Newhaven Wildlife Sanctuary

Ecohealth Report 2021

australian wildlife conservancy

Summary

Australian Wildlife Conservancy (AWC) has implemented an Ecological Health Monitoring Program (Ecohealth) across Newhaven Wildlife Sanctuary (Newhaven), to measure the changes in the status and trend of conservation assets, and threats to those assets. Metrics from the program are reported in annual Ecohealth Reports and Scorecards. This is the Ecohealth Report for 2021. Values of metrics derived in this report were based on data collected during surveys carried out between 2007-2021. The complete set of metrics and their values are summarised in the accompanying Ecohealth Scorecard.

In implementing the Ecohealth program in 2021, AWC conducted 1,234 live trap nights, 509 nest box checks, 43,435 camera trap nights, 96 scat plots, 64 warrens surveys and radio-tracked 36 individual animals. These surveys detected three reintroduced mammals, one extant mammal and one introduced herbivore.

In implementing the Ecohealth program in 2021, AWC monitored populations of three locally-extinct mammals reintroduced to Newhaven: Mala (*Lagorchestes hirsutus*), Red-tailed Phascogales (*Phascogale calura*) and Brush-tailed Bettongs *(Bettongia penicillata*).

Prior to 2021 Newhaven had experienced three years of drought conditions. As a result of the La Niña climate cycle there was above average rainfall in 2021. Generally, wildlife species in semi-arid Australia are at their highest levels of abundance during these 'boom' conditions.

Reintroductions of the two species of locally-extinct mammals; Red-tailed Phascogale and Brush-tailed Bettong, into the fenced introduced predator-free area on Newhaven in 2021 have met the majority of success criteria to date. Red-tailed Phascogales were reintroduced to Newhaven in 2020 and are currently in the establishment phase. The majority of success criteria have been met in this phase, with occupancy continually detected around the release site and individuals captured maintaining body weights within 20% of the release weight. Red-tailed phascogales are notoriously difficult to capture, and are using nest boxes less than expected, however, this metric may not indicate concern given the availability of alternate shelter sites in the area. The continued detection on cameras is a positive sign.

Brush-tailed Bettongs were reintroduced to Newhaven in 2021 and are currently in the establishment phase. Thus far, Brush-tailed Bettongs have met the initial success criteria in this phase. Results from radio-tracking show that at 5 months post-release for cohort 1, and 3 months post-release for cohort 2, 77% of the Brush-tailed Bettongs were known to be alive, markedly higher than our minimum target of 50%. Generally, weights have remained stable with slight variation between cohorts released.

Mala were reintroduced to Newhaven between 2017 and 2020. During a health check of the Mala population conducted in August 2021, 18 individuals were caught. Over 80% the females were carrying pouch young, adult average weights and body condition have continued to improve from the height of the dry period in March 2020 to the highest levels since release.

The Black-footed Rock Wallaby (*Petrogale lateralis*) survey was undertaken in a modified form to collect scat samples for a pilot study on faecal DNA analysis, with survey results not comparable to previous years. A total of 70 samples were collected across two ranges (one inside and one outside the fence) from 97 sites that were surveyed and will be included as part of a larger research project that is ongoing. Data from 2015-2020 suggests there was a substantial decline in activity of Black-footed Rock-wallabies on Newhaven. The activity of adult rock-wallabies in the Wartikinpirri population (now within the fenced area) has increased since the fence was constructed in 2018.

The Great Desert Skink Survey was not carried out in 2021. The results from 2015-2020 show a generally increasing trend in the mean number of active Great Desert Skink (*Liopholis kintorei*) burrows at monitored sites.

Threat management at Newhaven focuses on fire, weeds and feral animal control. In 2021, densities of rabbits outside the fenced area had increased, presumably because of the increased rainfall. Prescribed burning was undertaken in accordance with the Newhaven burn plan and only one small wildfire outside the fenced area was detected on Newhaven in 2021. A number of fire-related metrics relating to the implementation of a conservation-oriented fire regime are on target.

Contents

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Introduction

Australian Wildlife Conservancy (AWC) currently owns, manages, or works in partnerships across 31 properties in Australia, covering almost 6.5 million hectares, to implement our mission: *the effective conservation of Australian wildlife and their habitats*. AWC relies on information provided by an integrated program of monitoring and research to measure progress in meeting its mission and to improve conservation outcomes.

AWC's Ecohealth Monitoring Program has been designed to measure and report on the status and trends of species, ecological processes and threats on each of these properties (Kanowski et al. 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 one of a series of annual Ecohealth Reports for Newhaven Wildlife Sanctuary (referred to here as Newhaven). The companion Ecohealth Scorecard presents the indicators and their metrics in a summary format.

Newhaven Wildlife Sanctuary

Newhaven (261,501 ha) is located in the south-western corner of the Northern Territory (Figure 1), near the intersection of three central Australian bioregions (Great Sandy Desert, Burt Plain and the MacDonnell Ranges Bioregions). It is surrounded by Yunkanjini Aboriginal Land Trust (ALT) to the north and west, Haasts Bluff ALT to the south and the Ngalurrtju ALT to the east.

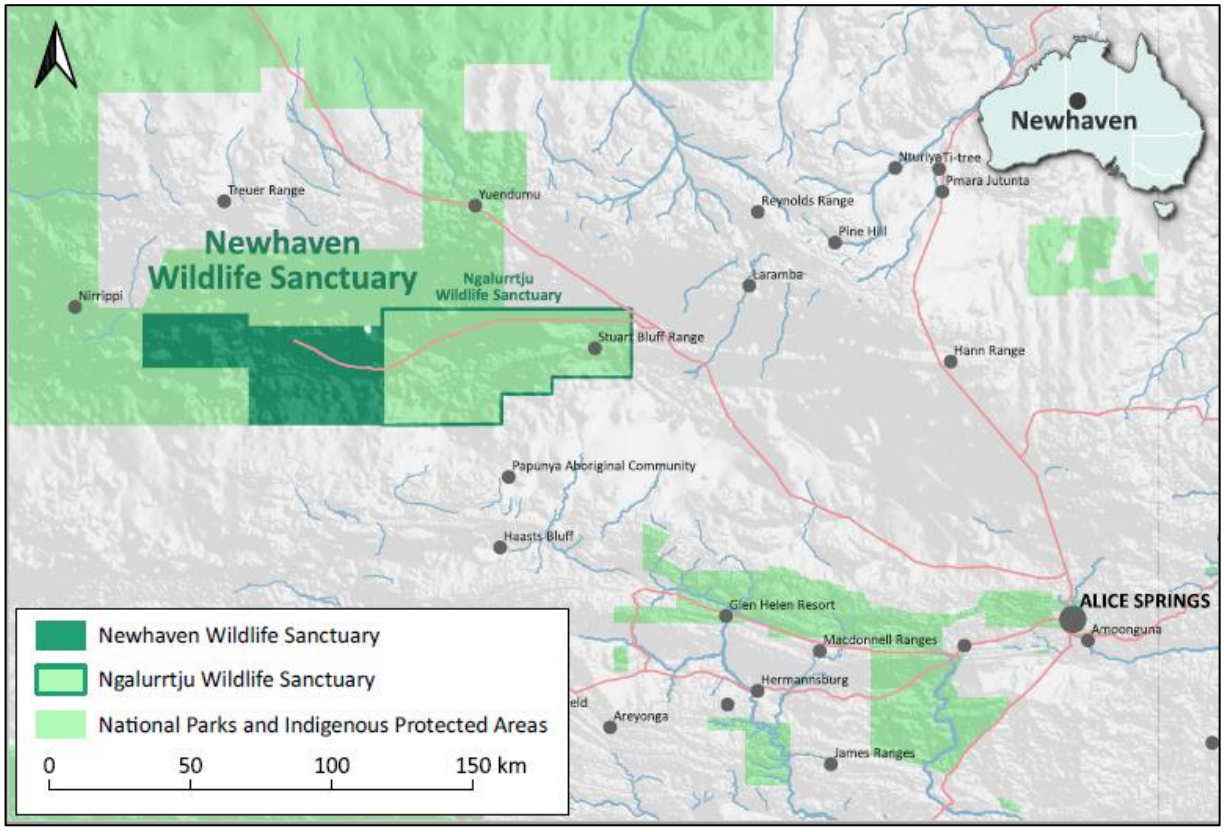

Figure 1. Location and regional context of Newhaven

The ranges, salt lakes, woodlands and sand plains of Newhaven are the traditional lands of the Ngalia-Warlpiri and Luritja people. Traditional Aboriginal land management was practiced up until the 1950s when people moved to newly established government settlements and cattle stations in the area. However, many Aboriginal people still maintain strong cultural links to the area. The communities of Nyirripi, Yuendumu, Karrinyarra, Papunya, Mt Liebig and Walungurru (Kintore) and the land trusts on which they sit, surround Newhaven. People with traditional ties to Newhaven live in all of these communities.

Newhaven was managed as a pastoral station from 1961 to 2000. The property was stocked (at relatively low numbers) with cattle, horses, donkeys and sheep.

BirdLife Australia (then Birds Australia) purchased Newhaven in 2000. The property was destocked in 2003.

In 2006, AWC acquired Newhaven and began to implement fire management, feral animal management and weed control on the property. In 2010, the Ngalia-Warlpiri were formally recognised as the Traditional Owners of Newhaven. Traditional Owner and ranger groups are actively involved in delivery of land management and science programs on Newhaven including fire management, feral animal control and biological surveys.

Newhaven contributes to the protection of the ecosystems of the Great Sandy Desert Bioregion. This bioregion is well represented within the National Reserves System, with >30% protected (Australian Government, Dept. of Environment and Energy 2016). Newhaven Sanctuary protects 67% of the Newhaven Lakes region, listed as a site of national significance for biodiversity conservation by the NT government.

Over 296 species of native vertebrates are currently known or considered likely to occur on Newhaven. These include 31 mammals, 175 birds, 84 reptiles and 6 frogs. Seven of these species are listed as threatened by the Commonwealth (Environment Protection and Biodiversity Conservation Act 1999) or Northern Territory (Territory Parks and Wildlife Conservation Act 2000). At least 19 mammal species have been lost from Newhaven: of which eight are globally extinct.

