red-tailed Phascogales (*Phascogale calura*), Numbats (*Myrmecobius fasciatus*) and Banded Hare-wallabies (*Lagostrophus fasciatus*) were detected at a higher number of sites in 2021 than previous years; Greater Bilbies (*Macrotis lagotis*) and Western Barred Bandicoots (*Perameles bougainville*) continued to be detected across the safe haven; Numbats, Banded Hare-wallabies and Greater Bilbies were breeding; Brushtail Possums (*Trichosurus vulpecula*) were released inside and outside the fenced area in 2021, and the reintroduction is on track to meet short-term success criteria; there were an estimated 1,873 Woylies (*Bettongia penicillat*a) in the fenced area, well above the success criterion of 300 individuals and Mt Gibson is now a source population for reintroductions to other AWC sanctuaries. In addition, Greater Stick-nest Rats (*Leporillus conditor*) continue to be detected at known sites of occupancy but there is insufficient evidence to assess against success criteria and Shark Bay Mice (*Pseudomys fieldi*) have not met success criteria.

The Standard Trapping Survey was run for the second time in 2021, allowing for comparison of data for mammal and reptile assemblages across the wider sanctuary for 2019 and 2021. The majority of the assemblages showed a stable or increasing trend, and any declines in detection are likely due to the cooler weather experienced during the 2021 surveys. Continued monitoring will provide more robust information on long-term trends as well as comparisons inside and outside the safe haven.

In 2021, rabbit (*Oryctolagus cuniculus*) occupancy within the fenced area showed a decline for the first time since 2018. Continued monitoring in conjunction with ongoing control will indicate whether this is a sign of changes in the population of rabbits within the fenced area at Mt Gibson.

Contents

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. 2018a). 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 Mt Gibson Wildlife Sanctuary (referred to here as Mt Gibson). The companion Ecohealth Scorecard presents the indicators and their metrics in a summary format.

Mt Gibson Wildlife Sanctuary

Mt Gibson Wildlife Sanctuary ('Mt Gibson') is located in south-western Australia and is 131,812 ha in extent (Figure 1). The property lies within a transition zone between the eucalypt-dominated south-west and the mulga-dominated Eremaean Botanical Provinces

Mt Gibson has a high diversity of habitats that previously supported a rich mammal fauna (Figure 2). At European settlement, Mt Gibson is likely to have sustained at least 33 species of terrestrial mammals (Baynes 2002). However, like much of semi-arid Australia, the area around Mt Gibson has lost a significant component of its mammal fauna, with three species globally extinct and another 13 extinct across most of their range. In total, 40 mammal species, 147 bird species, 67 reptile species and 6 amphibians are currently known or considered likely to occur at Mt Gibson. Two of the extant species present on Mt Gibson, Western Spiny-tailed Skink (*Egernia stokesii badia*) and Malleefowl (*Leipoa ocellata*) are listed as threatened nationally. Of the 700-800 plant species that occur on the sanctuary, 60 or more are of some level of conservation concern.

Mt Gibson is within the traditional lands of the Badimia people. Following European colonisation, and prior to AWC's acquisition of Mt Gibson in 2001, the property was run as a sheep (*Ovis aries*) station, and later as an Emu (*Dromaius novaehollandiae*) farm. AWC implements land management programs designed to maintain and restore the conservation values of the property. These programs include management of introduced predators and herbivores (i.e., eradicating feral goats (*Capra hircus*)), weeds and fire. Mt Gibson is an important part of the AWC estate because of its naturally occurring and diverse wildlife and for the conservation initiatives taking place on the sanctuary, notably the Mt Gibson Mammal Restoration Project. This project involves the reintroduction of 10 locally-extinct mammals, most to a 7,832 ha feral-predator proof fenced area ('safe haven') from which feral cats (*Felis catus*), foxes (*Vulpes vulpes*) and feral goats have been eradicated. To date, nine species have been reintroduced into the safe haven (Table 1). One species, the Common Brushtail Possum (*Trichosurus vulpecula*), has been reintroduced to sites both inside and outside the

fenced area. AWC is also undertaking research to inform the effective management of feral cats and foxes outside the fenced area, ahead of a proposed reintroduction of Western Quoll/ Chuditch (*Dasyurus geoffroii*).
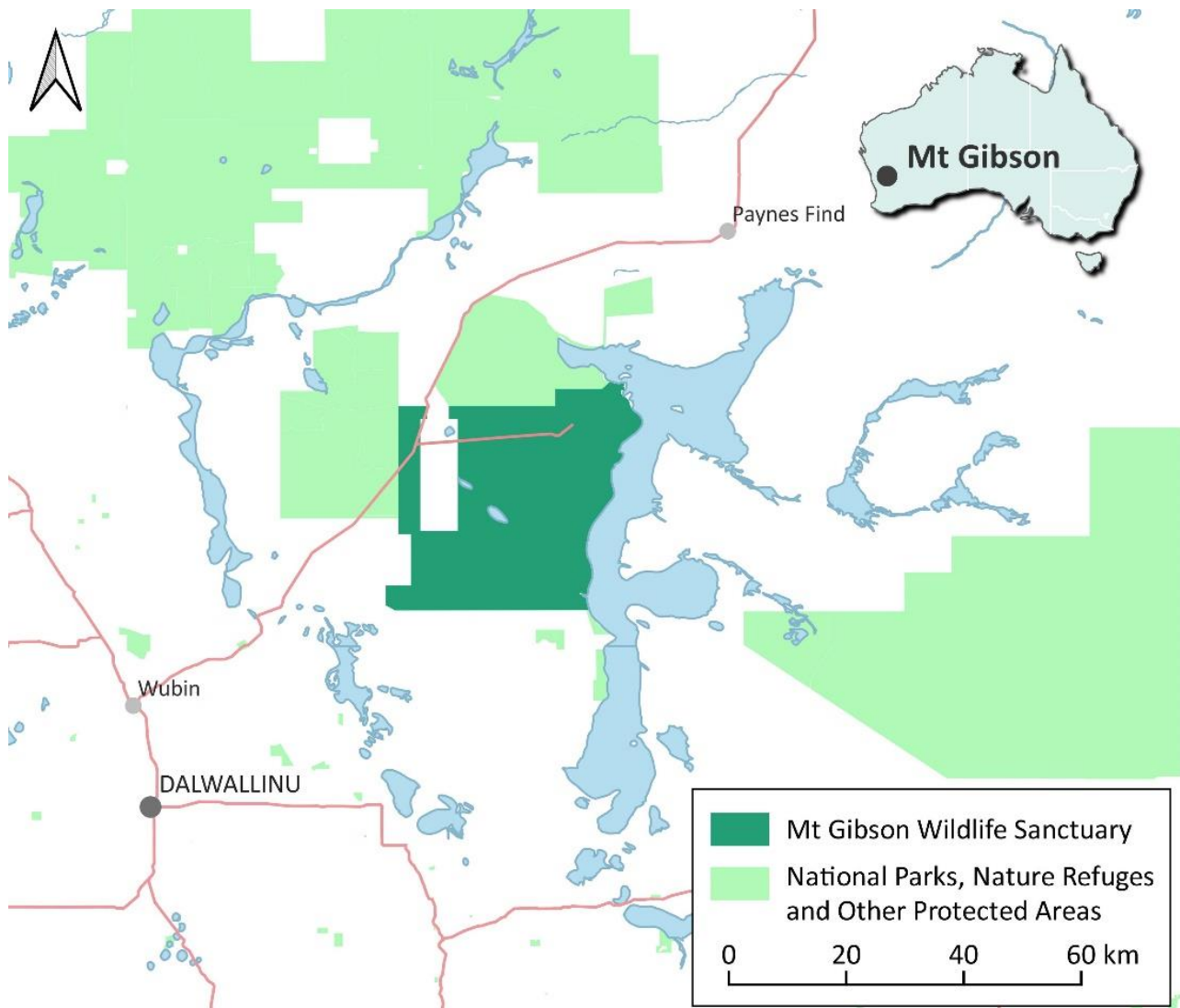

Figure 1. The location of Mt Gibson Sanctuary in the south-west of Western Australia.
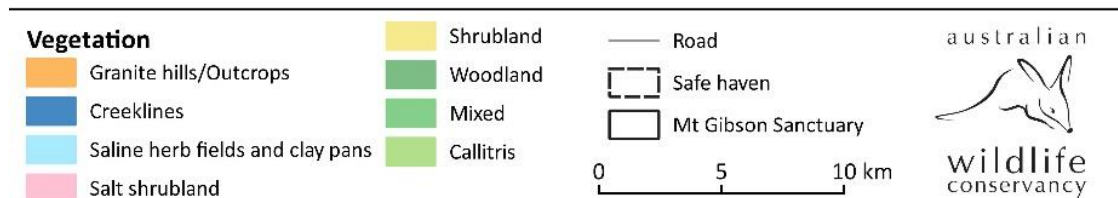
Figure 2. Mt Gibson Sanctuary (solid black line) and the fenced area (dashed black line), showing major vegetation elements.

Table 1. Species and number of individuals reintroduced to Mt Gibson's safe haven up to December 2021.

Species	Number of individuals reintroduced
Woylie (*Bettongia penicillata*)	162
Greater Stick-nest Rat (*Leporillus conditor*)	95
Numbat (*Myrmecobius fasciatus*)	64
Greater Bilby (*Macrotis lagotis*)	56
Red-tailed Phascogale (*Phascogale calura*)	165
Western Barred Bandicoot (*Perameles bougainville*)	64
Banded Hare-wallaby (*Lagostrophus fasciatus*)	119
Shark Bay Mouse (*Pseudomys fieldi*)	52
Common Brushtail Possum (*Trichosurus vulpecula*)	49

Nineteen different habitat types are present in the fenced area (Table 2), predominantly a mix of woodlands and shrublands (41% and 57% respectively).

Table 2. Vegetation types within 7,832 ha fenced area, Mt Gibson.

Vegetation type	Area (ha)	Proportion (%)
Acacia ramulosa dunefields	691	8.8
Callitris columellaris woodland	343	4.4
Callitris columellaris York Gum (*Eucalyptus loxophleba*) woodland	1097	14.0
Deep granitic shrubland	1657	21.2
Eucalyptus clelandii woodland	196	2.5
Lithic/breakaway/granite outcrop vegetation	96	1.2
Mallee/shrubland	583	7.4
Mallee/woodland	497	6.3
Mixed shrubland (*Acacia/Allocasuarina/Melaleuca*)	220	2.8
Red soil shrubland	74	0.9
Saline herbfields and claypans	1	0.0
Salmon Gum woodland	406	5.2
Salmon Gum/York Gum woodland	52	0.7
Salt shrubland	45	0.6
Sandplain shrubland	535	6.8
Sandplain shrubland/mallee	134	1.7
Shallow granitic shrubland	571	7.3
York Gum woodland	626	8.0

Climate and weather summary

The climate of Mt Gibson is semi-arid, with an annual rainfall of 342 mm (range 153 – 539 mm) (Figure 3), hot summers (mean maximum monthly temperature 37 $^{\circ}$C) and cool winters (mean minimum monthly temperature 6 $^{\circ}$C) (Figure 4). There is substantial variation in rainfall between years. In 2021, 496 mm of rainfall was recorded at Mt Gibson, well above the long-term average (Figure 5). Mt Gibson's wettest months are usually in the winter, but in 2021, much of the rainfall fell outside of this period. Of note, a weather system brought 107 mm of rainfall over three days in March, equating to 20% of Mt Gibson's average annual rainfall. This was followed by a tropical cyclone system (Serjoa) that passed within the vicinity of Mt Gibson in April, leading to 43 mm of rainfall over three days. Annual and monthly rainfall recorded at Mt Gibson has been provided (Figure 3 and Figure 5), given that it varies substantially from the closest weather monitoring station (75 km away) at Paynes Find. Consistent temperature data is not collected at Mt Gibson and therefore monthly mean maximum and minimum temperatures have been provided from the Paynes Find Monitoring Station (Figure 4).
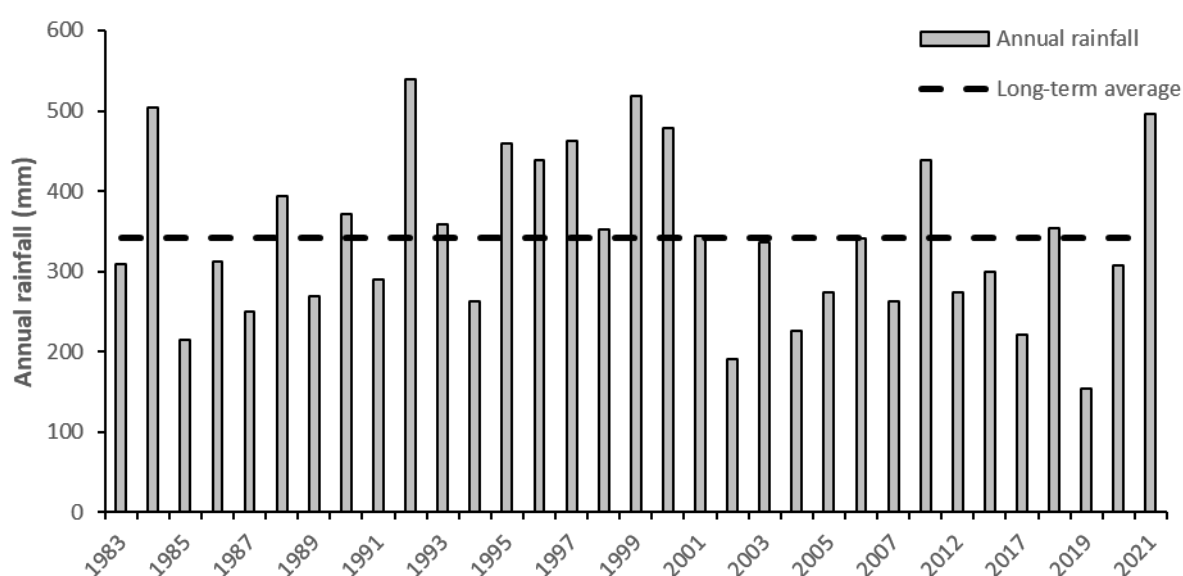

Figure 3. Annual rainfall at Mt Gibson (BOM Station No.010075). Dashed line = average 1983-2021, years with fewer than 350 days recorded have been deleted (BoM 2021).

Figure 4. Monthly mean maximum and minimum temperatures Paynes Find Monitoring Station (BOM Station No.007139). Paynes Find is 75 km north of Mt Gibson. Dashed line = average 1975-2021 (BoM 2021).

Figure 5. Monthly rainfall at Mt Gibson (BOM Station No.010075). Dashed line = average 1983-2021, years with fewer than 350 days recorded have been deleted (BoM 2021).

Methods

Monitoring and evaluation framework

Mt Gibson'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.

Reintroduced, threatened and iconic species

The Ecohealth program is focused on species of high conservation value, including **reintroduced species** (where present), and key **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).

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) and key species. The monitoring program aims to address questions relevant to the conservation of assemblages and key species.

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 and key species. At present, we will continue to present data on a range of metrics relating to indicator species and guilds.

Indicators and metrics

On Mt Gibson, 18 biodiversity (species and guilds) indicators have been selected for monitoring (Table 3). In this report, 17 of these indicators are reported on, including 9 reintroduced species, and the remainder are surveillance monitoring of faunal assemblages and surveillance species.

Threat metrics are selected to monitor the status and trends of introduced weeds, predators and herbivores, and fire regimes). Four threat indicators have been selected for monitoring (Table 4). Two of these threat metrics are reported on in this 2021 Ecohealth Report.

Table 3. Biodiversity indicators and metrics for Mt Gibson.

Reintroduced vertebrates

Indicator	Survey name/methods	Metric	Performance criteria
Red-tailed Phascogale (*Phascogale calura*)	Red-tailed Phascogale Survey Safe Haven Camera Survey	Site Abundance (425 ha survey area)	Increase in abundance
		Occupancy	Increase in distribution through fenced area
		Genetic diversity	Maintained/ increased genetic diversity relative to founders
		Breeding	Presence of new recruits one year post release; evidence of breeding/recruitment

Indicator	Survey name/methods	Metric	Performance criteria
		Survival	Survival of females one-year post-release
Numbat (*Myrmecobius fasciatus*)	Safe Haven Camera Survey	Population estimate	TBD. Increase in population size
		Occupancy	Increase in distribution through fenced area
		Breeding	Evidence of breeding/recruitment
		Genetic diversity	Maintained/ increased genetic diversity relative to founders
		Survival	Survival of radio-collared animals post-release
Western Barred Bandicoot (*Perameles bougainville*)	Safe Haven Camera Survey Safe Haven Mammal Trapping Survey BPCV1* Disease Monitoring Standard Trapping Survey	Population estimate	TBD. Increase in population size
		Occupancy	Increase in distribution through fenced area
		Health	Incidence of BPCV1 no higher than source populations (TBD in 2024)
		Genetic diversity	Maintained/ increased genetic diversity relative to founders
		Breeding	Evidence of breeding/recruitment
		Survival	Survival of radio-collared animals post-release
Greater Bilby (*Macrotis lagotis*)	Safe Haven Camera Survey	Population estimate	TBD
		Occupancy	Increase in distribution through fenced area
		Genetic diversity	Maintained/ increased genetic diversity relative to founders
		Breeding	Evidence of breeding/recruitment
		Survival	Survival of radio-collared animals post-release
Woylie (*Bettongia penicillata*)	Safe Haven Mammal Trapping Survey	Population estimate	>300 individuals by 5 years post-release
		Genetic diversity	Maintained/ increased genetic diversity relative to founders
		Breeding	Evidence of breeding/recruitment
		Survival	Survival of radio-collared animals post-release
Common Brushtail Possum (*Trichosurus vulpecula*)	Safe Haven Camera Survey	Population estimate	TBD
		Occupancy	Increase in distribution through fenced area
		Genetic diversity	Maintained/ increased genetic diversity relative to founders
		Breeding	Evidence of breeding/recruitment
		Survival	Survival of radio-collared animals post-release
Banded Hare-wallaby (*Lagostrophus fasciatus*)	Safe Haven Camera Survey	Population estimate	TBD
		Occupancy	Increase in distribution through fenced area
		Genetic diversity	Maintained/ increased genetic diversity relative to founders
		Breeding	Evidence of breeding/recruitment

Indicator	Survey name/methods	Metric	Performance criteria
		Survival	Survival of radio-collared animals post-release
Greater Stick-nest Rat (*Leporillus conditor*)	Greater Stick-nest Rat Survey Safe Haven Camera Survey	Site Abundance (14 ha survey area)	Maintenance of abundance at 50% of monitoring sites
		Occupancy	Increase in distribution through fenced area
		Genetic diversity	Maintained/ increased genetic diversity relative to founders
		Survival	Survival of radio-collared animals post-release
Shark Bay Mouse (*Pseudomys fieldi*)	Safe Haven Camera Survey Standard Trapping Survey	Occupancy	Increase in distribution through fenced area
		Genetic diversity	Maintained/ increased genetic diversity relative to founders
		Breeding	Evidence of breeding/recruitment

* BPCV1 disease is bandicoot papillomatosis carcinomatosis virus type 1

Vertebrate assemblages and surveillance species

Indicator	Survey name	Survey method	Metric/s
Mammals			
Small-medium sized mammals			
Short-beaked Echidna (*Tachyglossus aculeatus*)	Standard Trapping Survey	Camera traps	Occupancy
Reptiles			
Small reptiles (guild)	Standard Trapping Survey	Pitfall and Funnel traps	Richness
Barred Wedgesnout Ctenotus (*Ctenotus schomburgkii*)	Standard Trapping Survey	Pitfall and Funnel traps	Occupancy
Variegated Dtella (*Gehyra variegata*)	Standard Trapping Survey	Pitfall and Funnel traps	Occupancy
King's Slider (*Lerista kingi*)	Standard Trapping Survey	Pitfall and Funnel traps	Occupancy
Common Dwarf Skink (*Menetia greyii*)	Standard Trapping Survey	Pitfall and Funnel traps	Occupancy
Woodland Morethia Skink (*Morethia butleri*)	Standard Trapping Survey	Pitfall and Funnel traps	Occupancy
Gould's Goanna (*Varanus gouldii*)	Standard Trapping Survey	Camera traps	Occupancy
Birds			
Diurnal birds (guild)	Standard Bird Survey	2-ha Survey	Occupancy, richness

Table 4. Threat indicators and metrics for Mt Gibson in 2021.

Indicator	Survey name/ methods	Metric/s	Performance criteria
Pest animals			
Feral Cat (*Felis catus*)	Feral Predator Camera Survey – *methods under development*	TBD	TBD
Fox (*Vulpes vulpes*)	Feral Predator Camera Survey – *methods under development*	TBD	TBD

Indicator	Survey name/ methods	Metric/s	Performance criteria
Rabbit (*Oryctolagus cuniculus*)	Safe Haven Camera Survey	Occupancy	TBD
Fire			
Extent of planned burns	Fire Scar Analysis	Area burnt (ha) planned	TBD
Extent of unplanned burns	Fire Scar Analysis	Area burnt (ha) wildfire	TBD

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, as required to obtain timely information on each indicator. These include:

For key threatened and iconic vertebrates, including reintroduced species, a range of targeted surveys including:

- Safe Haven Camera Survey
- Safe Haven Mammal Trapping Survey
- Red-tailed Phascogale Trapping Survey
- Greater Stick-nest Rat Trapping Survey
- Bilby Spotlighting Survey
- Standard Trapping Survey (Pitfall)

For monitoring of assemblages and surveillance species, these include:

- Standard Trapping Survey
- Standard Bird Survey

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

- BPCV1 Disease Monitoring (Western Barred Bandicoot)
- Safe Haven Camera Survey
- Fire Scar Analysis

Six ecological surveys were conducted at Mt Gibson in 2021. Below is a list of surveys reported upon in this Ecohealth Report (Table 5). The methodology is described and results of these surveys and computations are reported on in this document.

Table 5. Survey history and effort for Ecohealth surveys on Mt Gibson reported on in this Report.

Survey name	Effort (2021)	Description/comment	Previous surveys
Safe Haven Mammal Trapping Survey	800 trap nights (TN)	Cage trapping targeting Woylies and Western Barred Bandicoots. In 2021, 80 sites, with four cage traps each were trapped for two nights and 40 sites were trapped for one night.	Annually 2017 to 2020 – 120 sites; 1,440 TN
Red-tailed Phascogale Trapping Survey	420 trap nights	Tree-mounted Elliot traps targeted Red-tailed Phascogales. 6 sites within the vicinity of release sites and camera trap detection hot spots, 20 traps at each site (n=120 traps). In 2021, 3 sites were trapped for 4 nights, and 3 sites were trapped for 3 nights.	None
BPCV1 Disease Monitoring	50 trap nights	Cage trapping targeting Western Barred Bandicoots. Sites within vicinity of release sites, 25 cage traps per site, trapped for 2-3 nights. In 2021, 1 site (n=25 traps) trapped for 2 nights.	2019 – 8 sites; TN 475 2020 – 1 site; TN 50
Safe Haven Camera Survey	2,940 trap nights	70 sites throughout the safe haven, each with two lured infrared camera traps. Cameras are deployed at each site for three weeks.	Annually: 2017 to 2020 – 70 sites; 2,940 TN

Survey name	Effort (2021)	Description/comment	Previous surveys
Standard Trapping Survey (Pitfall)	1,728 trap nights	In 2021, 20 sites inside the safe haven and 6 sites outside the safe haven were trapped (n=26 sites) of 56 sites across the wider Sanctuary. 17 sites opened for three nights, 9 sites opened for 2 nights. Outside sites have 8 pitfall, 12 funnel, 4 Elliot and 4 cage traps, and inside sites have 8 pitfall, 12 funnel, and 4 Elliot traps.	2019 – 18 sites inside, 6 sites outside; TN 1,192
Standard Trapping Survey (Camera)	728 trap nights	In 2021, 20 sites inside the safe haven and 6 sites outside the safe haven were trapped (n=26 sites) of 56 sites across the wider Sanctuary. Each site consists of two cameras deployed for 2 weeks.	2019 – 18 sites inside, 6 sites outside; TN 672

Survey design and methods

Safe Haven Mammal Trapping Survey

The annual Safe Haven Mammal Trapping Survey was designed primarily to obtain a population estimate for Woylies (*Bettongia penicillata*), however population estimates are now obtained for Western Barred Bandicoots (*Perameles bougainville*) as well. Additional data are collected for other small to medium-sized mammals. There are 120 sites throughout the safe haven (Figure 6). All sites are 50 m from a road or track.

Each site comprises four standard cage traps, one of which was fitted with a wooden excluder to reduce trap saturation by Woylies and increase trap success of other small-medium mammal species (Figure 6). The safe haven was split into three sections (north, central and south) with 40 sites per section, each surveyed independently. In 2021, due to inclement weather, the survey was run for a total of five nights (central and south sections for 2 nights each, north section for 1 night). Traps were lured with universal bait balls (peanut butter, sardines and oats). Traps were opened before sunset and checked and closed each morning within three hours of dawn.

All Ecohealth indicator species (new animals and recaptures from previous sessions) were processed with the following standard data collected: species identification; sex and reproductive status; microchip and DNA for new animals; weight and pes length. Western Barred Bandicoots (new animals and recaptures from previous sessions) were checked for signs of the bandicoot papillomatosis carcinomatosis virus type 1 (BPCV1; see section below for methods describing the targeted BPCV1 Disease Monitoring survey), a condition found in many populations of Western Barred Bandicoot.
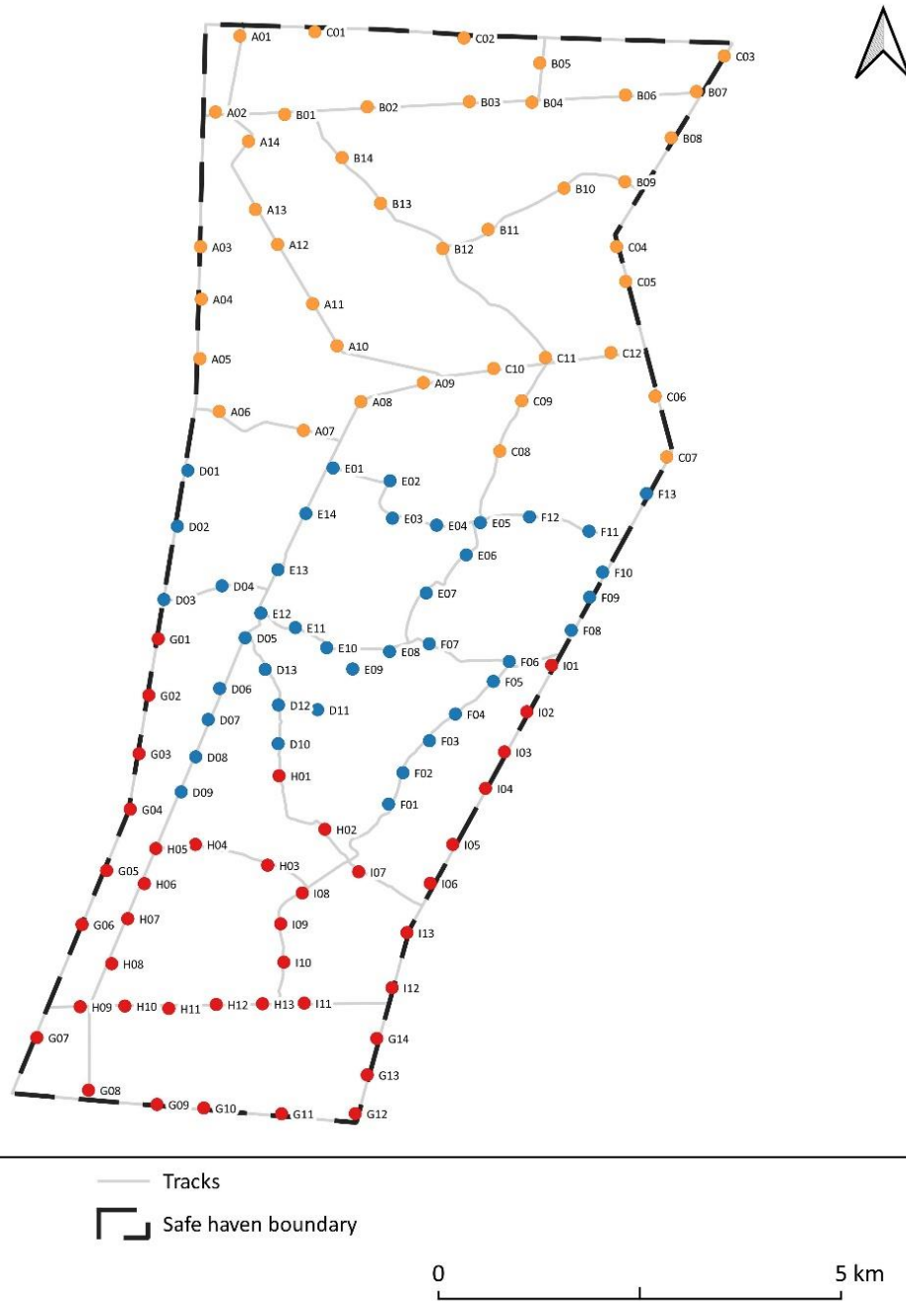
Figure 6. Trapping sites run during the Safe Haven Mammal Trapping Survey.