In early 2019, Newhaven's 9,450 ha introduced predator-free exclosure was completed (Figure 2) and declared free of introduced cats, foxes, camels and rabbits. At least 10 locally extinct mammal species are planned to be reintroduced to Newhaven. Mala (*Lagorchestes hirsutus*) were reintroduced into the fenced area during 2019 and 2020, Red-tailed Phascogales (*Phascogale calura*) in 2020 and 2021, and Brush-tailed

Bettongs (*Bettongia penicillata*) in 2021 (Table 1). This exclosure is also expected to benefit extant fauna such as the Black-footed Rock-wallaby (*Petrogale lateralis*) and Great Desert Skink (*Liopholis kintorei*) that are threatened by introduced predators (cats, *Felis catus*; and foxes, *Vulpes vulpes)*.

Table 1. Source of mammal reintroductions at Newhaven

Species	Founders
Red-tailed Phascogale	115 total: all from Alice Springs Desert Park with original founders sourced from 5 wild sites in WA. 29 adults in June 2020, 61 sub-adults in Nov 2020, 25 adults in April 2021
Brush-tailed Bettong	70 total: all from Mt Gibson (44 in August 2021; 26 in October 2021)
Mala	114 total: 29 from Watarrka NP in 2017, 34 from Scotia in 2018, 9 from Alice Springs Desert Park in 2019, 42 from Scotia in 2020

The vegetation of Newhaven was mapped by Latz et al. (2003), with additional detailed work focused on the central part of Newhaven (Schubert and Latz 2015), where the introduced predator-free area was established. Over 600 plant species have been recorded on Newhaven, including nine species listed as 'near threatened' in the NT. A total of 23 vegetation types have been identified on the property; these have been categorised into seven broad vegetation communities, in addition to salt lakes (Figure 2). Spinifex-dominated vegetation communities are widespread on Newhaven. Three vegetation communities cover two-thirds of Newhaven: Hard Spinifex Sandplains, which occupy 33% of the total area, predominantly in the western and northern part of the sanctuary; Spinifex Dunefields, occupying 19% of the sanctuary, mainly in the south; and Semi-saline Spinifex Sandplains, occupying 14% of Newhaven, in the east. Calcrete Grasslands, which occupy 16% of the sanctuary, in the south-east, are the only extensive vegetation type not dominated by Spinifex (Figure 2).

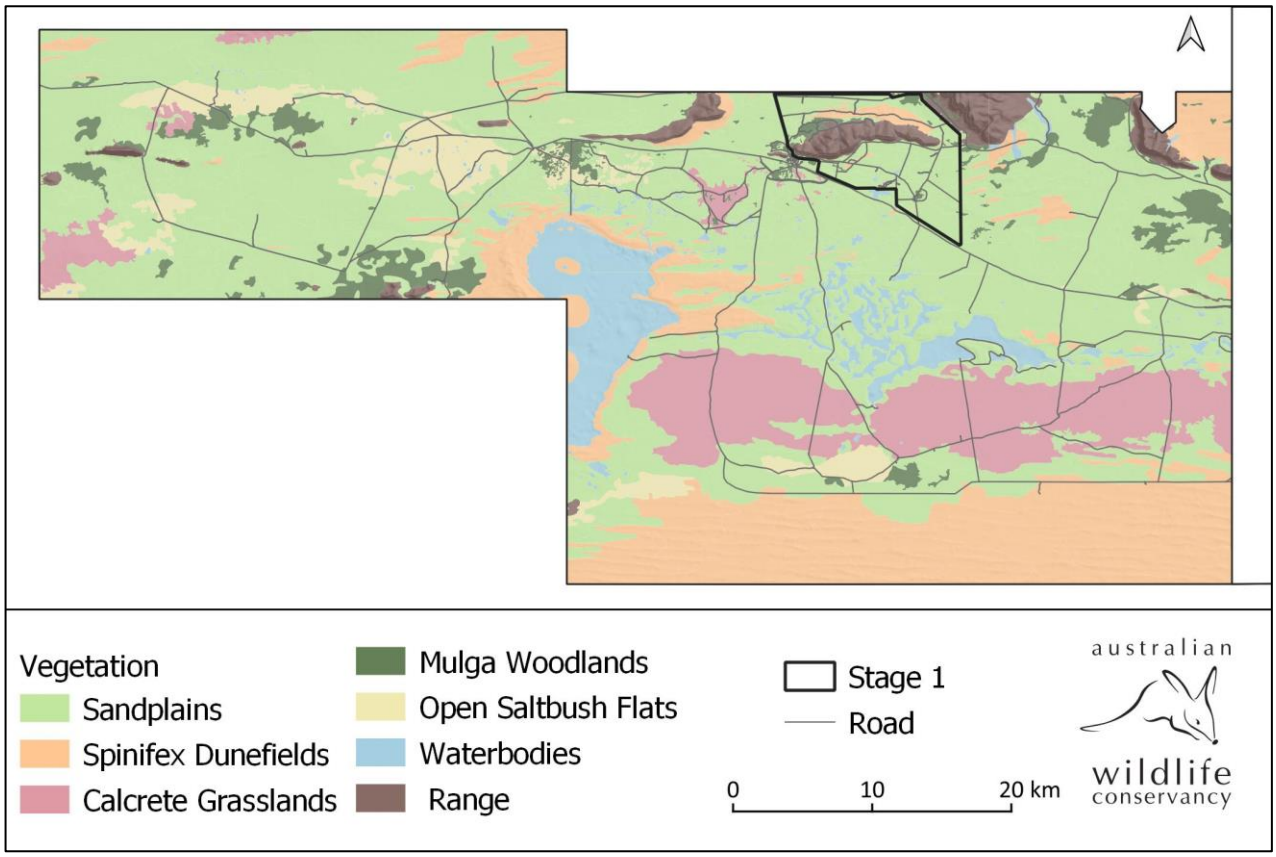

Figure 2. Extent and distribution of broad vegetation types of Newhaven. The solid black lines show the fenced area.

Climate and weather summary

The climate at Newhaven is arid tropical (Thackway and Cresswell 1995) with hot summers and cool to cold winters. Temperature is recorded at the closest weather station at Yuendumu (75 km to the northwest; station ID 015611). The January mean maximum and minimum temperatures are 36.5°C and 22.5 °C (1965 to 2019). The July mean maximum and minimum temperatures are 22.2 °C and 6.4 °C (BOM 2021a) (Figure 3). Mean annual rainfall, based on records collected at Newhaven homestead from 1962 until present, is 328 mm (BOM 2021b) (Figure 4). However, variation in rainfall between years is very high, with long periods of drought interrupted by flooding rains. Rain events may occur at any time but are most common between November and March (Latz et al. 2003) (Figure 5).

The years 2018-20 saw minimal rainfall at Newhaven with a record low of 42 mm recorded in 2019 followed by 183 mm in 2020 (BOM 2021b) (Figure 4). In 2021 Newhaven experienced above average rainfall of 458 mm recorded (BOM 2021b) (Figure 4).

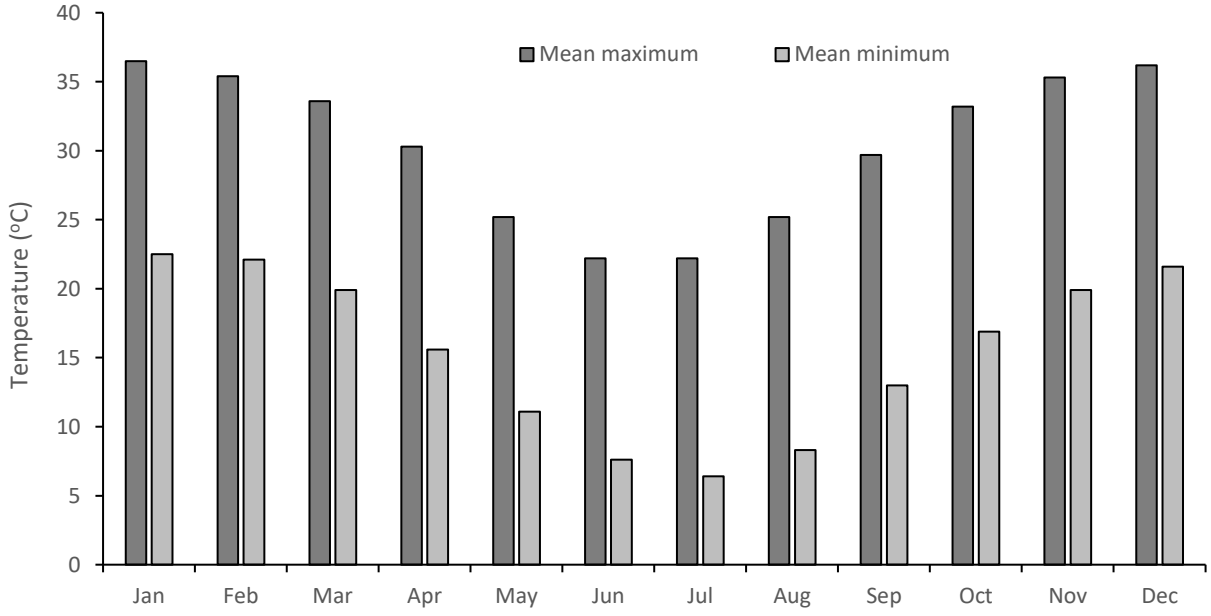

Figure 3. Mean maximum and minimum monthly temperatures at Yuendumu (station ID 015528) from 1965 to 2019.

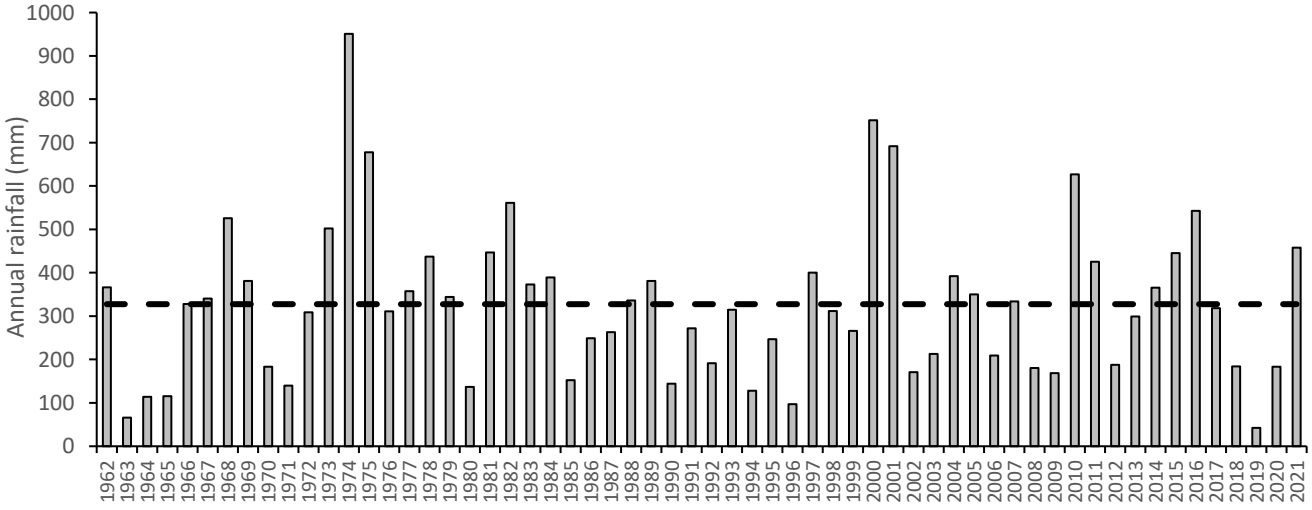

Figure 4. Annual rainfall recorded at Newhaven homestead (station ID 015611) from 1962 to 2021. The dashed horizontal line is the mean rainfall.

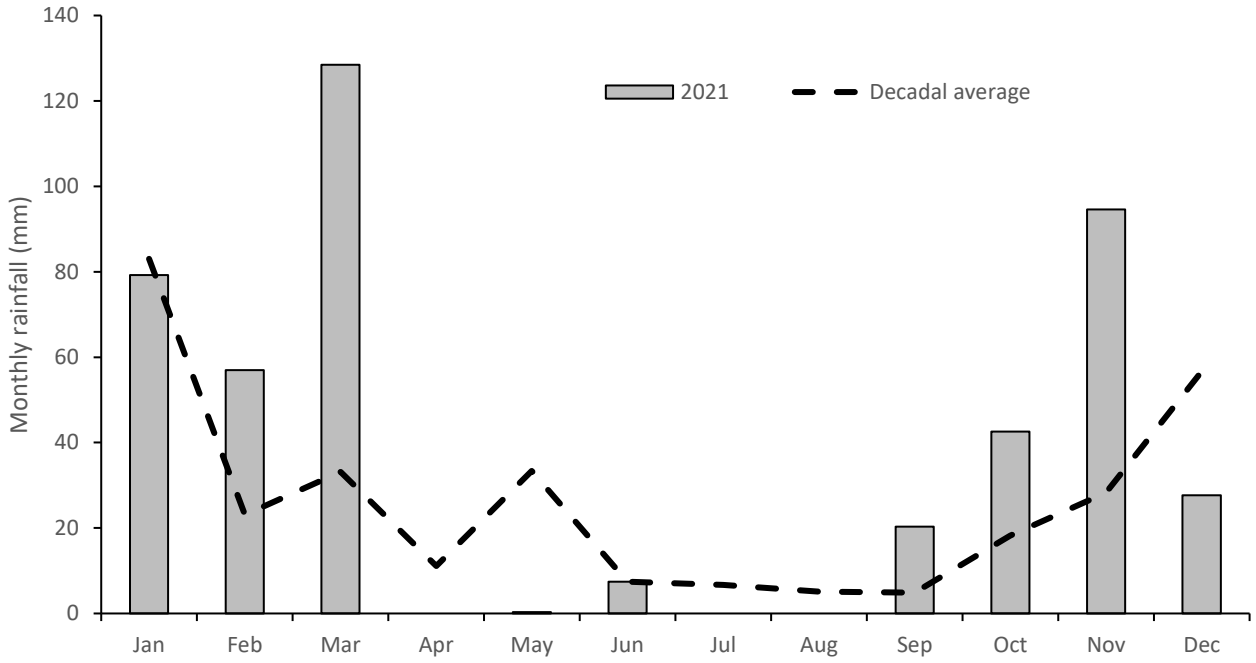

Figure 5. Monthly rainfall at Newhaven in 2021. Dashed line is the decadal average.

Methods

Monitoring and evaluation framework

Newhaven'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). The monitoring program aims to address questions relevant to the conservation of assemblages.

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

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

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

Indicators and metrics

On Newhaven, 35 biodiversity indicators (species and guilds) have been selected for monitoring (Table 2). Nine of these indicators are reported on in this 2021 Ecohealth report, most related to threatened and iconic species. There was no surveillance monitoring of fauna in 2021.

Threat metrics are selected to monitor the status and trends of introduced weeds, predators and herbivores, and fire regimes. Six threat indicators have been selected for monitoring (Table 3). Two of these threat metrics were reported on in 2021.

Table 2. Biodiversity indicators and metrics for Newhaven.
Reintroduced vertebrates

Indicator	Survey name/ methods	Metric	Performance criteria
Red-tailed Phascogale (RTP) (*Phascogale calura*)	Red-tailed Phascogale Survival/ Telemetry Red-tailed Phascogale Survey/ Nest boxes, Camera traps Red-tailed Phascogale Health Check/ Elliot traps	Survival	- Survival of founders through >50% radio-tracked RTP known to still be alive at 1 month post-release. - Detection of RTP at >50% of the nest boxes 2 weeks post release. - Adults present at 6 month and 12 month checks
		Occupancy	- Evidence of establishment through detection at nest boxes and camera traps at 6 mths and 12 mths post-release.
		Genetic diversity	- Founding genetic diversity retained 10 years post breeding season from final release cohort
Brush-tailed Bettong (*Bettongia penicillata*)	Brush-tailed Bettong Survival/ Telemetry Brush-tailed Bettong Health Check/ Cage traps	Survival	- Survival of founders through >50% radio-tracked Brush-tailed Bettongs known to still be alive at 6 months post-release.
		Condition	- Condition of founders through individual body weight maintained or increased (within 20% of release weight)
		Reproduction	- Effective breeding by at least 50% females at 2 years post-release and maintained for 4 years
		Recruitment	- Presence of new bettongs in population.
		Population estimate	- Population self-sustaining and increasing (relative to environmental conditions). AWC expects a population increase of at least 30% from the founding population size 3 years after release.
		Genetic diversity	- Increased or maintained [nominally within 90% of that in founding populations].

Indicator	Survey name/ methods	Metric	Performance criteria
			- No evidence of inbreeding or outbreeding depression.
Mala (*Lagorchestes hirsutus*)	Mala Health Check/ Thomas traps	Survival	- >50% at 3 months following release to the new fenced area*
		Reproduction	- Evidence of breeding and recruitment, with >50% of females with dependent young
		Recruitment	- >20% of the population as F1 (i.e. non-founders) within 2 years post-release*
		Population estimate	- An increase in population size, nominally to 250 by 5 years post-release, and 800 by 10 years post-release (again, numbers will be dependent on favourable rainfall)
		Genetic diversity	- Evidence that genetic diversity has been maintained, or increased, relative to founding populations, as determined by genetic analysis (nominally, at 8 years post-release)

**conditional on average or above average rainfall*

Key threatened and iconic vertebrates

Indicator	Survey name	Survey method	Metric/s
Mammals			
Brush-tailed Mulgara (*Dasycercus blythi*)	Track Survey	Tracks plots	Occupancy
Black-footed Rock-wallaby (*Petrogale lateralis*)	Black-footed Rock-wallaby Survey	Scat plots, transects	Activity, occupancy
Reptiles			
Great Desert Skink (*Liopholis kintorei*)	Great Desert Skink Survey	Counts of active GDS burrows on fixed transects at known key sub-populations	Activity, occupancy
Birds			
Rufous-crowned Emu-wren (*Stipiturus ruficeps*)	TBD	TBD	Occupancy
Dusky Grasswren (*Amytornis purnelli*)	Grasswren survey	Playback – survey method under development	Occupancy

Vertebrate assemblages and surveillance species

Indicator	Survey name	Survey method	Metric/s
Mammals			
Assemblage richness	Standard Trapping Survey, Track Survey, incidentals	Various	Number of species
Small-medium mammals			
Assemblage richness	Standard Trapping Survey, incidentals	Various	Number of species
All small-medium mammals (trappable)	Standard Trapping Survey	Box traps, cage traps, pitfall traps	Abundance, richness
Dasyurids - guild	Standard Trapping Survey	Box traps, pitfall traps	Abundance, richness

Indicator	Survey name	Survey method	Metric/s
Rodents - guild	Standard Trapping Survey	Box traps, pitfall traps	Abundance, richness
Large macropods			
Red Kangaroo (*Macropus rufus*)	Track Survey	TBD	Occupancy
Predators			
Dingo (*Canis lupis dingo*)	Track Survey	TBD	Occupancy
Bats			
Microbats - guild	Bat Survey	TBD	Activity, richness
Reptiles			
Assemblage richness	Standard Trapping Survey, incidentals	Various	Number of species
All reptiles (less large varanids /snakes)	Standard Trapping Survey	Pitfall traps, funnel traps	Abundance, richness
Reptiles – skinks (guild)	Standard Trapping Survey	Pitfall traps, funnel traps	Abundance, richness
Reptiles – geckos (guild)	Standard Trapping Survey	Pitfall traps, funnel traps	Abundance, richness
Reptiles – agamids (guild)	Standard Trapping Survey	Pitfall traps, funnel traps	Abundance, richness
Reptiles – pygopods (guild)	Standard Trapping Survey	Pitfall traps, funnel traps	Abundance, richness
Reptiles - varanids (guild)	Standard Trapping Survey	Pitfall traps, funnel traps	Abundance, richness
Reptiles – snakes (guild)	Standard Trapping Survey	Pitfall traps, funnel traps	Abundance, richness
Gould's Goanna (*Varanus gouldii*)	TBD	Track and/or Camera Survey	Occupancy
Perentie (*Varanus giganteus*)	TBD	Track and/or Camera Survey	Occupancy
Birds			
Assemblage richness	Standard Bird Survey, Incidentals	Various	Number of species
All birds	Standard Bird Survey	20-min counts	Abundance, richness
Honeyeaters - guild	Standard Bird Survey	20-min counts	Abundance, richness
Ground active birds - guild	Standard Bird Survey	20-min counts	Abundance, richness
Nocturnal birds - guild	TBD	TBD	TBD
Frogs			
All frogs	Standard Trapping Survey, Frog Targeted Survey (TBD)	Pitfall traps	Activity, richness

Vegetation indicators and surveillance species

Indicator	Survey name	Survey method	Metric/s
Vegetation			
Tree cover and composition	Vegetation Survey	Vegetation transects	Percent canopy cover, richness
Shrub cover and composition	Vegetation Survey	Vegetation transects	Percent shrub cover, richness
Ground cover and composition	Vegetation Survey	Vegetation transects	Percent ground cover, richness

Table 3. Threat indicators and metrics for Newhaven in 2021.