Figure 7. Standard cage trap with wooden excluder (Photo: G Anderson/AWC).

Red-tailed Phascogale Trapping Survey

The Red-tailed Phascogale Survey is conducted annually in February to obtain a site abundance estimate. The inaugural survey was undertaken in 2021. Six sites have been established in the vicinity of translocation release sites and camera trap detection hot spots (Figure 8). The 425 ha survey area was within the safe haven and characterised by Callitris-York Gum and Shrubland vegetation.
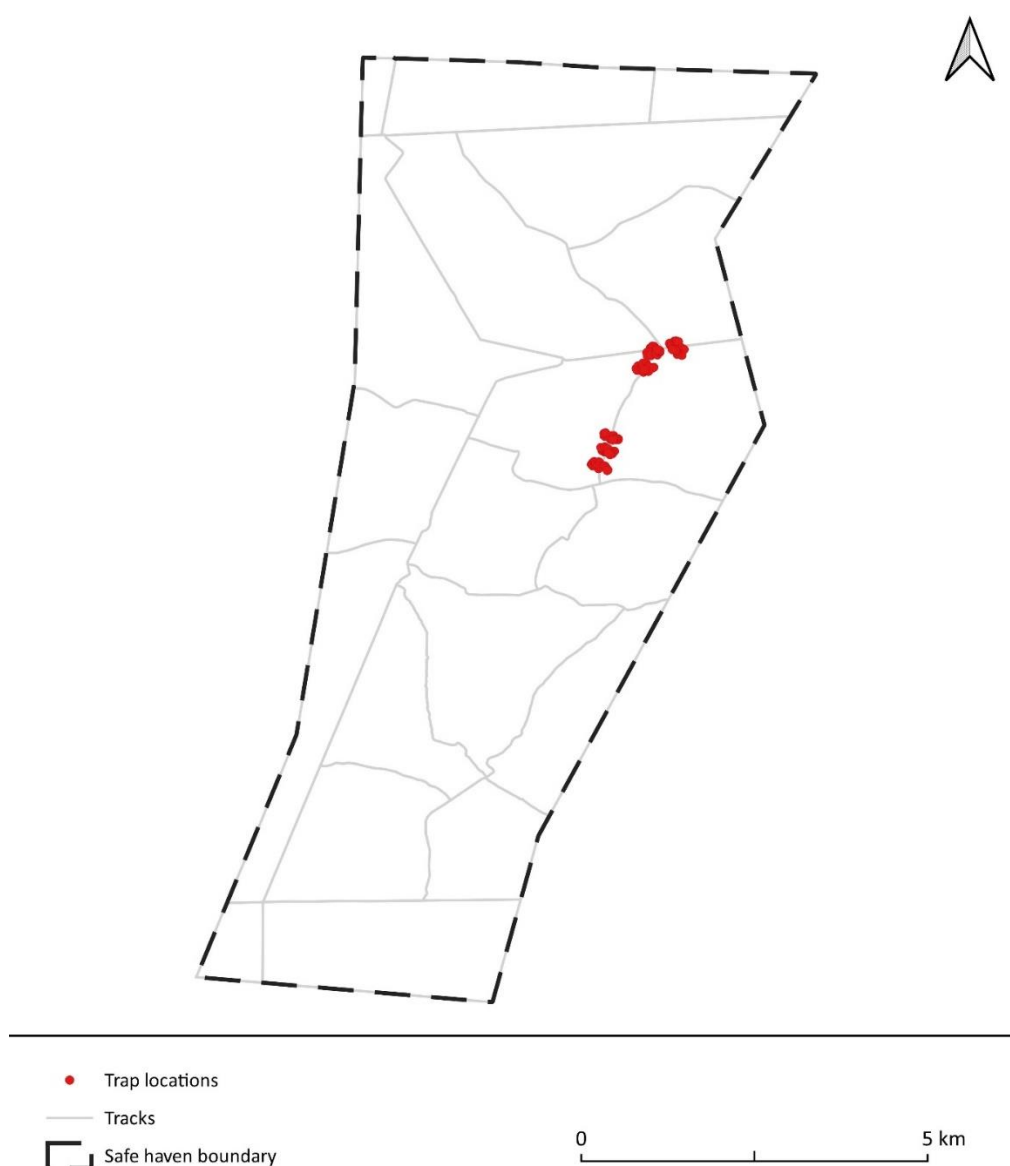
Figure 8. Sites for the Red-tailed Phascogale Trapping Survey

Each site consists of 20 Elliot traps (n=120) deployed on tree-mounted platforms. Traps were no more than 150 m from the road. Traps were pre-lured with universal bait (peanut butter, sardines and oats) for three weeks prior to trapping. Sites are opened for three or four nights. Traps are opened before sunset and checked and closed each morning by three hours after dawn.

Standard morphometric measurements (weight, sex, age, breeding condition) and a DNA sample were taken from new animals.

BPCV1 Disease Monitoring

Western Barred Bandicoots were translocated from Bernier Island to Mt Gibson in 2018 and 2019 as part of AWC's Mt Gibson Mammal Restoration Project. A novel virus known as the Bandicoot papillomatosis and carcinomatosis syndrome or BPCV1 has been detected in individuals on Bernier Island. As stipulated by the Western Australian Department of Biodiversity and Attractions (DBCA), disease monitoring in the Mt Gibson bandicoot population is undertaken every six months for three years post reintroduction.

BPCV1 Disease Monitoring was undertaken at one site in March 2021 (Figure 9). This site was selected based on proximity to translocation release sites and previous captures of Bernier Island animals. An adequate number of Western Barred Bandicoots were trapped and checked for BPCV1 during the Safe Haven Mammal Trapping Survey in July 2021, and so targeted BPCV1 Disease Monitoring was not undertaken in the second

half of the year. Additional Western Barred Bandicoots were trapped and checked for BPCV1 during the Standard Trapping Survey (Pitfall) in October 2021.

BPCV1 disease monitoring was undertaken using cage traps with wooden excluders fitted (Figure 7). The trapping grid comprised of five by five lines of traps, spaced 25 m apart. Traps were baited with universal bait balls (peanut butter, sardines and oats). Traps were wired open and pre-lured for three nights, followed by two trap nights.

All Bandicoots captured were thoroughly inspected for signs of BPCV1. Signs of the wart-like disease include regions of hair loss, red discolouration of the skin, raised, rough and thickened skin, and nodular cutaneous masses that may be infected or ulcerated. Standard morphometric measurements (weight, age, sex, breeding condition, microchip) were taken for new and previous session recaptures, and a DNA sample was collected from new animals.
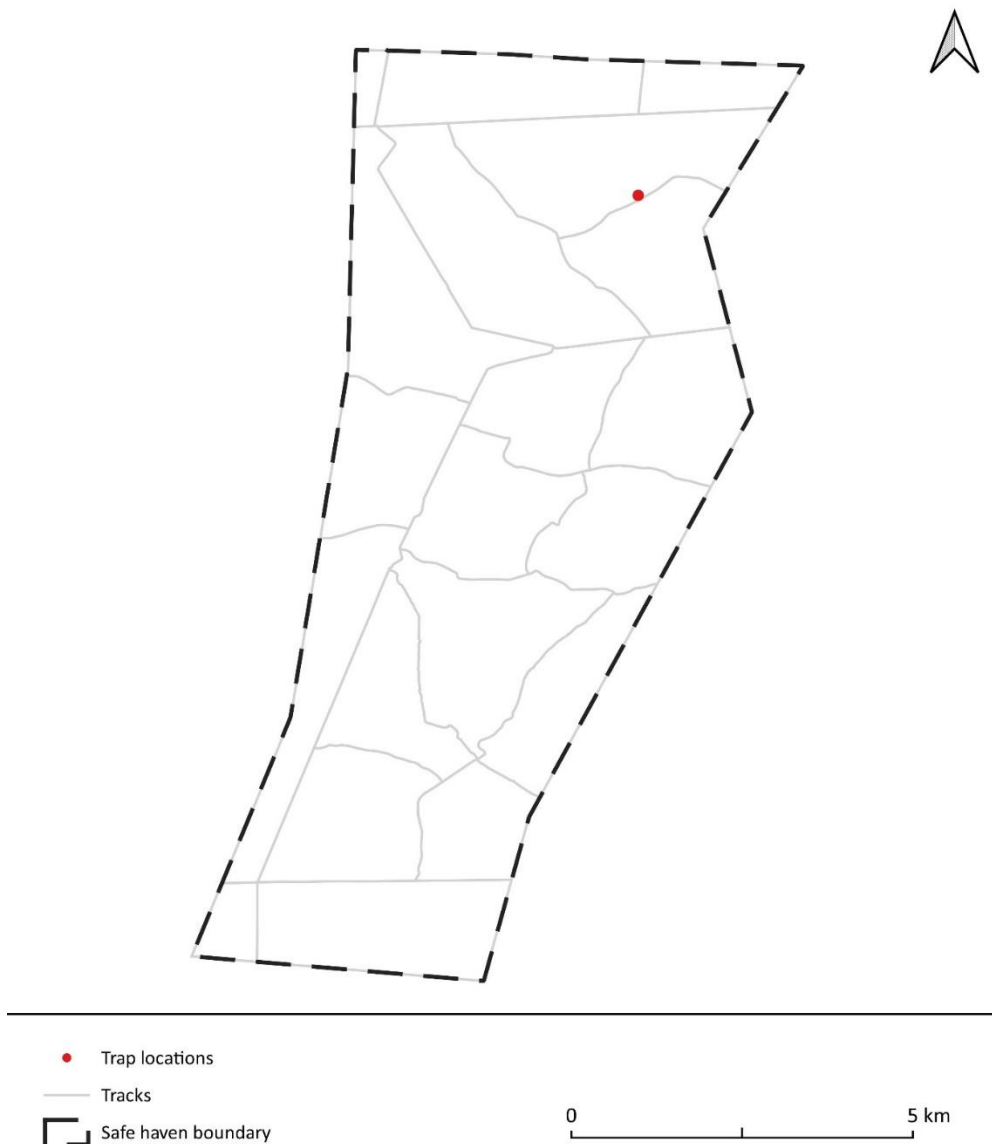

Figure 9. Trapping site for BPCV1 Disease Monitoring in Western Barred Bandicoots in 2021.

Safe Haven Camera Survey

The Safe Haven Camera Survey is conducted annually to determine occupancy of reintroduced mammals. Seventy permanent monitoring sites (Figure 10) were selected based on their distribution across eight broad vegetation types: *Callitris*-York Gum woodland; Granite outcrop; Mallee; Mallee-woodland; Salmon Gum woodland; Shrubland; York Gum woodland and Other Eucalyptus woodland. Site locations were derived with a stratified sampling approach and the 'Random Points Inside Polygons' tool in QGIS (QGIS Development

Team 2018). Sites were randomly distributed across the safe haven, stratified by vegetation type, with a mean distance among sites of 788 m and a minimum distance of 367 m between each site.

At each site, two Reconyx Hyperfire cameras (n=140) were deployed approximately 5 m apart. Cameras were attached to a star picket, facing downwards, one metre above the ground. A lure canister and a cork tile marked with a 50 x 50 mm grid (used as a scale reference) were positioned at the base of the star picket within the camera's field of view. At each site, one canister contained apple and Dairy Krave and the other contained a universal bait ball (peanut butter, sardines and oats). Camera settings were selected as outlined in Table 6.

The survey was conducted between December 2020 and March 2021. Cameras were deployed within each zone of the safe haven (north, central and south) for a period of three weeks (Table 7).

Figure 10. Camera monitoring sites for the Safe Haven Camera Survey.

Table 6. Camera settings used for Safe Haven Camera Survey and Standard Trapping Survey (Camera).

Setting Type	Camera setting
Advanced setup	Trigger
Motion sensor	On
Sensitivity	High
Pictures per trigger	3
Picture interval	Rapid fire
Quiet period	No delay

Table 7. Survey timetable for 2021 Safe Haven Camera Survey.

Zone	Number of sites	Survey period
North safe haven	23 sites (46 cameras)	28/01/2021 – 08/03/2021
Central safe haven	22 sites (44 cameras)	05/01/2021 – 28/01/2021
South safe haven	25 sites (50 cameras)	12/12/2020 – 06/01/2021

Standard Trapping Survey

Pitfall Trapping

The Standard Trapping Survey is run biennially in early summer (October-November). There are a total of 56 sites identified across Mt Gibson Sanctuary, with 20 of these inside the safe haven (Figure 11). The trapping sites are in the process of being established, with 26 sites established and thirty additional planned. In 2019, the survey was run at 24 established sites (20 inside and 4 outside the safe haven), and in 2021, the survey was run at 26 established sites (20 inside and 6 outside the safe haven). In 2021, nine of the inside sites were only run for two nights due to inclement weather (rain).

These sites are spread across the seven major vegetation classes present at Mt Gibson: woodland, shrubland, Callitris, granite hill/outcrop, saline herbfield/claypan, and salt shrubland. All sites are within 500 m of a track.
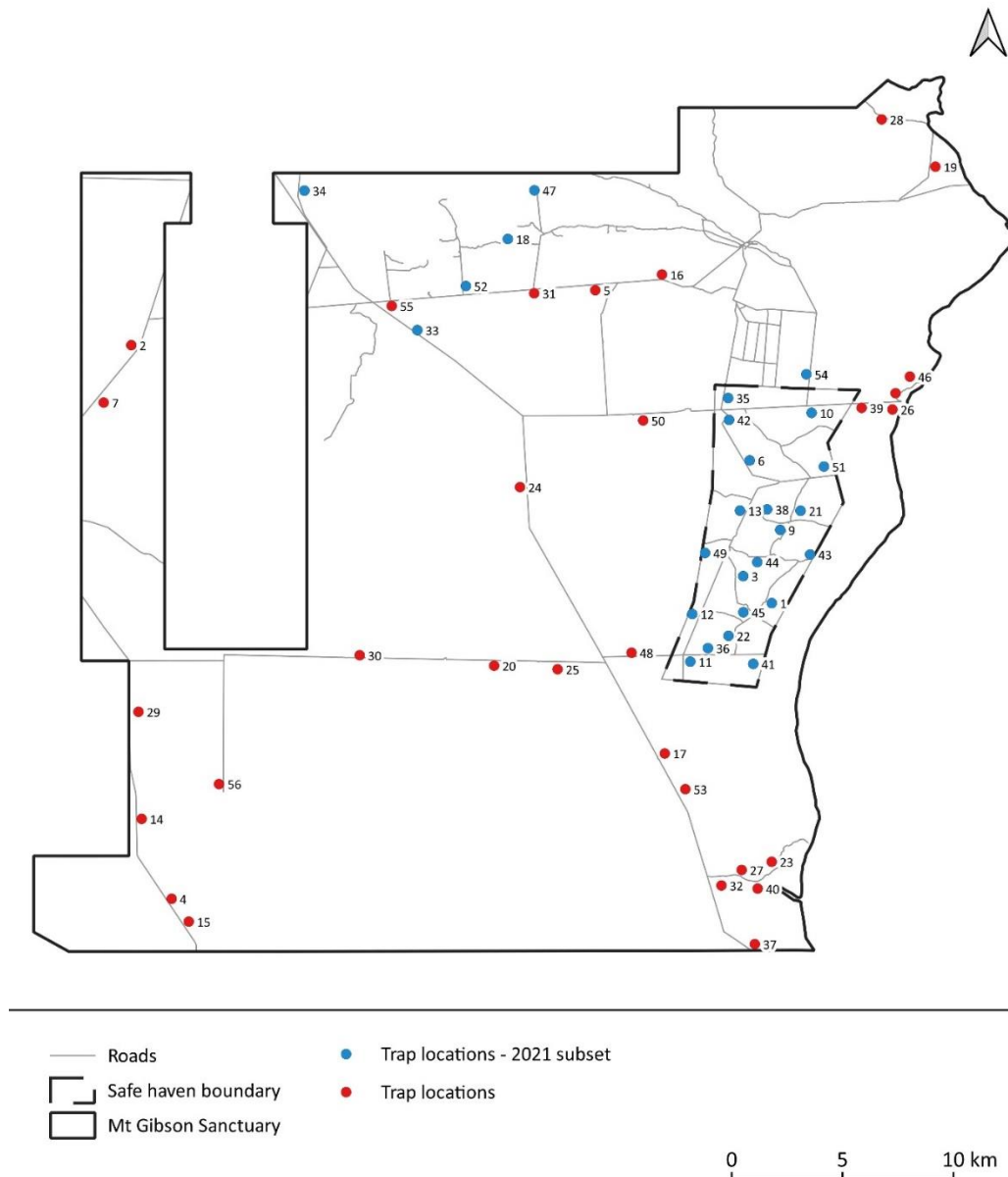
Figure 11. Site locations for the Standard Trapping Survey at Mt Gibson.

Each site has two 'T' formations, each consisting of 2 drift fences (20 m x 10 m; Figure 12). Outside sites have 8 pitfall, 12 funnel, 4 Elliot and 4 cage traps; inside sites have 8 pitfall, 12 funnel, and 4 Elliot traps inside wired open cages with wooden excluders attached (to prevent captures of Woylies).

Each site is trapped for three nights in a row, consisting of afternoon and morning checks. All traps are checked within three hours of sunrise, and then again in the late afternoon. Cage and Elliot traps are closed after each morning check and reopened in the afternoon.

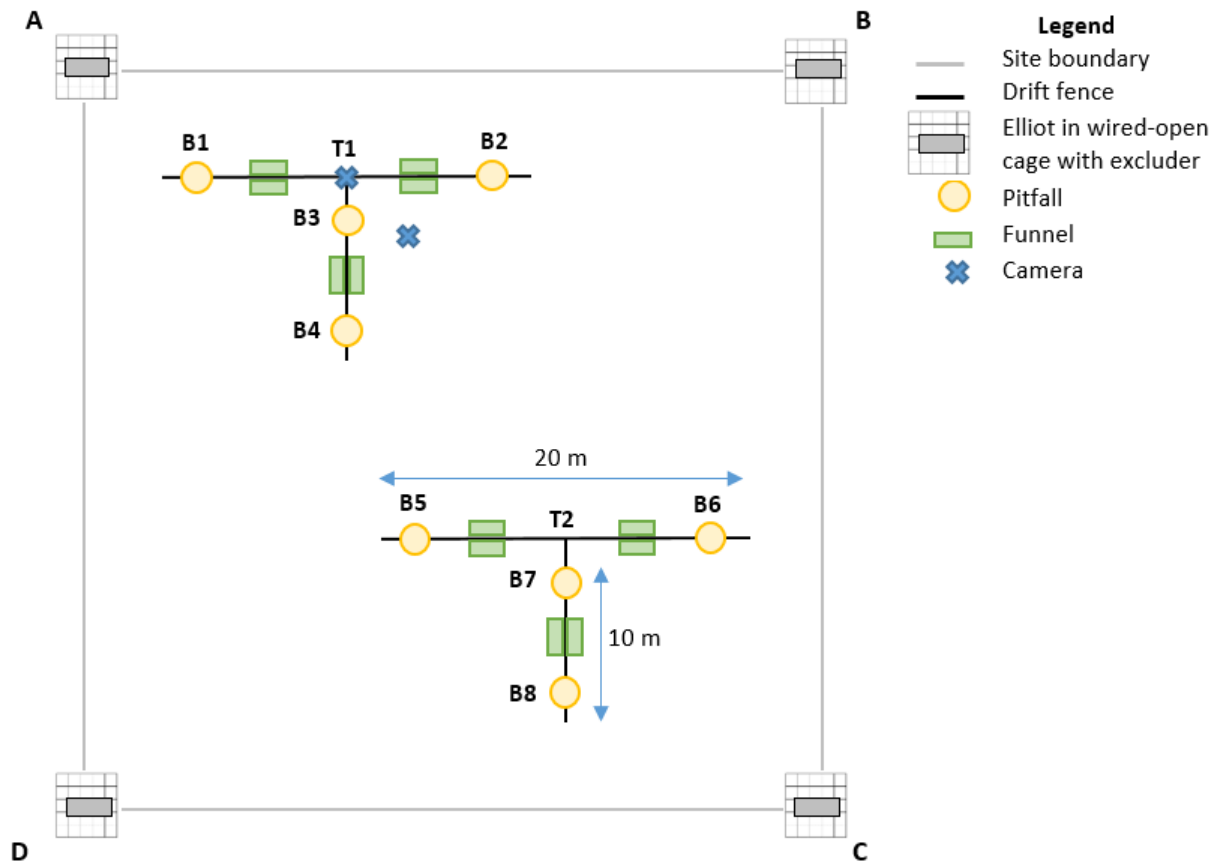All captures were processed with the standard data collected in Table 8.

Figure 12. Diagram of site setup for the Standard Trapping Survey (Pitfall) at Mt Gibson.

Table 8. Identification and measurements required for captures.

Assemblage	Identification	Measurements	Marking
Reptiles	Yes, to species level	Snout-vent length	Paint pen
Amphibians	Yes, to species level	N/A	None
Mammals	Yes, to species level	• Weight, age, sex and breeding condition • DNA (reintroduced species) • Western Barred Bandicoots BPCV1 check	Medium size mammals– microchip Small mammals – paint pen
Birds	Yes, to species level	N/A	None
Invertebrates	No – release immediately	N/A	None

Camera trapping

Immediately following the live trapping, cameras are deployed at the same 26 site subset of the 56 sites noted above (Figure 11).

At each site, two Reconyx Hyperfire cameras are deployed for two weeks (Figure 13). One camera is downward-facing, attached to a star picket at 1 m high at the junction of the T. The camera is lured with a universal bait ball (peanut butter, sardines and oats). The other camera is forward facing. It is attached to a fence dropper at 50 cm high. The camera is at a 45° angle, approximately 2 m from the lure. Camera settings were selected as outlined in Table 6.
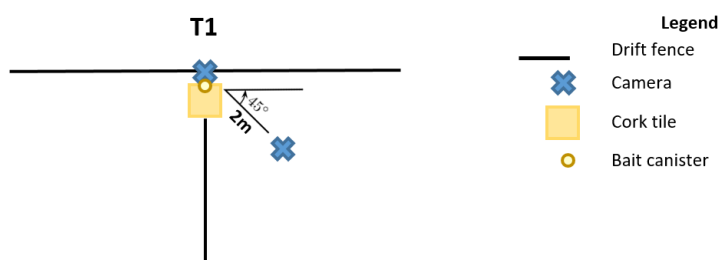
Figure 13. Diagram of camera setup at a Standard Trapping Survey site.

Analysis methods

Most Ecohealth metrics are common across the indicator species for Mt Gibson. Unless noted otherwise, the metrics are calculated as set out in Table 9 below.

Table 9. Metrics and associated calculations for Mt Gibson's Ecohealth indicators.

Indicator	Metric	Survey data sources	Description	Analysis summary/calculation
Red-tailed Phascogale Greater Stick-nest Rat	Site abundance	Red-tailed Phascogale Trapping Survey Greater Stick-nest Rat Trapping Survey	Estimate of number of individuals across survey sites based on live trapping.	An estimate of the number of individuals across survey sites (over an area of 425 ha and 14 ha for Red-tailed Phascogale in 2021 and Greater Stick-nest Rat in 2020 respectively) was generated using Spatially Explicit Capture-Recapture (SECR) methods (Efford and Fewster 2013). Package SPACECAP (Gopalaswamy et al. 2012) was run within R software (R Core Team 2013). SPACECAP provides for the inclusion of a covariate to assess 'trap happiness'. Models with different configurations of detection function (half-normal or exponential), with or without a covariate for trap response, and different home range probabilities were assessed by comparing convergence and Bayesian-p values (Gopalaswamy et al. 2012). Models that converged well and had a Bayesian-p value closest to 0.5 were considered the best model.
Western Barred Bandicoot Woylie	Population Estimate	Safe Haven Camera Survey Safe Haven Mammal Trapping Survey	Estimate of number of individuals across survey sites based on live trapping.	An estimate of the number of individuals across survey sites (over the entire 7,832 ha area of the Safe Haven) was generated using Spatially Explicit Capture-Recapture (SECR) methods (Efford and Fewster 2013). Package SPACECAP (Gopalaswamy et al. 2012) was run within R software (R Core Team 2013). SPACECAP provides for the inclusion of a covariate to assess 'trap happiness'. Models with different configurations of detection function (half-normal or exponential), with or without a covariate for trap response, and different home range probabilities were assessed by comparing convergence and Bayesian-p values (Gopalaswamy et al.

Indicator	Metric	Survey data sources	Description	Analysis summary/calculation
				2012). Models that converged well and had a Bayesian-p value closest to 0.5 were considered the best model.
Various	Occupancy	Safe Haven Camera Survey; Safe Haven Mammal Trapping Standard Trapping Survey	A measure of distribution; the proportion of sites where the species was recorded using remote camera traps.	Number of sites at which the species was recorded / number of sites surveyed.
Western Barred Bandicoot	Proportion of animals with BPCV1	Safe Haven Mammal Trapping Survey BPCV1 Disease Monitoring	The proportion of animals with BPCV1.	Number of animals with BPCV1 / total number of animals trapped
Small reptiles (guild)	Richness	Standard Trapping Survey (Pitfall)	A measure of diversity; average number of species per site.	Total number of small reptile species recorded across the entire survey and then averaged across sites.

Fire Scar Analysis

No wildfires occurred on Mt Gibson during 2021. The extent of planned burns in 2021 was estimated by multiplying length and width of the burnt area. For previous fires, fire scars were measured by walking the perimeter of the burned area using a handheld GPS unit with tracking function. The area of the scar in hectares was calculated using ArcMap 10 with Spatial Analyst (Environmental System Research Institute Inc., Redlands, CA, USA).

Results

Reintroduced vertebrates

Red-tailed Phascogale

A total of 165 Red-tailed Phascogales (*Phascogale calura*) were translocated to Mt Gibson between 2017 and 2019. Due to their small size, short life span and semi-arboreal habits, this species is challenging to monitor. The translocation success criteria reflect these challenges, being limited to survival and recruitment in the short-term (up to 5 years post-release), and an increase in population size and genetic diversity over the longer-term (5 years or more post-release; Ruykys et al. 2017c).

Short term success criterion have been met. In 2021, the reintroduction of Red-tailed Phascogales had been in progress for 4 years since the first release and 2 years since the final release of founders. The success criterion relevant to this time period is the presence of new recruits entering the population. Occupancy of Red-tailed Phascogales in the fenced area has increased since 2018 (Figure 14). These results are consistent with dispersal through the fenced area and, presumably, growth in population size, suggesting the reintroduction of this species is on track to meet this longer-term success criterion.

During the Red-tailed Phascogale Trapping Survey ten individual Red-tailed Phascogales were captured, including five females (four sub-adults, one adult) and five males (all in breeding condition). All captures during the survey were of new individuals. Due to the short life span of Red-tailed Phascogales (1 year for males, 2 years for females), captures of founding individuals was considered unlikely. The results of this

survey provided evidence that founding individuals survived post-release and successfully bred, as indicated by the presence of new individuals. The presence of sub-adult and adult individuals indicates there is ongoing recruitment into the population each year. The survey allowed for collection of genetic samples for future genetic analysis. The data was sufficient to conduct a SECR analysis to obtain a site abundance estimate. Site abundance (within a 425 ha survey area) was estimated to be 95 individuals (95% CI, 12 to 195).
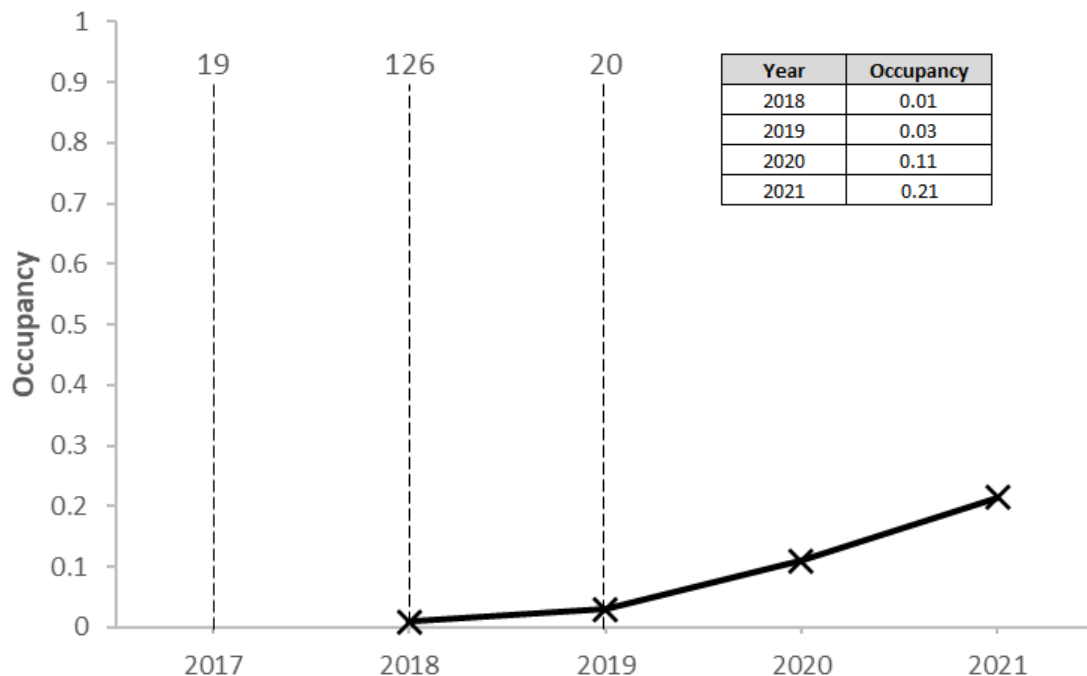

Year	Occupancy
2018	0.01
2019	0.03
2020	0.11
2021	0.21

Figure 14. Proportion of sites Red-tailed Phascogales detected in the annual Safe Haven Camera Survey, 2018-2021. The dashed lines represent reintroduction events of Red-tailed Phascogales into the Safe Haven. The numbers above the dashed line are the number of individuals reintroduced.