Indicator	Survey name/ methods	Metric/s	Performance criteria
Pest animals			
Cats (*Felis catus*)	Feral Predator Survey (outside fence area; TBD)	Activity	TBD
Foxes (*Vulpes vulpes*)	Feral Predator Survey (outside fence area; TBD)	Activity	TBD
Camels (*Camelus dromedarius*)	Camel Survey (TBD)	TBD	TBD
Rabbits (*Oryctolagus cuniculus*)	Rabbit Survey/ warren activity (outside fence area only)	Density	TBD
Weeds			
TBD	TBD	TBD	TBD
Fire			
Fire extent	Fire Scar Analysis (Webb et al. 2022)	Proportion (%) and area (ha) of property burnt by winter fire, prescribed summer fire, summer fire, all fire	Reduce the extent of individual fires
Fire severity		Proportion (%) of total annual fire scar caused by severe fires and fire sensitive vegetation communities burnt in severe fires	Reduce severity of fire and protect fire sensitive vegetation communities from fire
Long unburnt vegetation		Proportion (%) of long unburnt spinifex dominated vegetation communities and mean distance to long unburnt	Maintain availability of long unburnt vegetation
Diversity of age classes in spinifex vegetation communities		Proportion (%) of spinifex dominated vegetation communities within defined age classes	Maintain diversity of age classes in spinifex dominated vegetation communities

Survey types and history

To report on the Biodiversity and Threat Indicators, our survey teams conduct a variety of surveys repeated on a schedule of 1-5 years, as required to obtain timely information on each indicator. These include:

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

- Red-tailed Phascogale Survival
- Red-tailed Phascogale Survey
- Red-tailed Phascogale Health Check
- Brush-tailed Bettong Survival
- Brush-tailed Bettong Health Check
- Mala Health Check
- Black-footed Rock-wallaby Survey
- Great Desert Skink Survey
- Track Survey

For surveillance monitoring of assemblages, these include:

- Standard Trapping Survey
- Standard Bird Survey
- Track Survey

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

- Rabbit Survey
- Fire Scar Analysis
- Track Survey
- Feral Predator Survey (TBD)
- Camel Survey (TBD)

Seven of the ecological surveys were conducted at Newhaven in 2021. Below is a list of surveys reported upon in this Ecohealth Report (Table 4). The Fire Scar Analysis has been completed using satellite data from 1991 (15 years prior to acquisition) to 2006 and on -ground knowledge of sanctuary managers in more recent years. The methodology is described and results of these surveys and computations are reported on in this document.

Table 4. Survey history and effort for Ecohealth surveys on Newhaven reported upon in this report.

Survey name	Effort (2021)	Description/comment	Previous surveys
Red-tailed Phascogale Survival	9 individuals tracked for 16 days	Red-tailed Phascogales released into the fenced area tracked with radio-collars to determine survival.	n/a
Red-tailed Phascogale Survey	43,435 camera trap nights 509 nest box checks	Targeted monitoring to monitor occupancy following reintroduction. In 2021, 119 cameras left in-situ year-round. 52 nest boxes checked weekly for first 4 weeks post release, then checked monthly.	2020 –18,793 camera trap nights and 634 nest box checks
Red-tailed Phascogale Health Check	600 trap nights	Targeted trapping to monitor health following reintroduction In 2021, 6 transects of 25 Elliot traps per transect checked over 4 nights.	n/a
Brush-tailed Bettong Survival	27 individuals tracked for 6 months	Brush-tailed Bettongs released into the fenced area tracked with radio-collars to determine survival.	n/a
Brush-tailed Bettong Health Check	234 trap nights	Targeted trapping to monitor health following reintroduction.	n/a

Survey name	Effort (2021)	Description/comment	Previous surveys
		In 2021: two surveys: 18 traps in September (5 nights); 18 traps October-November (8 nights).	
Mala Health Check	400 trap nights	Targeted trapping to monitor health following reintroduction. Five sites, 20 traps per site, checked over 4 nights.	2020 – 374 trap nights 2019 – 146 trap nights
Black-footed Rock-wallaby Survey	96 plots	1 m plot centroids at 190 plots over 4 separate ranges. Total scat count within each plot. In 2021, modified survey which surveyed 2 ranges in order to collect scat for DNA analysis.	2021 – 96 plots on 2 ranges 2020 – 125 plots on 3 ranges 2019 - 190 plots on 4 ranges 2018 – 215 plots on 5 ranges 2017 – 196 plots on 5 ranges 2016 – 215 plots on 5 ranges 2015 – 180 plots on 4 ranges
Great Desert Skink Survey	0 km	Eight sites each with 11 pre-defined, 500 m long, transects.	Annually 2015-2020 – 44 km walked
Track Survey	0 plots	74 track plots stratified by habitat across whole property.	2015 – 74 track plots 2014 – 73 track plots 2013 – 72 track plots 2012 – 73 track plots annually 2008 – 2011 – 100 track plots
Rabbit Survey	10.5 hours assessing warrens	64 warrens at 13 sites outside the fenced area were searched for signs of activity.	Annually, 2015-21 – 10.5 hours assessing warrens

Survey design and methods

Red-tailed Phascogale Survival

This species was monitored as per protocols set out in the relevant Translocation Proposal (Collett et al. 2020). In April 2021, the third and final cohort of Red-tailed Phascogales were reintroduced into the fenced area from a breeding program at Alice Springs Desert Park. This cohort comprised of 25 animals (14 males, 11 females). Nine individuals (5 males, 4 females) were fitted with coded VHF radio-collars and tracked daily for 16 days using a combination of car mounted Omi antennas, hand-held Yagi antennas and 2 fixed telemetry towers which recorded the unique identification of individuals that came within range of the tower's antennas.

Red-tailed Phascogale Survey

The Red-tailed Phascogale is a small semi-arboreal species that is challenging to monitor with standard techniques. Evidence of establishment throughout the 'Establishment Zone' (a 9 km^2 area within the fenced area, surrounding the release sites) was monitored using two methods: (1) a grid of 67 camera traps surrounding the release site, and (2) checks for occupancy of nest boxes (Figure 6).

For method (1), 67 cameras were set up at a spacing of approximately 500 m in the Establishment Zone. In addition, a total of 52 cameras were positioned beneath all nest boxes. All cameras were left in situ year-round. Camera traps were unbaited for the first 2 weeks post-release, after which time they were lured with universal bait (i.e., peanut butter, sardines, oats). All cameras were set 1.5 m above the ground, facing downwards at a 45^{o} angle towards a bait, and set to take 3 images with no delay between triggers. The cameras were checked weekly in the first month following release, and monthly from 5 weeks post-release.

For method (2), nest boxes used to release animals were checked weekly for signs of occupation in the first month post-release. Subsequently, all 52 nest boxes within the Establishment Zone were checked monthly, commencing from the fifth week post-release. Occupation was defined as either the physical presence of an animal or the presence of Red-tailed Phascogale scat and scent.