Numbat

A total of 64 Numbats (*Myrmecobius fasciatus*) were translocated to Mt Gibson between 2016 and 2018. The success criteria developed for this species includes survival, breeding and evidence of an established home range in the short-term (1 year post-release); breeding and dispersal (or population growth) through the fenced area in the mid-term (2 years post-release); and breeding, population growth and a viable, genetically diverse population (>5 years post-release) (Ruykys et al. 2015a).

In 2021, the reintroduction of Numbats had been in progress for 5 years since the first release and 3 years since the final release of founders. The success criterion relevant to this time period is mid- to long-term: evidence of breeding, dispersal and population growth.

Evidence of breeding was obtained by observations and camera detections of sub-adult Numbats and occupancy has increased since 2018 (Figure 15). These results are consistent with dispersal through the fenced area and, presumably, growth in population size, suggesting the reintroduction of this species is on track to meet the success criteria.

AWC is currently investigating methods to measure population size directly. In 2021, a drive survey method was trialled, and viability of the results are being assessed. The translocation is also reaching the stage of genetic assessment. Hand capture of Numbats began at the end of 2021 to collect DNA samples for genetic assessment.
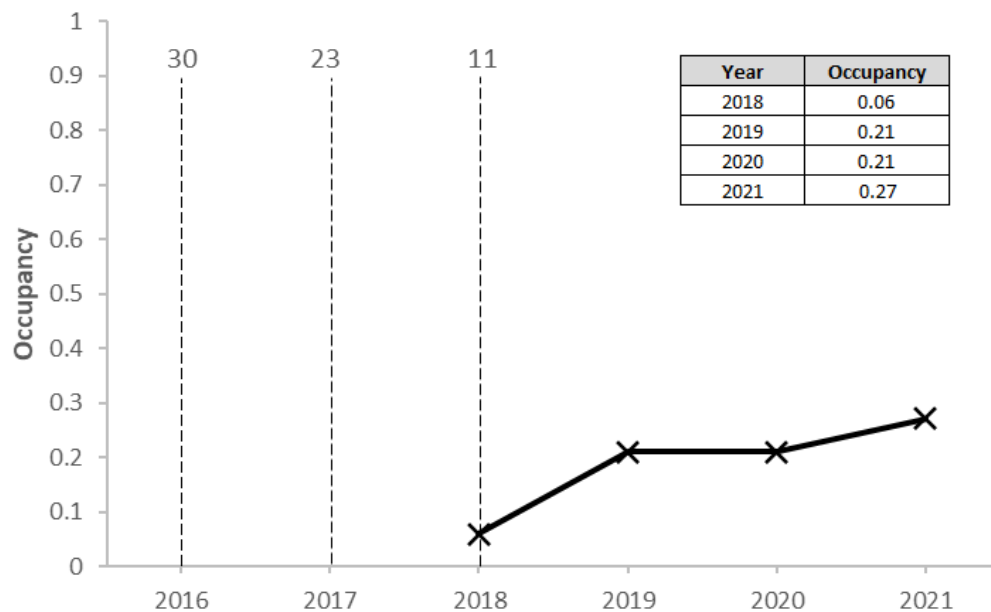
Year	Occupancy
2018	0.06
2019	0.21
2020	0.21
2021	0.27

Figure 15. Proportion of sites Numbats detected in the annual Safe Haven Camera Survey, 2018-2021. The dashed lines represent reintroduction events of Numbats into the Safe Haven. The numbers above the dashed line are the number of individuals reintroduced.

Western Barred Bandicoot

A total of 64 Western Barred Bandicoots were translocated to Mt Gibson between 2017 and 2019. The success criteria developed for this species include survival, maintenance of bodyweight, and maintained occupancy in the short-term (1 year post-release), breeding and increased occupancy (or population size) in the mid- to long-term (2 to 5 years post-release), and a viable, healthy and genetically diverse population 5-10 years post-release (Smith et al. 2017). The health criteria relate to the incidence of BCPV1, which has been detected in the source populations.

In 2021, the reintroduction of Western Barred Bandicoots had been in progress for 4 years since first release and 2 years since final release of founders. The relevant criteria relating to this time period were the mid-term: evidence of successful recruitment and increase in area of occupancy (or population size).

Reintroduction of this species is currently meeting relevant success criteria. During trapping surveys, there were captures of Mt Gibson-bred individuals and female bandicoots with pouch young, demonstrating that the population is successfully breeding. Occupancy has declined slightly since last year, however overall it has increased since 2018 (Figure 16).

A preliminary population estimate of 116 individuals (95% CI 26 to 254) was obtained from SECR models of captures from 2020 trapping data. However, due to a reduced trapping effort during the 2021 Safe Haven Mammal Trapping Survey, there were not an adequate number of Western Barred Bandicoots to obtain an updated population estimate. Population estimates for the Western Barred Bandicoot are expected to become more robust over time as the population increases in size. Captures of Western Barred Bandicoots in 2021 included new individuals and females with pouch young, indicating there is ongoing recruitment into the population.

An assessment of the incidence of BPCV1 disease in translocated Western Barred Bandicoots is not required until 5 years post-release. However, all individuals trapped are checked for clinical signs of BPCV1. In 2021, a total of 19 bandicoots captured at Mt Gibson were evaluated. Of these, 18 were in good condition with no clinical signs of BPCV1. The remaining animal had possible symptoms of the disease (wart-like growth) - the animal was swabbed, and the sample analysed but returned a negative result. Similarly, all bandicoots swabbed in 2019 and 2020 returned negative results for BPCV1. The assessments conducted to date have found no evidence of BPCV1 in the Western Barred Bandicoot population established Mt Gibson, and therefore the translocation criteria has, so far, been met.
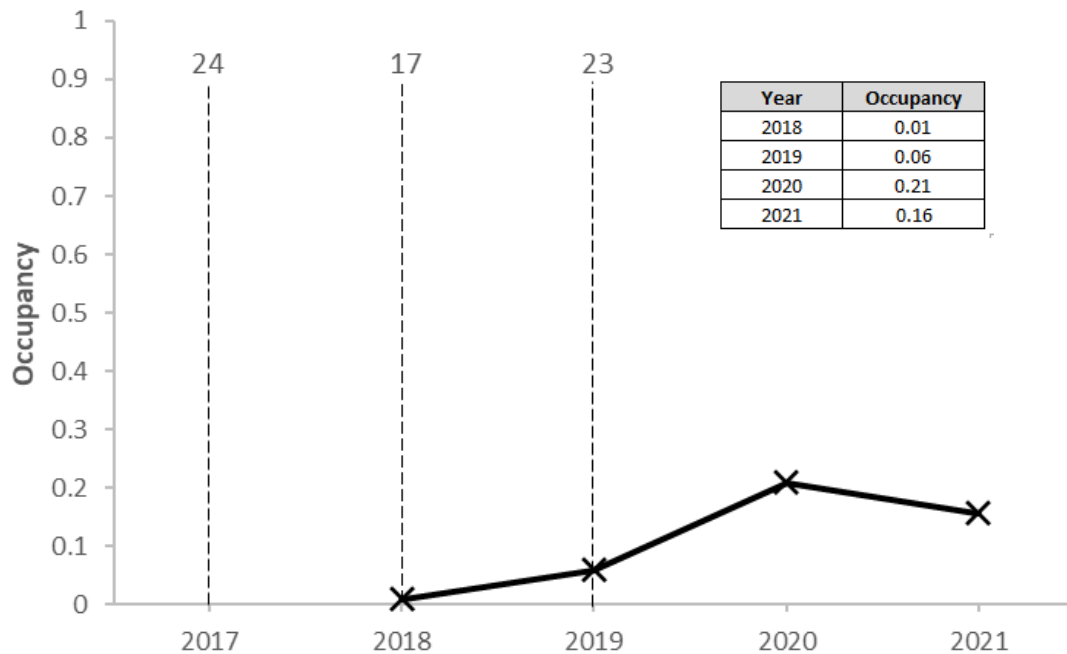
Year	Occupancy
2018	0.01
2019	0.06
2020	0.21
2021	0.16

Figure 16. Proportion of sites Western Barred Bandicoot detected in the annual Safe Haven Camera Survey, 2018-2021. The dashed lines represent reintroduction events of Western Barred Bandicoots into the Safe Haven. The numbers above the dashed line are the number of individuals reintroduced.

Greater Bilby

A total of 56 Greater Bilbies (*Macrotis lagotis*) were translocated to Mt Gibson between 2016 and 2018. The success criteria developed for this species include survival in the short-term (1 year post-release), an increase in population size in the mid-term (2 years post-release), and increase in population and ongoing breeding over the longer term (5 years post-release), with the ultimate objective of establishing a viable, genetically diverse population (Ruykys et al. 2016).

In 2021, the reintroduction of Bilbies had been in progress for 5 years since first release and 3 years since final release of founders. The relevant criteria relating to this time period were long-term: an increase in population size beyond the number of founders and evidence of ongoing successful recruitment.

There has been considerable evidence of breeding and recruitment, with captures and observations of sub-adults and females with pouch young. There has been a substantial increase in the occupancy of Bilbies since 2018 (Figure 17). These results are consistent with dispersal through the fenced area and, presumably, growth in population size, suggesting the reintroduction of this species is on track to meet the success criteria.

AWC is currently investigating methods to measure population size directly. On other AWC properties, spotlight surveys are used to estimate population size (e.g., Berry et al. 2019). On Mt Gibson, AWC commissioned the collection and analysis of scat DNA to estimate population size (Dziminski et al. 2020); whether this approach provides more robust data and/or is more cost-effective than spotlighting is yet to be determined.
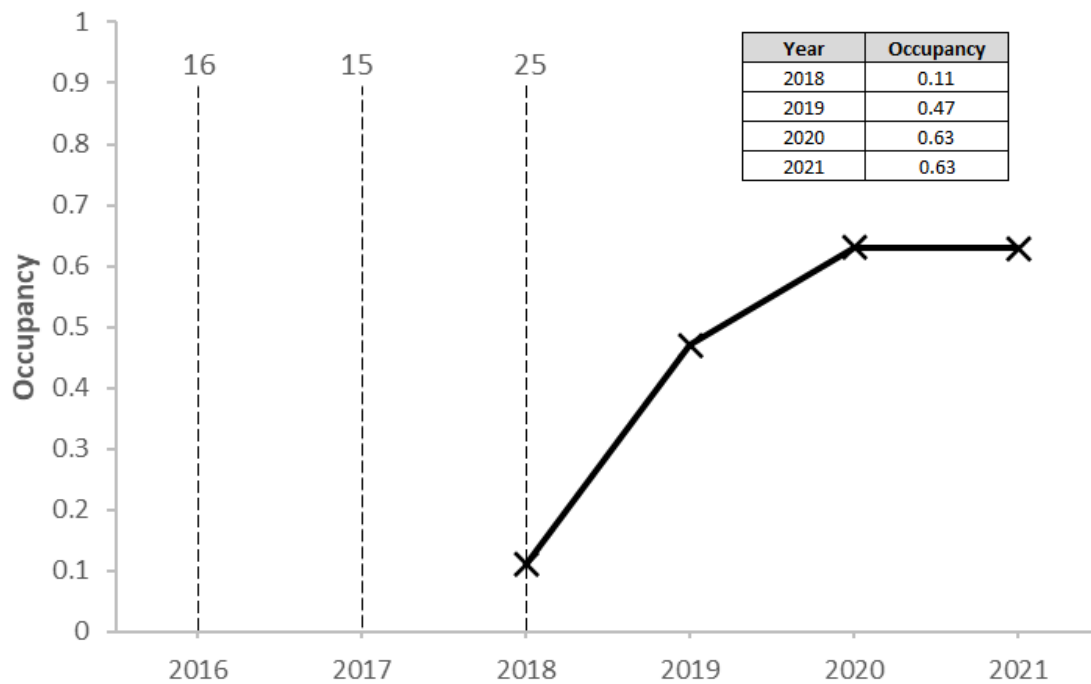
Figure 17. Proportion of sites Greater Bilby detected in the annual Safe Haven Camera Survey, 2018-2021. The dashed lines represent reintroduction events of Greater Bilbies into the Safe Haven. The numbers above the dashed line are the number of individuals reintroduced.

Woylie

A total of 162 Woylies were translocated to Mt Gibson between 2015 and 2018. The success criteria for this species were survival (3-9 months post-release), recruitment and breeding in the short-term (1-2 years post-release), a self-sustaining population >300 in the long-term (5 years post-release), with an increase in genetic diversity relative to source populations (Ruykys et al. 2015b).

In 2021, the reintroduction of Woylies had been in progress for 6 years since first release and 3 years since final release of founders. The relevant criteria relating to this time period were the long-term: a population of >300 individuals.

Woylie occupancy increased quickly since release and they are distributed throughout the safe haven. In 2021, the population estimate for Woylies at Mt Gibson was 1,873 (95% CI 1,183 to 2,664) (Figure 18), well above the threshold for longer-term success. (Note, the uncertainty bounds for the 2021 estimate are much greater due to the reduced trapping effort.)

The population was founded with individuals from four source populations, representing a genetic mix of primarily Dryandra and Perup wild genetic stock. An initial genetic assessment of the reintroduced population (N=19, 2018-2019) showed moderate levels of genetic diversity (H_O = 0.0825; H_E = 0.0849) compared to other reintroduced (range H_O: 0.070 – 0.114; H_E: 0.071 – 0.117) and remnant (range H_O: 0.095 – 0.11; H_E: 0.098 – 0.110) populations (Farquharson et al. 2021). Currently, supplementation is not necessary as estimates of inbreeding (F_{IS} = 0.0011) and relatedness (MK = 0.0631) are low (Farquharson et al. 2021). AWC will continue to collect genetic material from the population for ongoing genetic monitoring.

Based on the large population size and diverse genetics, in 2021, Mt Gibson was used as a source population for reintroductions of Woylies into fenced areas at two of AWC's sanctuaries: Newhaven Sanctuary in the Northern Territory and Mallee Cliffs Sanctuary in New South Wales. A total of 124 woylies, of even sex ratio, were translocated out of the population.
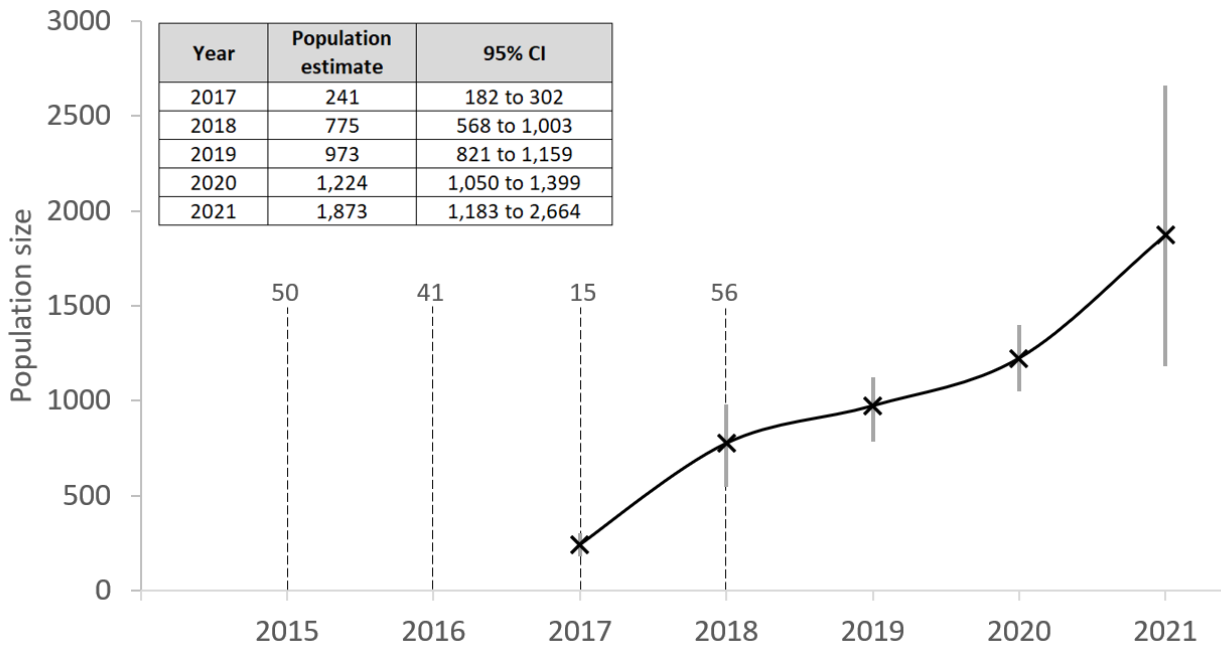
Figure 18. Population estimates of Woylies reintroduced to Mt Gibson (+/- SE). The dashed lines represent reintroduction events of Woylies into the Safe Haven. The numbers above the dashed line are the number of individuals reintroduced.

Common Brushtail Possum

A total of 40 Brushtail Possums were translocated to both inside and outside the safe haven at Mt Gibson in 2021, with planned follow-up translocations for 2022. The success criteria developed for this species include survival and maintenance in occupancy in the short-term (1 year post-release), evidence of recruitment and increasing occupancy in the mid-term (1-2 years post-release), occupancy of predicted habitat across the sanctuary, increasing population size and genetic diversity over the longer-term (5 years post-release), with an ultimate objective of establishing a viable, genetically diverse population (Jackson et al. 2020).

In 2021, the reintroduction of the Brushtail Possum has been in progress for less than 1 year since first release. The relevant criteria relating to this time period were the short-term: survival of >50% of radio-tracked individuals, and maintenance or increase in occupancy.

Short-term success criteria are on track to being met.

A subset of translocated individuals was radio-tracked post-release (n=15). There were no known mortalities of radio-collared individuals. Based on radio-tracking data (Figure 19), remote camera detections and trapping, Brushtail Possums have maintained occupancy around release sites and dispersed beyond these areas across the wider sanctuary.
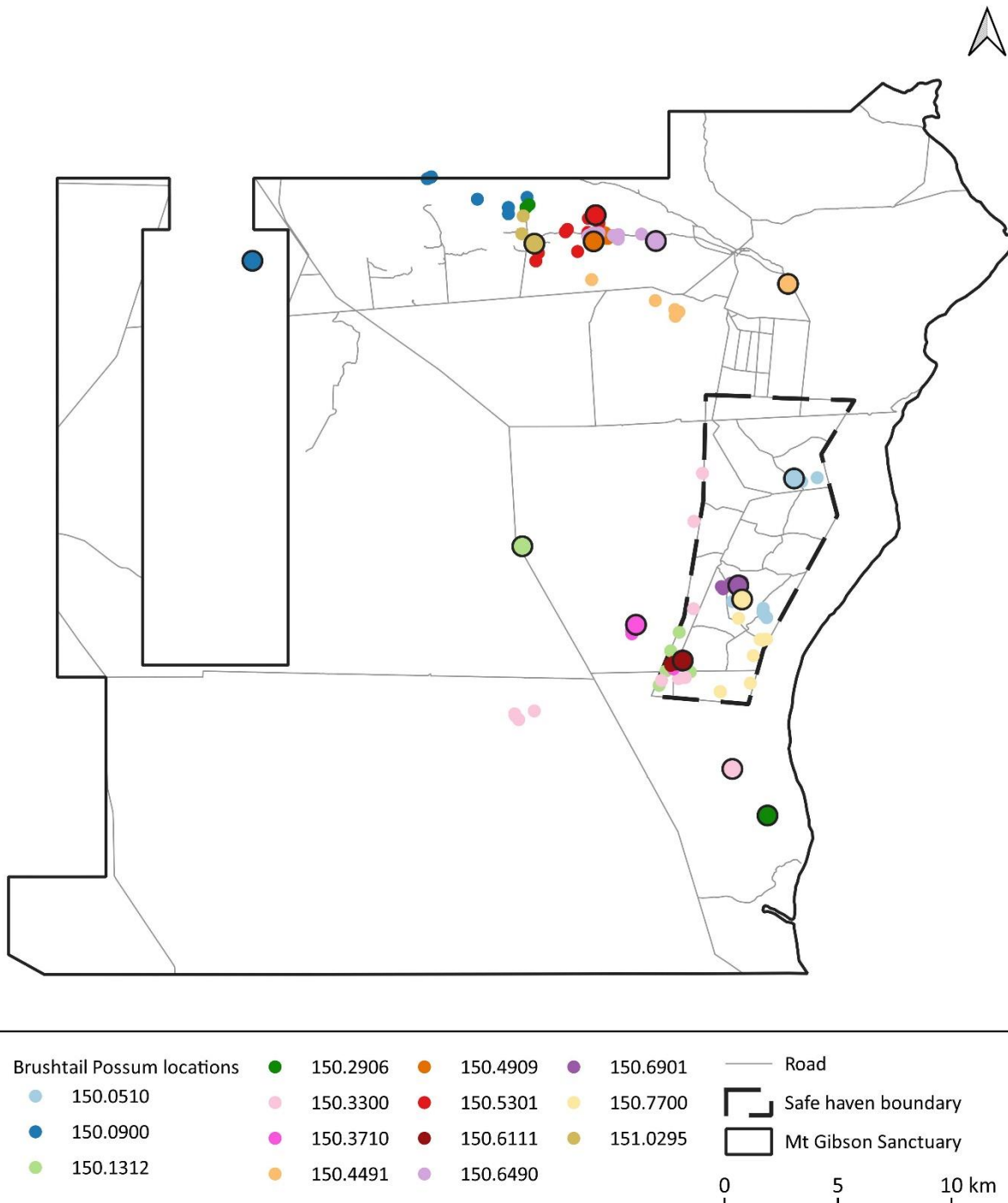
Figure 19. Movements of radio-collared Brushtail Possums at Mt Gibson up to eight month post-release. Each dot/number refers to a founder individual. Larger symbols represent the most recent tracked to source or triangulated locations, except for individual 150.4491 which represents the most recent detection from a high point as tracking to source or triangulation has not been possible.

Banded Hare-wallaby

A total of 119 Banded Hare-wallabies (*Lagostrophus fasciatus*) were translocated to Mt Gibson in 2017 and 2018. The success criteria developed for this species include survival and maintenance of bodyweight in the short-term (1 year post-release), breeding and increase in occupancy and population size in the mid-term (1-4 years post-release), and ongoing evidence of breeding, increase in population size and occupancy of suitable habitat across the safe haven, and maintained genetic representative of the founding populations in the long-term (5-10 years) , with the ultimate objective of establishing a viable, genetically diverse population (Ruykys et al. 2017b).

In 2021, the reintroduction of Banded Hare-wallabies had been in progress for 4 years since first release and 3 years since final release of founders. The relevant criteria relating to this time period were the mid-term: evidence of breeding and occupancy/population size.

Mid-term success criteria have been met. There has been evidence of breeding with observation and remote camera detections of sub-adults and females with pouch young and occupancy has gradually increased since 2018 (Figure 20). Prior to 2020, most detections of Banded Hare-wallabies were in the northern third of the fenced area; however, in 2020 and 2021, the species was detected in the southern third of the safe haven for the first time. These results are consistent with dispersal through the fenced area and, presumably, growth in population size, suggesting the reintroduction of this species is on track to meet the longer-term success criteria.

AWC is currently investigating methods to measure population size directly. In 2018, AWC participated in a research project that demonstrated that Banded Hare-wallaby scats can be collected to obtain genetic information that is suitable for obtaining population estimates via SECR analysis (Cowen et al. 2022). Whether this approach will be suitable for Mt Gibson is yet to be determined.
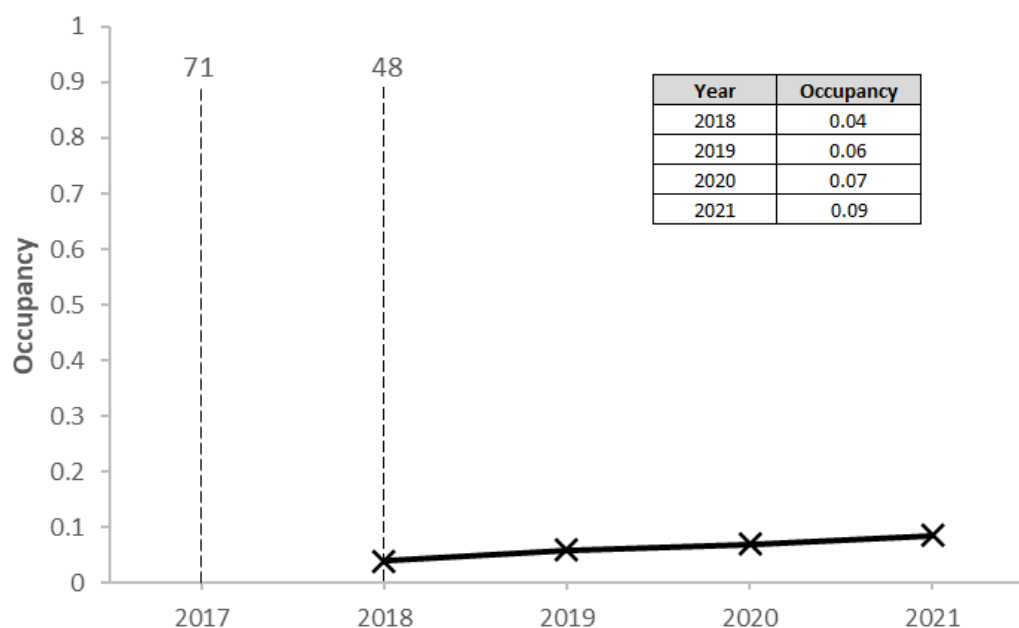

Year	Occupancy
2018	0.04
2019	0.06
2020	0.07
2021	0.09

Figure 20. Proportion of sites Banded Hare-wallaby detected in the annual Safe Haven Camera Survey, 2018-2021. The dashed lines represent reintroduction events of Banded Hare-wallabies into the Safe Haven. The numbers above the dashed line are the number of individuals reintroduced.

Greater Stick-nest Rat

A total of 95 Greater Stick-nest Rats (*Leporillus conditor*) were translocated to Mt Gibson between 2011 and 2019. The 2011 translocation was to a small breeding area, where animals were maintained until the main fenced area on Mt Gibson was completed. Animals were released from the breeding area in 2015, and the population was supplemented with translocations in 2015, and again in 2018 and 2019. The success criteria developed for the 2018 and 2019 supplementation include survival and maintenance of occupancy (1 year post-release), increase in occupancy to suitable habitat within the safe haven and maintenance of abundance at 50% of monitoring sites in the mid- to long-term (1-5 years), and genetic representative of the founding populations in the long-term (5 years), with the ultimate objective of establishing a viable, genetically diverse population (Kanowski et al. 2018b).

In 2021, the reintroduction of Greater Stick-nest Rats had been in progress for 3 years since first-release and 2 years since final release of founders. The relevant criteria relating to this time period were the mid- to long-term: increase in occupancy and maintenance of abundance.

There is insufficient evidence to determine whether Greater Stick-nest Rats are meeting success criteria in the mid- to long-term, although incidental observations indicates that Greater Stick-nest Rats are persisting in several high-quality habitat areas within the safe haven.

In 2021, Greater Stick-nest Rats were not detected at any sites during the Safe Haven Camera Survey (Figure 21). Previously, Greater Stick-nest Rats have only been detected at two of the sites in 2020. The low number of detections are likely to be an artefact of the surveys and/or the habitat requirements of Greater Stick-nest Rats, rather than a decline in occupancy. This is supported by regular opportunistic sightings of Greater Stick-nest Rats in areas where they have previously been detected, indicating maintenance of occupancy.