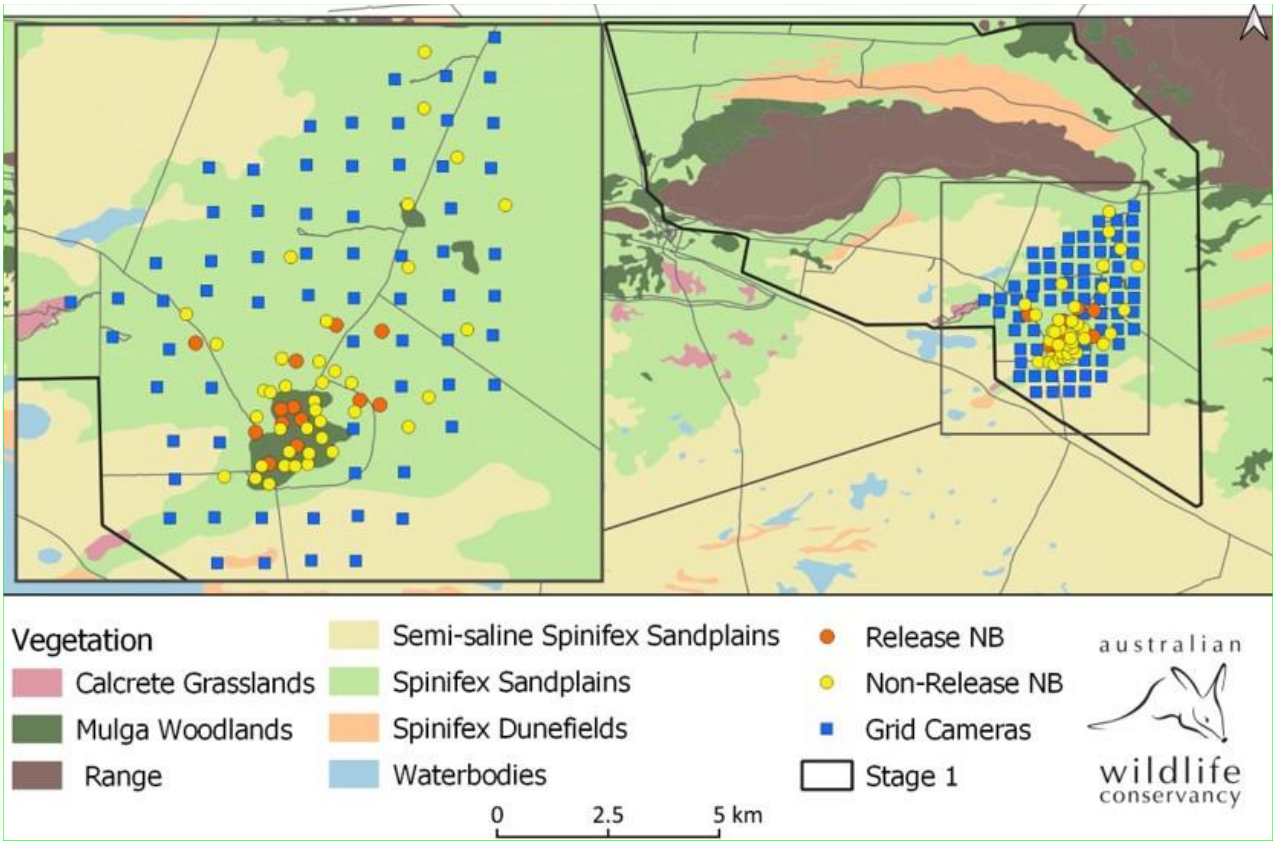

Figure 6. Location of Red-tailed Phascogale nest boxes and camera traps throughout the Establishment Zone on Newhaven. Release NB = nest boxes that were used to release the phascogales, Non-Release NB = nest boxes that were empty at the time of the release.

Red-tailed Phascogale Health Check

Health checks of Red-tailed Phascogales were conducted in May 2021. To capture animals for assessment, 6 transects of 25 Elliot traps per transect spaced at 30 m apart were set across the Establishment Zone. The traps had been pre-baited for 1 week prior to the health check. The health check was conducted over 5 nights. Data on body weight, coat condition, breeding status (whether females were carrying pouch young) and morphometric data were recorded for all captured animals but are not reported on in this Ecohealth Report. These data were used to report on the survival of founding adults up to 6 months and 12 months after release.

Brush-tailed Bettong Survival

There were 70 Brush-tailed Bettongs translocated from Mt Gibson to Newhaven in August and October 2021. This species was monitored as per protocols set out in the relevant Translocation Proposal (Kanowski et al. 2021a). To monitor survival, 27 individuals (14 males, 13 females) were fitted with coded VHF radio-collars. Animals were tracked daily for 1 month post-release, then weekly until 3 months post-release and, finally, monthly from 3 to 6 months post-release. Radio-tracking was conducted using a combination of car mounted Omi antennas, hand-held Yagi antennas and 8 fixed telemetry towers which automatically recorded the tag number of radio-collared individuals that came within range of the tower's antennas. At 6 months post-release all remaining radio-collars were removed from individuals.

Brush-tailed Bettong Health Check

Health checks of Brush-tailed Bettongs were conducted in September and November-December 2021. To capture animals for assessment, targeted trapping was conducted over 5 nights in September and 8 nights in November-December. Eighteen traps were set during both trapping periods with trap site locations based on data from radio-collared individuals. Traps were set prior to sunset and baited, then left undisturbed for a minimum of 2 hours after sunset before checking. Data on body weight, condition, breeding status (whether females were carrying pouch young) and morphometric data were recorded for all captured animals. A condition score was allocated to each individual as follows:

1 Emaciated (no fat/muscle conditions
2 Very underconditioned (bones prominent)
3 Underconditioned (some bones prominent)
4 Slightly under conditioned (lean but still with muscle mass)
5 Ideal condition (smooth lines)
6 Slightly over-conditioned (some accumulation of body fat)
7/8 Very over-conditioned (noticeable fat around body/tail, muscle definition lacking)
9 Obese (bulging fat deposits)

Mala Health Check

Mala were monitored as per protocols set out in relevant Translocation Proposals (Kanowski et al. 2018b) in August 2021. Five grids of 20 traps spaced at 100 m were set over 4 nights (Figure 7). The traps had been pre-baited for one week prior to the survey. Traps were set prior to sunset and baited, then left undisturbed for a minimum of 2 hours after sunset before checking. Various data were collected, including breeding status (whether females were carrying pouch young) for all captured animals.

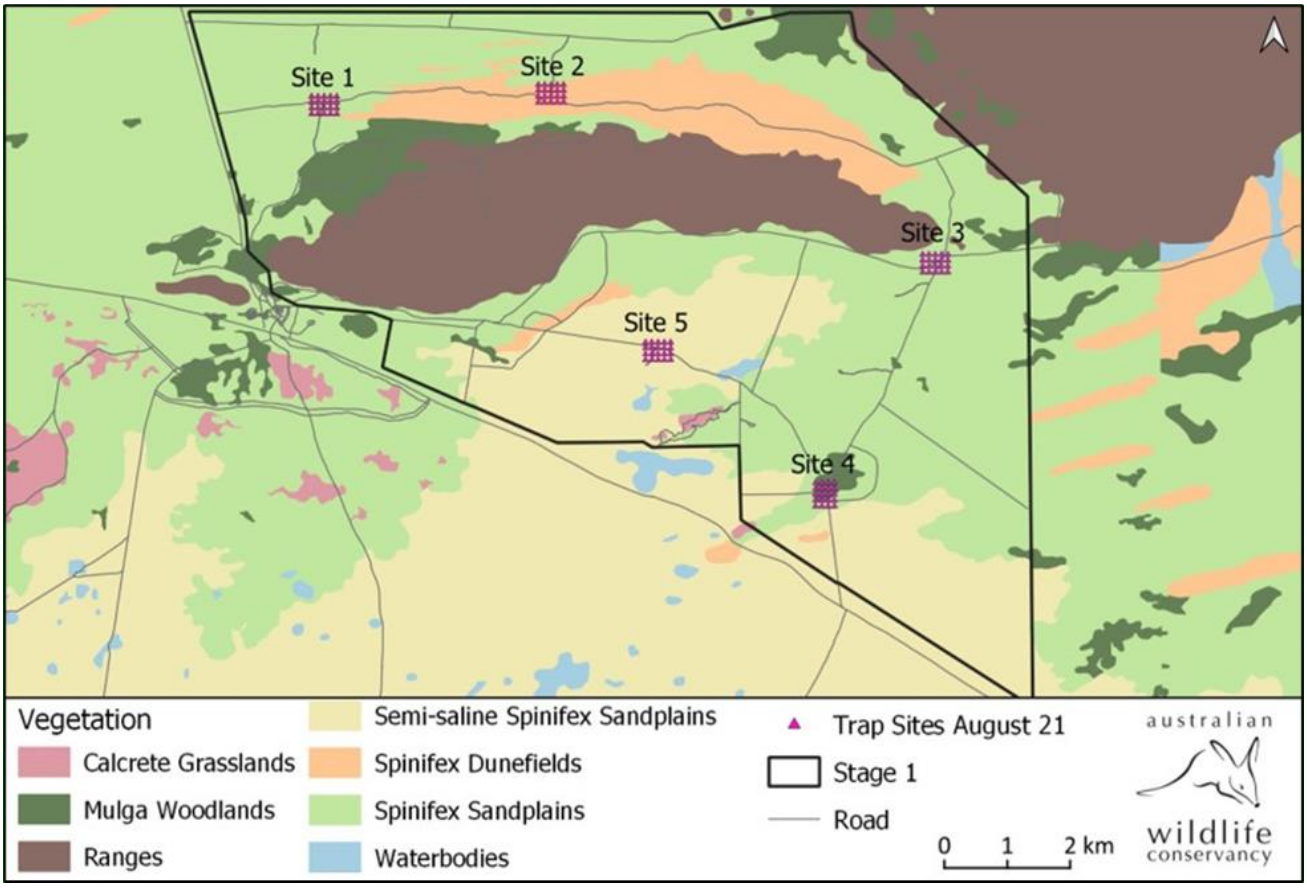

Figure 7. Location of trap sites for Mala survey to estimate population size.

Track Survey

Track plots are used to monitor the abundance of Brush-tailed Mulgara The tracking survey was undertaken annually from 2008-2015 in March-April when reptile and small mammal are at peak activity. The survey comprised of 73, 2-ha sites across Newhaven that were stratified by broad vegetation type (Figure 8).

Tracking is undertaken early morning and late afternoon with each 2-ha site walked for 30 minutes. The site is thoroughly searched by a zig-zag walking pattern up one side of the plot and down the other side (Figure 9).