In 2020, targeted trapping provided a site abundance estimate for two sites (14 ha) of 18 individuals (95% CI 10 to 30; refer to Mt Gibson Ecohealth Report 2020 for details on methods). In 2021, a trial spotlighting survey was undertaken in place of trapping to determine if it would be a suitable method to obtain an abundance estimate. This trial was not successful and therefore there is no estimate for 2021. Abundance will be assessed via trapping surveys again in 2022 to enable assessment of success criteria.
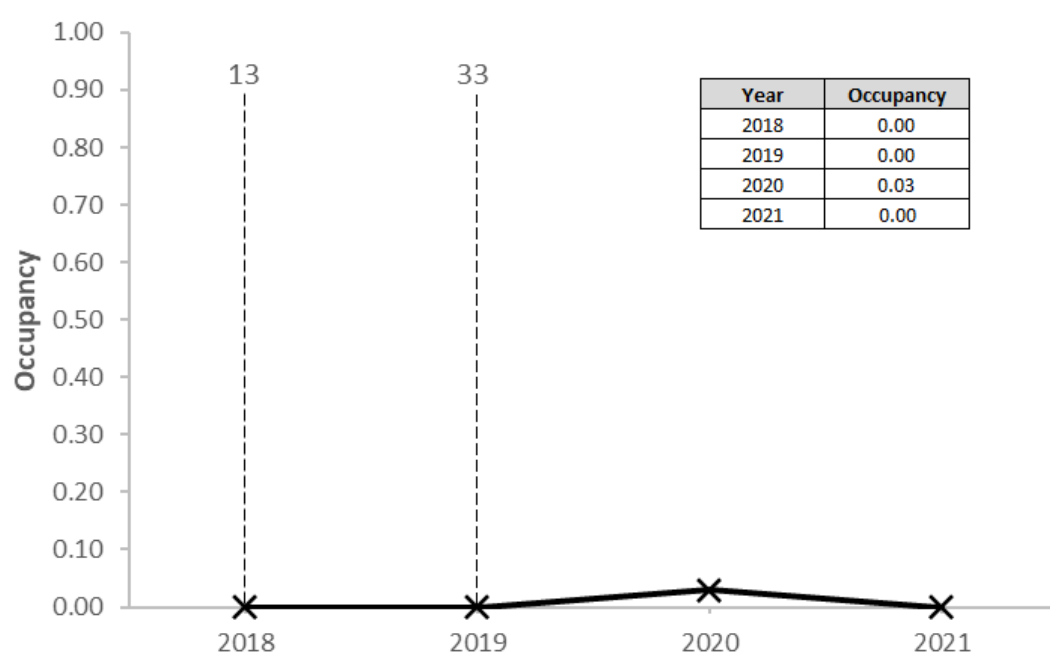

Year	Occupancy
2018	0.00
2019	0.00
2020	0.03
2021	0.00

Figure 21. Proportion of sites Greater Stick-nest Rats detected in the annual Safe Haven Camera Survey, 2018-2021. The dashed lines represent reintroduction events of Greater Stick-nest Rats into the Safe Haven. The numbers above the dashed line are the number of individuals reintroduced. Not depicted are the original reintroduction in 2011 (n=39) and supplementation in 2015 (n=10).

Shark Bay Mouse

A total of 52 Shark Bay Mice (*Pseudomys fieldi*) were translocated to Mt Gibson in 2017 and 2018; planned follow-up translocations have yet to be conducted. The success criteria developed for this species include evidence of breeding and increase in distribution in the short-term (2 years post-release), evidence of breeding and increase in population size and/or occupancy in the mid-term (2-5 years post-release), and evidence of successful recruitment, increase in population size and/or occupancy and genetic representative of the founding populations in the long-term (5 years post-release), with an ultimate objective of establishing a viable, genetically diverse population (Ruykys et al. 2017a).

To date, the success criterion for the reintroductions conducted have not been met. Other than detections obtained immediately post-translocation, there has been no subsequent evidence of Shark Bay Mice on Mt Gibson. There were no detections of Shark Bay Mice during the 2021 Standard Trapping Survey, which has been designed to target Shark Bay Mice.

Assemblages and surveillance species

Mammals
Short-beaked Echidna

The results of the cameras from the Standard Trapping Survey show that the occupancy of Short-beaked Echidnas (*Tachyglossus aculeatus*) across the sanctuary has increased slightly from 2019 to 2021 (Figure 22). This is likely to be within natural variation expected from climatic changes and/or influences of probability of detecting individuals.
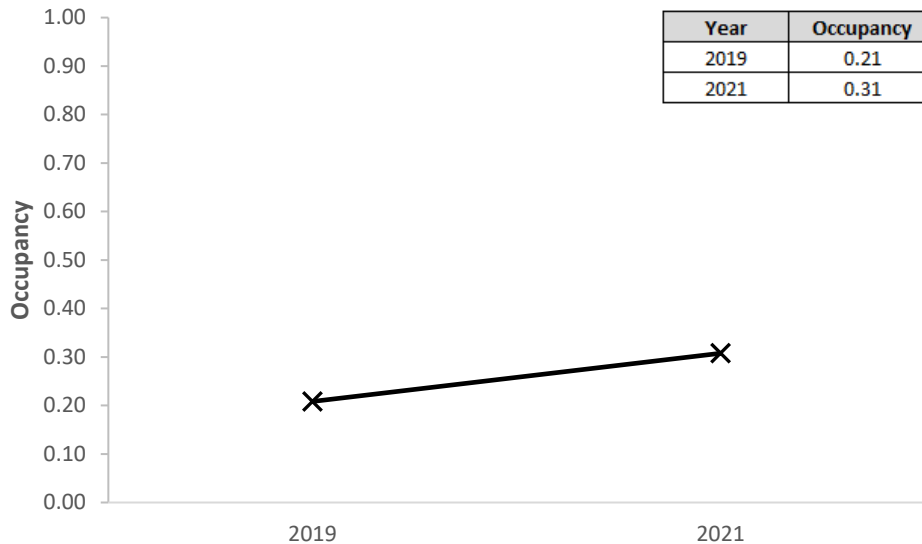
Year	Occupancy
2019	0.21
2021	0.31

Figure 22. Proportion of sites Short-beaked Echidna detected in the Standard Trapping Survey, 2019 and 2021.

Reptiles
Small Reptiles

On Mt Gibson, 58 species of small reptiles have been confirmed to be extant on the sanctuary. Of these, a total of 30 species have been detected during the Standard Trapping Survey across 2019 and 2021.

The results of live trapping from the Standard Trapping Survey show that species richness has remained stable from 2019 to 2021 (Figure 23). The 2021 survey was run slightly earlier (end of October) compared to 2019 (beginning of November), and Mt Gibson experienced cooler weather (Figure 4). It is likely that lower capture rates of reptiles in 2021 compared to 2019 were related to the cooler weather.
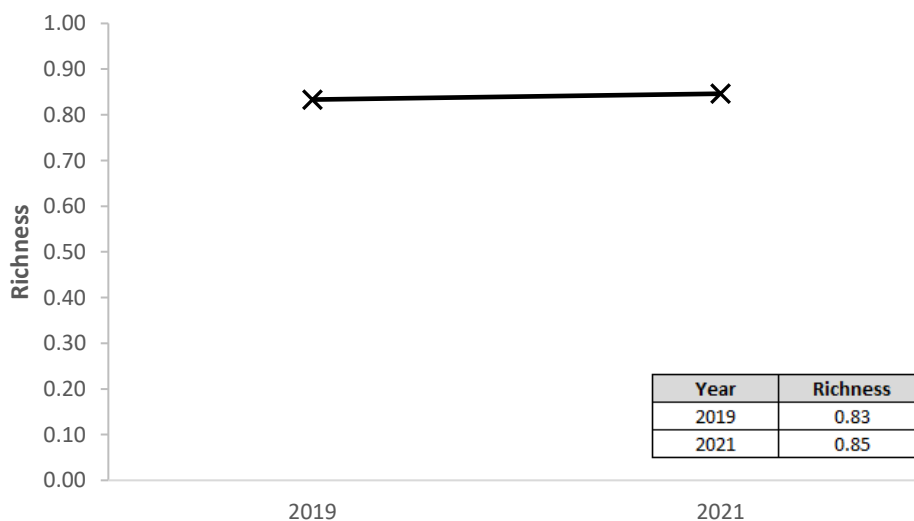
Year	Richness
2019	0.83
2021	0.85

Figure 23. Total species richness of small reptiles detected in the Standard Trapping Survey, 2019 and 2021.

Barred Wedgesnout Ctenotus

The results of live trapping from the Standard Trapping Survey shows that the occupancy of Barred Wedgesnout Ctenotus (*Ctenotus schomburgkii*) across the sanctuary has slightly increased from 2019 to 2021 (Figure 24). Cooler weather and the earlier timing of the 2021 survey is expected to decrease reptile activity. It is unknown whether the observed increase in Barred Wedgesnout Ctenotus is a reflection of a change in population. Continued monitoring will provide more robust information on long-term trends.
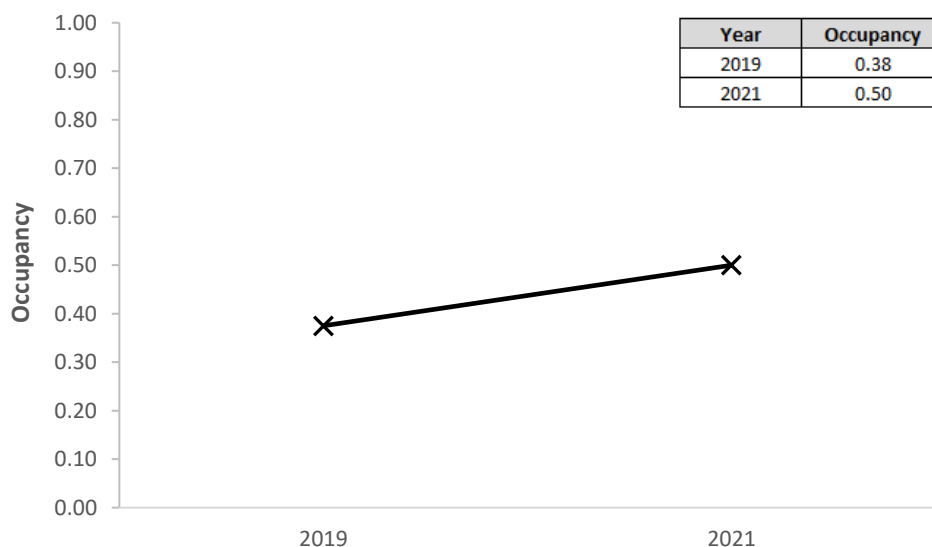

Year	Occupancy
2019	0.38
2021	0.50

Figure 24. Proportion of sites Barred Wedgesnout Ctenotus detected in the Standard Trapping Survey (Pitfall), 2019 and 2021.

Variegated Dtella

The results of live trapping from the Standard Trapping Survey shows that the occupancy of Variegated Dtella (Gehyra variegata) across the sanctuary declined substantially from 2019 to 2021 (Figure 25). This decline is likely an artefact of the cooler weather reducing Variegated Dtella activity, rather than a change in the population on Mt Gibson. Continued monitoring will provide more robust information on long-term trends.
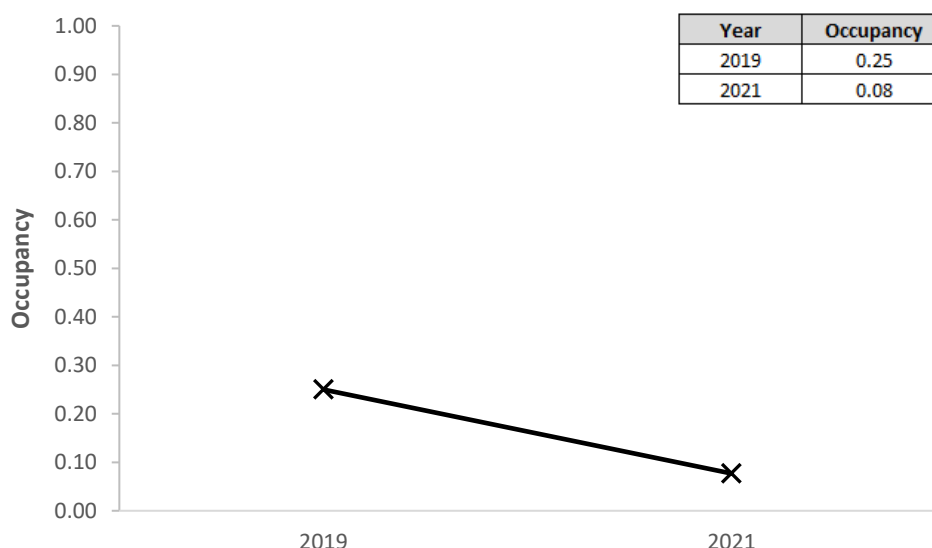

Year	Occupancy
2019	0.25
2021	0.08

Figure 25. Proportion of sites Variegated Dtella detected in the Standard Trapping Survey (Pitfall), 2019 and 2021.

King's Slider

The results of the Standard Trapping Survey (Pitfall) shows that the occupancy of King's Slider (*Lerista kingi*) across the sanctuary slightly increased from 2019 to 2021 (Figure 26).
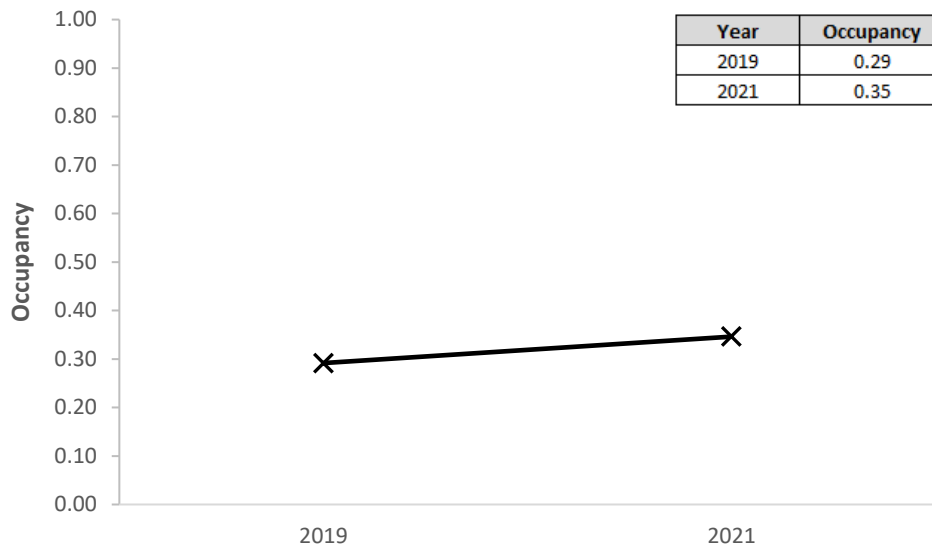
Year	Occupancy
2019	0.29
2021	0.35

Figure 26. Proportion of sites King's Slider detected in the Standard Trapping Survey (Pitfall), 2019 and 2021.