Every track, burrow, digging, scat or sighting of species of interest seen within the 2-ha site is recorded and signs are aged. Following completion of the survey every species/animal group that has been recorded is given an overall record of abundance on a scale of 1 to 3:

1. Signs present across all 4 quarters of the plot
2. Signs present in half to ¾ of the plot

3. Signs present in ¼ of the plot or only 1 individual noted

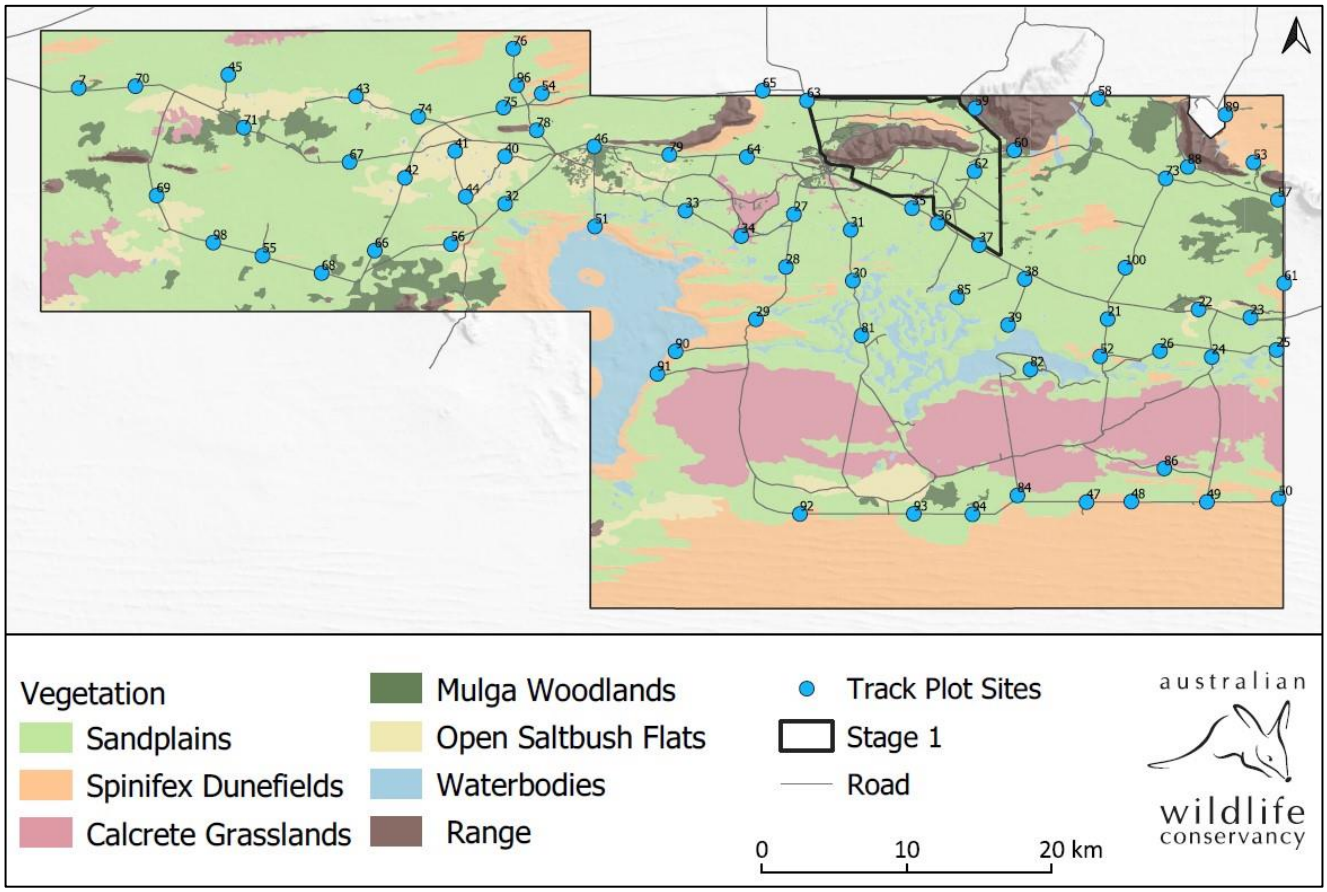

Figure 8. Track plot sites across Newhaven.

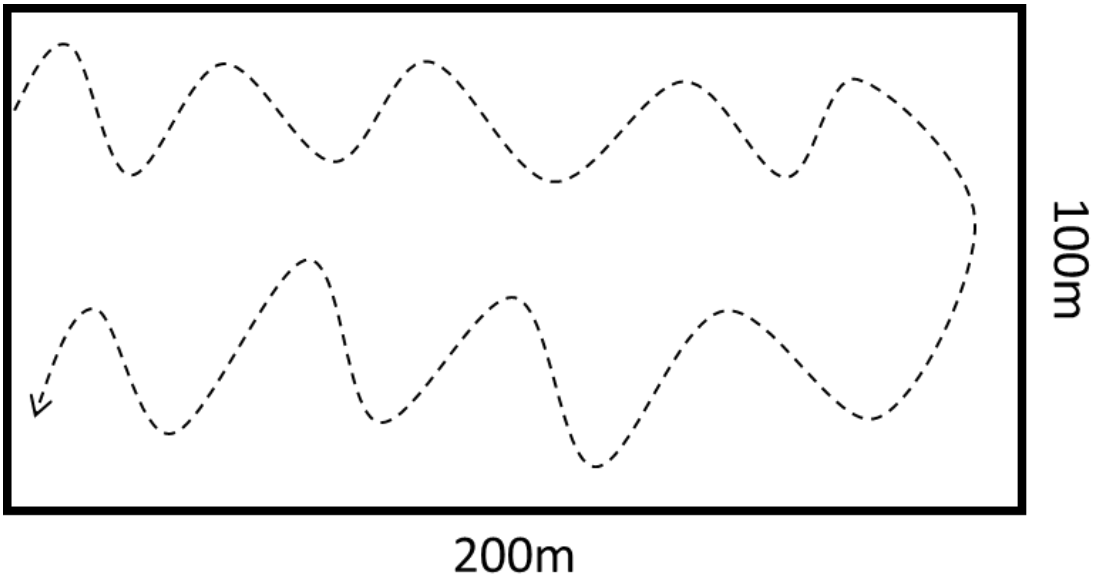

Figure 9. Track plot search pattern

Black-footed Rock-wallaby Survey

Black-footed Rock-wallaby (BFRW) on Newhaven occur as small, presumably isolated, populations on quartzite ranges distributed across the northern portion of the sanctuary. The activity survey measures the accumulation of Black-footed Rock-wallaby scats over a 12-month period. There are 190 permanent

monitoring plots across the 4 known occupied ranges: Robb's Hill, Wartikinpiri Range, Yaripilangu Range and Siddeley Range (Figure 10).

The activity of Black-footed Rock-wallaby has been monitored annually since 2015 (Schofield 2015). Originally 4 locations were targeted for surveys: Mount Gurner, Robb's Hill, Wartikinpiri Range and Siddeley Range (Figure 10). AWC subsequently gained access to Yaripilangu with colonies there first surveyed in July 2017. Mt Gurner has not been surveyed since 2018, because no evidence of BFRW occupation was detected during the 2017 survey.

In 2020, 125 1 m^2 permanent scat plots were surveyed across 3 known sites of Black-footed Rock-wallaby occupancy. The Siddeley Range was not surveyed due to Covid-19 restrictions affecting the availability of volunteers to undertake the survey.

In 2021, as part of a project to determine effective monitoring techniques to assess the Newhaven Black-footed Rock-wallaby population size and structure a modified survey was conducted at 96, 1m^2 permanent scat plots across 2 known sites of Black-footed Rock-wallaby occupancy, Wartikinpiri range and Yaripilangu range. The aim of the survey was to collect fresh scat that can be used for DNA analysis to determine the genetic health and structure of the population inside and outside of the fenced area. As the survey was conducted 6 months after the 2020 survey the results are not comparable. Further monitoring techniques will be trialled in 2022.

Centroids for the scat plots are permanently marked. A string 56.4 cm long was used to measure a radius of a circle (1m^2) that defines the plot. Only scats found within this circle were recorded. As scats were counted and recorded they were removed from the plots and discarded.

Total scat counts were recorded of the Black-footed Rock-wallaby (classified separately as Adult or Sub-adult and fresh, old or ancient, based on size and shape (Table 5) and appearance – i.e., sheen, colour and surface integrity (Table 6), respectively. Rock-wallaby scats were distinguished by size and shape from Euro (*Macropus robustus*).

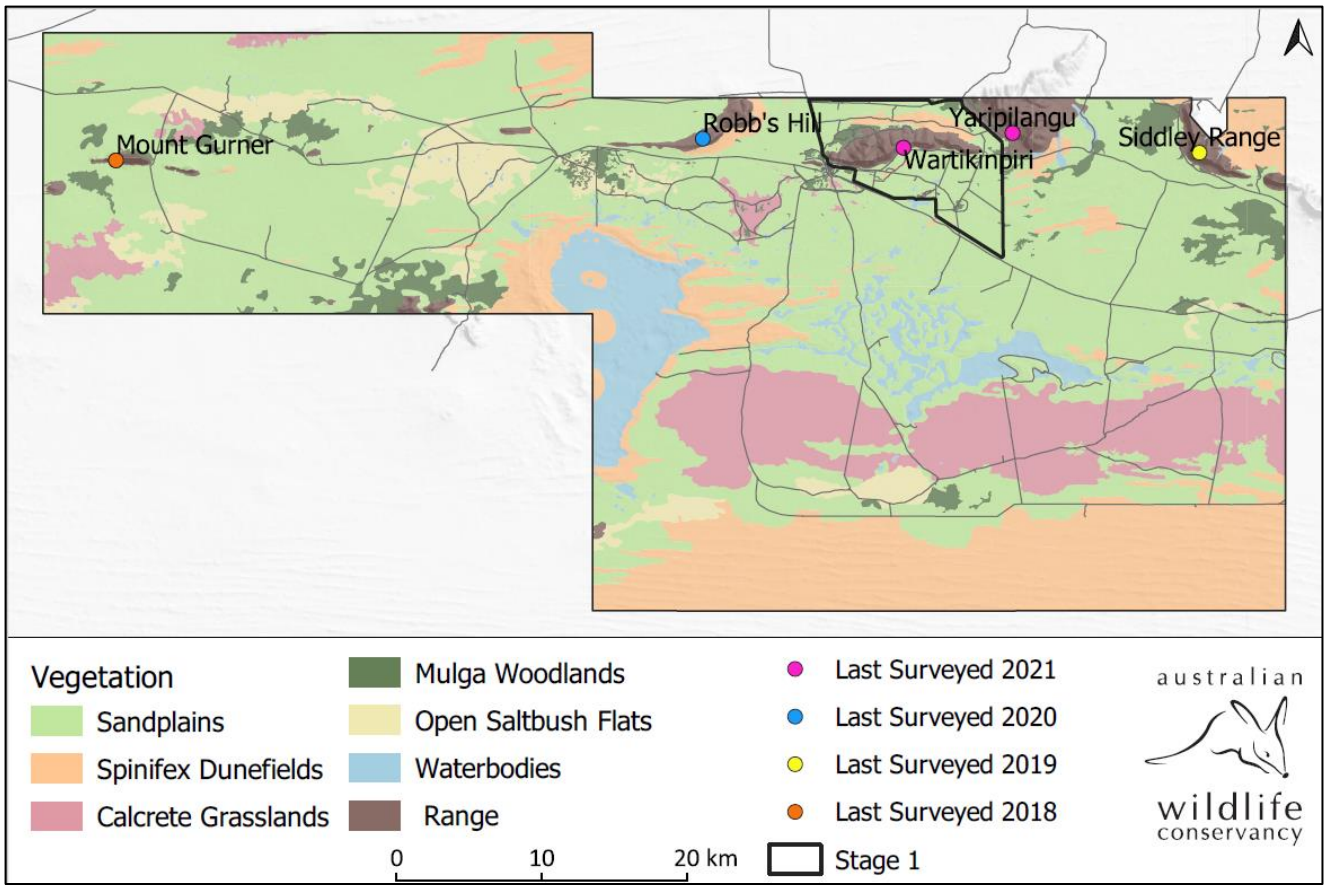

Figure 10. **Location of monitoring sites and status of BFRW Activity Survey on Newhaven**

Table 5. Black-footed Rock-wallaby animal age scat classification

Classification	Scat Appearance
Adult BFRW	All macropod scats <2 cm in length and >1 cm in diameter. For visual identification characteristics see Appendix 1: Pictorial Guide to macropod scats found on Newhaven.
Sub-adult BFRW	All macropod scats <2 cm in length and <1 cm in diameter. For visual identification characteristics see Appendix 1: Pictorial Guide to macropod scats found on Newhaven.

Table 6. Black-footed Rock-wallaby scat age classification definitions

Classification	Scat Appearance
Fresh	Black scat with majority of surface glossy, 70% of surface intact, but including some scats with widespread surface cracking, tessellated appearance, or with areas of dullness or breaks in surface.
Old	Grey or whitish scat or black/dark brown with no glossy sheen, or some gloss but less than 70% surface intact.
Ancient	Grey-brown to whitish with the outer surface powdery and lacking any fibrous material. These can be reduced through decomposition to 'sub-adult' scat size. Check timing of last fires as if more than 12 months prior any burnt scats can be categorised as 'Ancient'.

Great Desert Skink Survey

Since 2015, surveys have been conducted in February when Great Desert Skink populations are at peak activity. The abundance of Great Desert Skinks (GDS) was monitored at 8 sites, each 50 ha in extent, distributed across suitable habitat on Newhaven, representing a range of - fire histories (Figure 11). These sites are predominantly within the habitat Semi-Saline Spinifex Plains. This vegetation type occupies around 13%of Newhaven and is typically dominated by *Triodia pungens,* and a range of shrubs, such as *Hakea leucoptera* and *Melaleuca glomerata* (Latz et al. 2003).

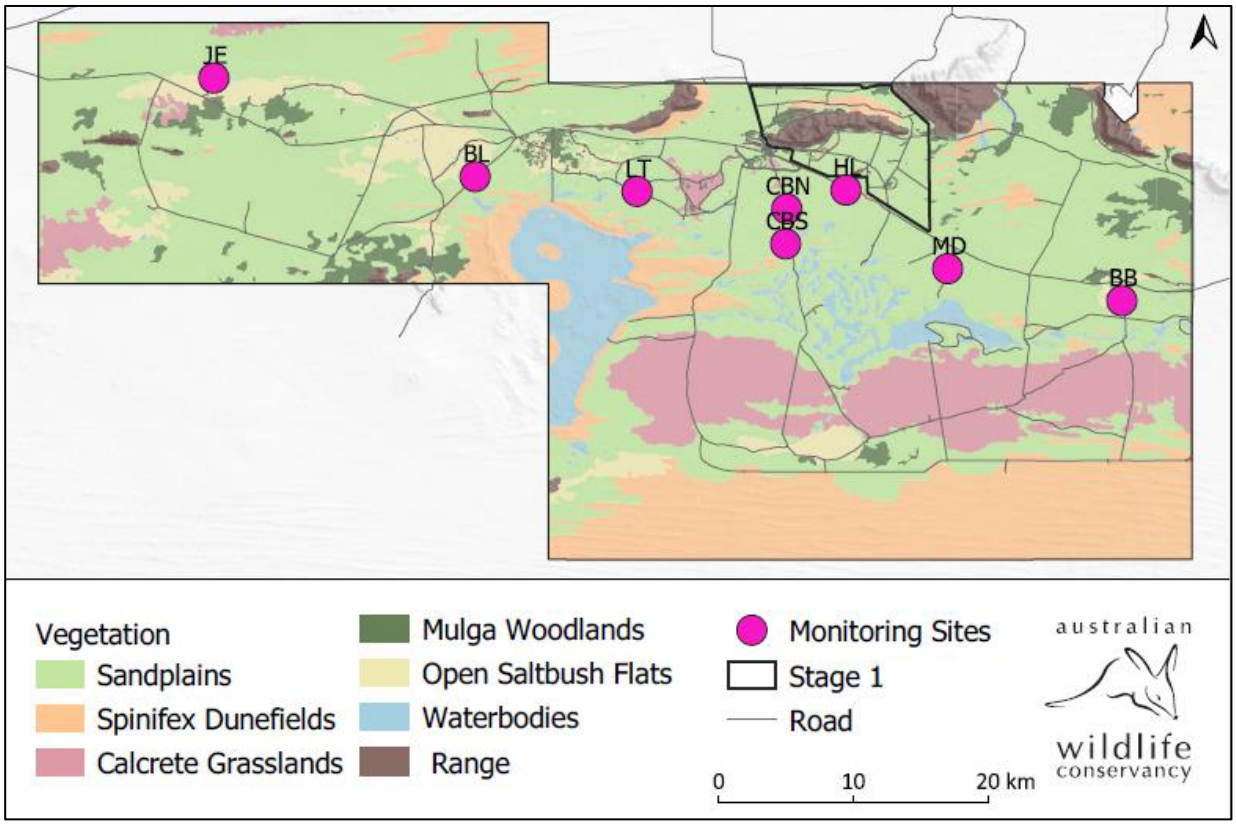

Figure 11. Great Desert Skink monitoring sites on Newhaven. JE = Jilpalpa East, BL = Blue Lagoon, L = Lakes Tour, CBN = Camel Bore North, CBS = Camel Bore South, HL = Honeymoon Lake, MD = Mulgara Drive, BB = Blom Bore.

At each site, surveys are conducted along 11 parallel transects, each 500 m in length and spaced at 100 m intervals (Figure 12). Some transects encompass waterbodies, reducing the total area surveyed. The pre-defined transects were walked by 2 observers searching 5 m either side of the transect line for GDS burrow systems. The burrow systems were confirmed as being actively occupied by GDS through the presence of a fresh scats at a GDS latrine and identifiable GDS tracks at burrow entrances. For each new and previously located burrow-system the following data were recorded:

- burrow system ID or coordinates;
- burrow system occupancy;
- number of active or inactive burrow entrances;
- number of latrines;
- presence and count category (0-5, 6-10, >10) of adult, sub-adult and juvenile GDS scats in the latrine;
- approximate dimensions of the complete burrow system;
- vegetation cover abundance;
- burn type; and
- sign of predator activity at burrow system.

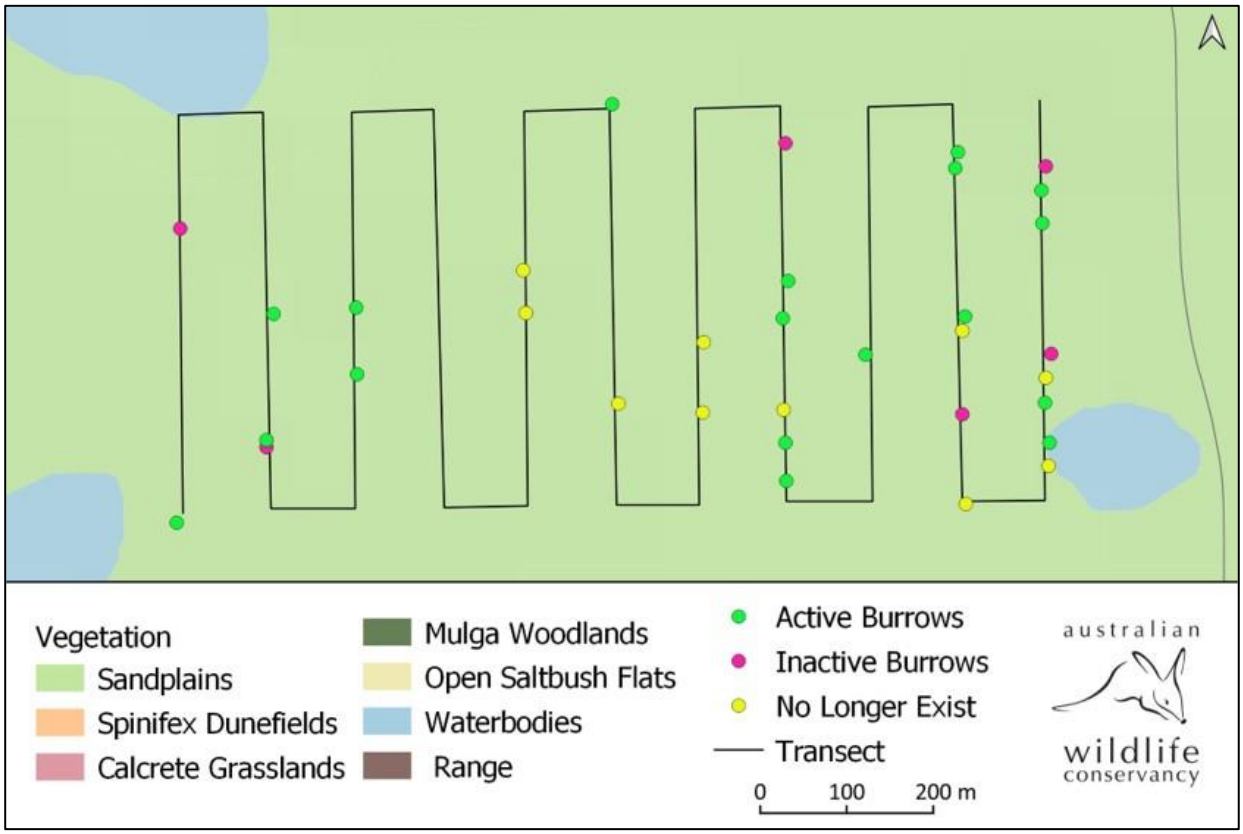

Figure 12. An example of a Great Desert Skink monitoring site with tracking transect and previously recorded burrow-systems on Newhaven. Map also shows roads and waterbodies across the site.