Common Dwarf Skink

The results of the Standard Trapping Survey (Pitfall) shows that the occupancy of Common Dwarf Skink (*Menetia greyii*) across the sanctuary remained stable from 2019 to 2021 (Figure 27).
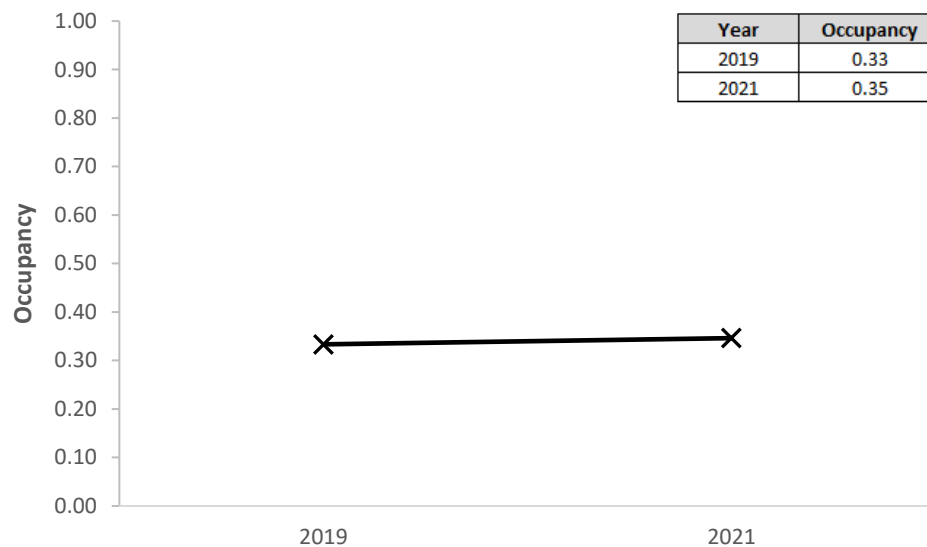
Year	Occupancy
2019	0.33
2021	0.35

Figure 27. Proportion of sites Common Dwarf Skink detected in the Standard Trapping Survey (Pitfall), 2019 and 2021.

Woodland Morethia Skink

The results of the Standard Trapping Survey (Pitfall) shows that the occupancy of Woodland Morethia Skink (*Morethia butleri*) across the sanctuary increased from 2019 to 2021 (Figure 28).
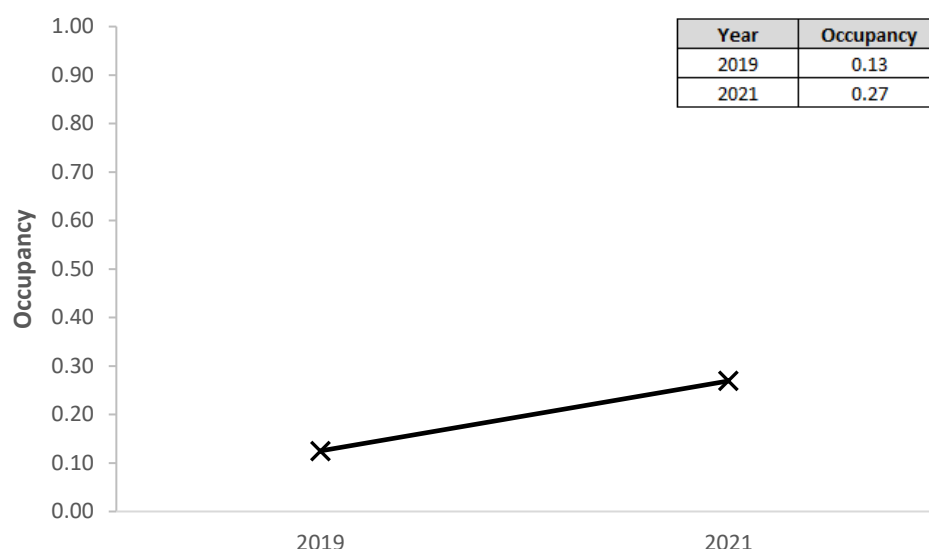
Year	Occupancy
2019	0.13
2021	0.27

Figure 28. Proportion of sites Woodland Morethia Skink detected in the Standard Trapping Survey (Pitfall), 2019 and 2021.

Gould's Goanna

The results of the Standard Trapping Survey (Camera) shows that the occupancy of Gould's Goanna (*Varanus gouldii*) across the sanctuary decreased from 2019 to 2021 (Figure 29). This decline is likely an artefact of the cooler weather and early timing reducing Gould's Goanna activity, rather than a change in the population on Mt Gibson. Continued monitoring will provide more robust information on long-term trends.
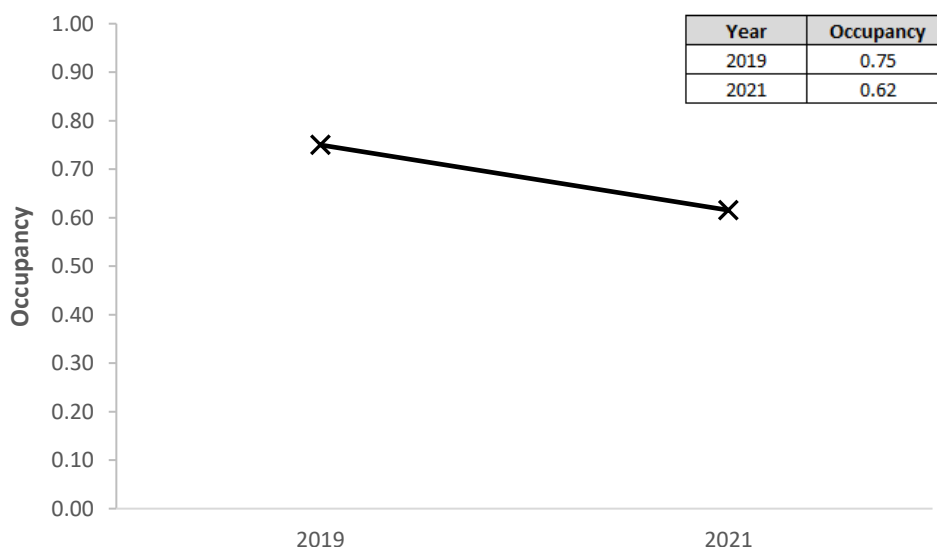

Year	Occupancy
2019	0.75
2021	0.62

Figure 29. Proportion of sites Gould's Goanna detected in the Standard Trapping Survey (Camera), 2019 and 2021.

Threat indicators

Feral animals

Rabbit

The results of the Safe Haven Camera Survey shows that the occupancy of rabbits across the fenced area decreased from 2020 to 2021, following a steady increase from 2018 (Figure 30). Continued monitoring in conjunction with ongoing control will indicate whether this is a signal of changes in the population of rabbits within the fenced area at Mt Gibson, or whether it is a natural oscillation.
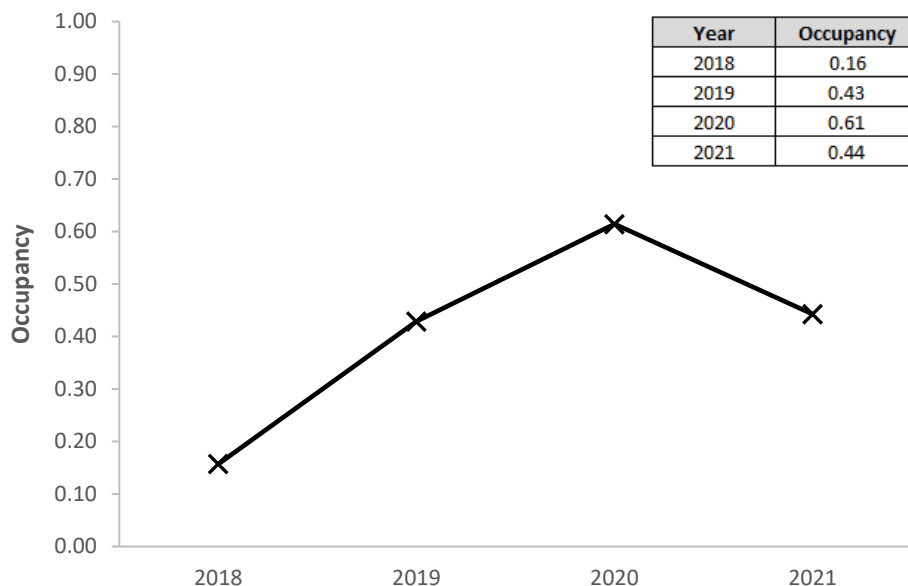
Year	Occupancy
2018	0.16
2019	0.43
2020	0.61
2021	0.44

Figure 30. Proportion of sites rabbits detected in the annual Safe Haven Camera Survey, 2018-2021.

Fire

In 2021, the area burnt during the asset protection burns undertaken at Mt Gibson in 2021 was 3.32 ha. No unplanned fires occurred in 2021.

Discussion

The results of this monitoring program show that seven of the nine species of mammals reintroduced to Mt Gibson are meeting success criteria relevant to the stages of translocation: the 2 species that are not meeting the success criteria were the Greater Stick-nest Rats and the Shark Bay Mouse. Greater Stick-nest Rats are known to be persisting, but monitoring methods need to be improved to provide sufficient evidence that they are meeting success criteria. The remaining species, Shark Bay Mouse, has not been detected for several years.

The seven reintroduced mammals that are meeting the success criteria demonstrate the effectiveness of the fenced area on Mt Gibson in protecting threatened species from feral predators and large herbivores. Red-tailed Phascogales, Numbats and Banded Hare-wallabies were detected at a higher number of sites in 2021 than previous years and Greater Bilbies and Western Barred Bandicoots continued to be detected across the safe haven The Woylie population continued to increase and, in 2021, the population was harvested for reintroductions to other AWC sites. The Common Brushtail Possum was the first species to be reintroduced both inside and outside of the safe haven, and early results show that the species is establishing across the wider sanctuary.

In 2021, the second Standard Trapping Survey was undertaken. The data from the 2019 and 2021 surveys were used to select Mt Gibson's indicator species. Continued monitoring, with expansion to include the remaining 30 sites that are in the process of being established, will provide more robust information on long-term trends of these species and allow comparison of biodiversity indicators inside versus outside the fenced area.

In 2021, rabbit occupancy within the fenced area declined for the first time since 2018. Continued monitoring in conjunction with ongoing control will indicate whether this is a signal of changes in the population of rabbits within the fenced area at Mt Gibson.

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References

Baynes A (2002) *Final report on the original mammal fauna of Mt Gibson Station*. Australian Wildlife Conservancy, Perth, WA.

Berry LE, L'Hotellier FA, Carter A, Kemp L, Kavanagh RP, Roshier DA (2019) Patterns of habitat use by three threatened mammals 10 years after reintroduction into a fenced reserve free of introduced predators. *Biological Conservation* 230, 1-9.

Berry L, Holland G, Anson J, Pierson J, Kanowski J (2021) *Bridled Nailtail Wallaby: Population Management Plan, Scotia Wildlife Sanctuary*. Australian Wildlife Conservancy, Perth, WA.

Bureau of Meteorology (BoM) (2021) Climate Data Online. http://www.bom.gov.au/climate/data/

Cowen S, Smith M, McArthur S, Rayner K, Jackson C, Anderson G, Ottewell K (2022) Novel microsatellites and investigation of faecal DNA as a non-invasive population monitoring tool for the banded hare-wallaby (*Lagostrophus fasciatus*). *Australian Journal of Zoology*, DOI: 10.1071/ZO21015

Dziminski M, Carpenter F, Morris F (2020) Monitoring the abundance of wild and reintroduced bilby populations. *The Journal of Wildlife Management* 85, 240-253.

Efford MG, Fewster RM (2013) Estimating population size by spatially explicit capture–recapture. *Oikos* 122, 918–928.

Farquharson KA, McLennan EA, Wayne A, Smit M, Peel E, Belov K, Hogg CJ (2021) Metapopulation management of a critically endangered marsupial in the age of genomics. *Global Ecology and Conservation*, 31, e01869.

Gopalaswamy AM, Royle AJ, Hines JamesE, Singh P, Jathanna D, Kumar NS, Karanth KU (2012) Program SPACECAP: software for estimating animal density using spatially explicit capture-recapture models. *Methods in Ecology and Evolution* 3, 1067–1072.

Jackson C, Smith M, Kanowski J (2020) *Reintroduction of the Brushtail Possum (Trichosurus vulpecula) to Mt Gibson Wildlife Sanctuary, WA*. Australian Wildlife Conservancy, Perth, WA.

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

Kanowski J, Smith M, Ruykys L (2018b) *Supplementation of a population of Greater Stick-nest Rats (Leporillus conditor) from a population on St Peter Island, South Australia*. Australian Wildlife Conservancy, Perth, WA.

QGIS Development Team (2018) QGIS Geographic Information System. Open Source Geospatial Foundation Project. QGIS Development Team.

R Core Team (2013) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Ruykys L, Groom C, Smith M, Kanowski J (2017a) *Translocation of Shark Bay Mice (Pseudomys fieldi) from Bernier, Faure and North West Islands to Mt Gibson Wildlife Sanctuary*. Australian Wildlife Conservancy, Perth, WA.

Ruykys L, Smith M, Kanowski J (2016) *Translocation of the Greater Bilby (Macrotis lagotis) from national captive facilities,Scotia and Yookamurra Wildlife Sanctuaries to Mt Gibson Wildlife Sanctuary, WA*. Australian Wildlife Conservancy, Perth, WA.

Ruykys L, Smith M, Kanowski J (2017b) *Translocation of Banded Hare-wallabies (Lagostrophus fasciatus) to Mt Gibson Sanctuary and Faure Island, WA*. Australian Wildlife Conservancy, Perth, WA.

Ruykys L, Smith M, Kanowski J (2017c) *Translocation of Red-tailed Phascogale (Phascogale calura Gould, 1844) from Wheatbelt remnants and reserves to Mt Gibson Wildlife Sanctuary*. Australian Wildlife Conservancy, Perth, WA.

Ruykys L, Smith M, Kanowski J (2015a) *Translocation of Numbats (Myrmecobius fasciatus) to Mt Gibson Sanctuary from Perth Zoo; Scotia Sanctuary, NSW; and Yookamurra Sanctuary, SA*. Australian Wildlife Conservancy, Perth. WA.

Ruykys L, Smith M, Kanowski J (2015b) *Translocation of Woylies (Bettongia penicillata) to Mt Gibson and Karakamia Wildlife Sanctuaries, Western Australia. Australian Wildlife Conservancy*, Perth, WA.

Smith M, Ruykys L, Groom C, Kanowski J (2017) *Translocation of Western Barred Bandicoots (Perameles bougainville bougainville) from Bernier, Dorre and Faure Islands, Shark Bay, to Mt Gibson Wildlife Sanctuary, and supplementation of the reintroduced population at Faure Island with individuals from Bernier and Dorre Islands*. Australian Wildlife Conservancy, Perth, WA.