Rabbit Survey

Based on surveys conducted in 2012-2015, 13 sites were selected for long-term monitoring outside the fenced area (Figure 13). These sites were based on the distribution and abundance of rabbits on Newhaven, and located within areas identified as preferred rabbit habitat. The survey is conducted annually in September/October to avoid typical breeding times for rabbits in the arid zone. During periods of above average rainfall, these dates may be altered to avoid overlap with extended breeding periods.

At each monitoring site, all warrens within a 25 ha (500 m X 500 m) were mapped. The number of active and inactive entrances at each warren was assessed using criteria adapted from Williams et al. (1995), with each of the 64 mapped warrens searched for approximately 10 minutes. Indicators of activity were:

- Fresh tracks/ scats in entrance
- No spider webs and no accumulated leaf litter in entrance
- Powdery loose soil on floor of entrance.

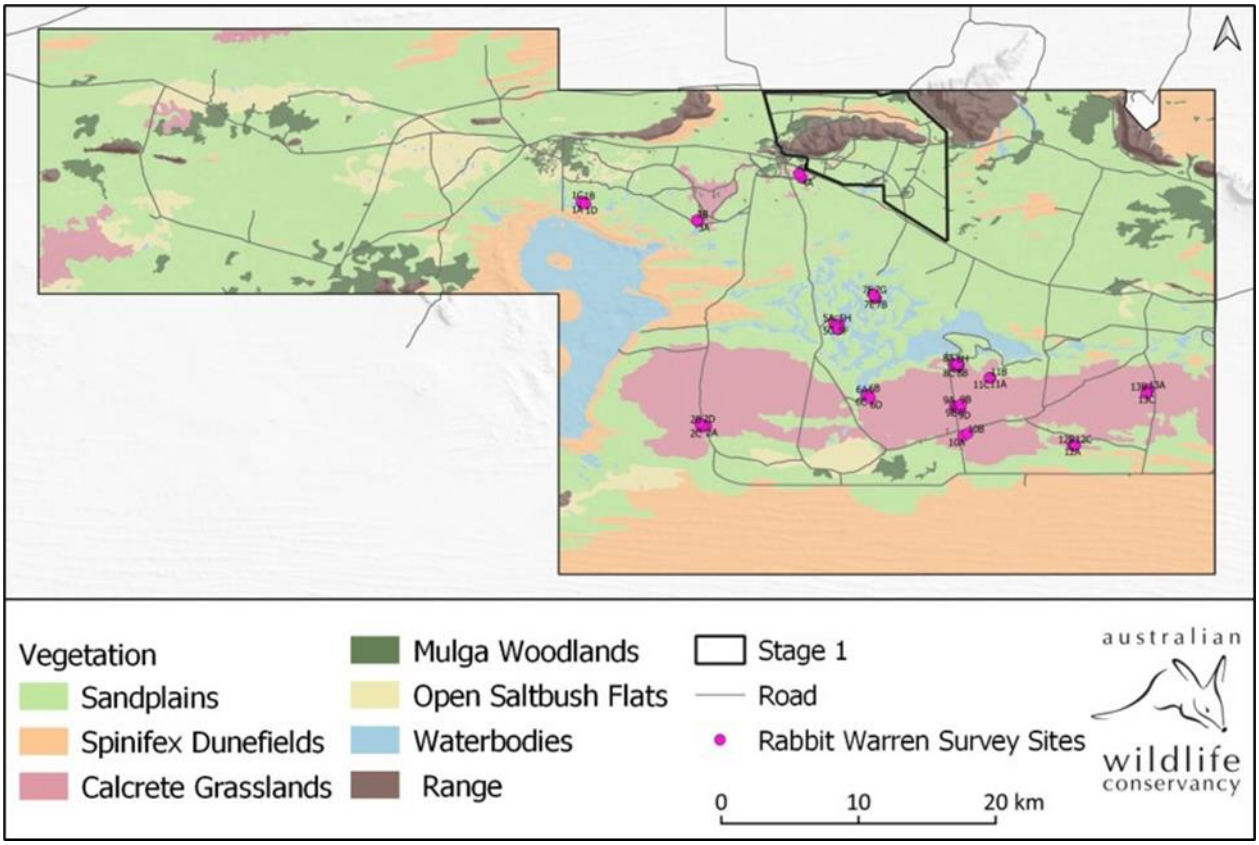

Figure 13. Newhaven rabbit warren survey sites outside the fenced area

Analysis methods

Most Ecohealth metrics are common across the indicator species for Newhaven. Unless noted otherwise, the metrics are calculated as set out in Table 7 below.

Table 7. Metrics and associated calculations for Newhaven

Indicator	Metric	Survey data sources	Description	Analysis summary / calculation
Assemblage richness	Number of species	All surveys and incidental records	A measure of intactness for the whole sanctuary	The number of species detected on the sanctuary within a stated period, e.g. 2008-2019, is compared to the number of species listed as 'confirmed', 'very likely' or 'likely' on the sanctuary species list.
Mala	Survival	Mala Health Check	The proportion of released animals that survive following a translocation	Percentage of radio-collared individuals that survive at 3 months post release.
	Reproduction	Mala Health Check	Measure of breeding success and recruitment	Percentage of females with dependent young and percentage

Indicator	Metric	Survey data sources	Description	Analysis summary / calculation
			into the population	of the population as F1 (i.e. non-founders).
Red-tailed Phascogale	Occupancy across Establishment Zone (camera traps and nest boxes)	Red-tailed Phascogale Survey	Measure of the area animals are recorded around the release location.	The percentage of camera traps at which Red-tailed Phascogales were detected: there were 119 camera traps set during 2021. The percentage of all 52 nest boxes at which Red-tailed Phascogales were detected.
	Survival	Red-tailed Phascogale Survey, Red-tailed Phascogale Survival	The proportion of released animals that survive following a translocation	Percentage of radio-collared individuals that survive at 1-month post-release. Percentage of nest boxes with RTP detections 2 weeks post release.
Brush-tailed Bettong	Survival	Brush-tailed Bettong Survival	The proportion of released animals that survive following a translocation	Percentage of radio-collared individuals that survive at 6 months post release
	Condition	Brush-tailed Bettong survey	Measure of weight and body condition of individuals in the population.	Weight and body condition are collated from each individual captured during a survey. Condition is measured on a 1-5 scale that is used to assess the overall health of individuals with the range and average value of scores calculated.
Brush-tailed Mulgara	Occupancy	Track Survey	A measure of distribution; the proportion of sites where the species was recorded using a particular search technique	Occupancy: (number of sites at which the species was recorded/ number of sites surveyed) [x 100])
Black-footed Rock-wallaby	Activity Occupancy	Black-footed Rock Wallaby Survey	Activity is a measure of the number of records per site/survey Occupancy is a measure of distribution; the proportion of sites where the species was recorded using a particular technique	Activity is the average number of scats (combined fresh and old scats) per plot (by age class), for each range surveyed, and across all ranges surveyed. Occupancy is the proportion of plots with fresh rock-wallaby scat detected (by age class), for each range surveyed, and across all ranges surveyed. (number of plots at which the species was recorded/ number of plots surveyed) [x 100])

Indicator	Metric	Survey data sources	Description	Analysis summary / calculation
Great Desert Skink	Activity Occupancy	Great Desert Skink Survey Track Survey	Activity is a measure of the number of records per site/survey Occupancy is a measure of distribution; the proportion of sites where the species was recorded using a particular technique	Activity is the average number of active burrows at each of the 8 closely-monitored sites, calculated first as the average number of active burrows per transect at each site, and then as the average across all sites. Only burrow systems located within 5 m each side of the transect were included in the data analysis. Occupancy: (number of sites at which the species was recorded/ number of sites surveyed) [x 100])
Rabbit	Density	Rabbit Survey	The concentration of individuals within a species in a specific geographic locale	The rabbit density is based on Williams et al. (1995) data on burrow occupancy, where in a non-breeding period, 1.6 active entrances equals one adult rabbit. An estimate of rabbit density for each site was calculated as follows: a=mean active entrances/warren d=warren density at site (warrens/ha) D=rabbits/ha Estimated density of rabbits: $D = d\left(\frac{a}{1.6}\right)$ The rabbit abundance estimates generated by this method are indices only but can be repeatedly collected to indicate changes in the population over time.

Fire Scar Analysis

Fire scar data were derived from Landsat satellite imagery and in later years supplemented by Sentinel-2 satellite imagery and on-ground knowledge of sanctuary managers. Data for earlier years were provided by Grant Allen (Parks and Wildlife Commission NT). Each scar was attributed by year, month and season. Fire scars detected from May to September (inclusive) were attributed as 'winter', whereas those detected October to April were attributed as 'summer'. For each year, unburnt areas were created by erasing the recorded fires from the entire boundary area. The maps and statistics for the analyses were created using ArcGIS (Environmental System Research Institute Inc., Redlands, CA, USA) with Spatial Analyst, and were semi-automated using Python scripting Webb et al. (2022). Graphs were produced using Microsoft Excel.

Results

Reintroduced vertebrates

Red-tailed Phascogales

The final translocation of Red-tailed Phascogales to Newhaven was conducted in April 2021. Nine of the 25 individuals were fitted with radio-collars to monitor survivorship. By Day 9 after the release, 4 individuals had not been detected for more than 4 consecutive days. Under the conditions of the translocation proposal if 3 collars failed to emit a signal for longer than 4 days then the collars of all animals had to be removed. Five animals were trapped and collars removed, one animal was found deceased and 4 were classified as missing. There was a known survival rate of 55% to Day 12 post-release.

Translocated Red-tailed Phascogales made consistent use of the nest boxes provided in the weeks following release, with 21% of nest boxes occupied in weeks 1, 2, 4 and in June (Figure 14). Nest box use increased to 40% occupation in July, then dropping down to 12% in August (Figure 14) the last month that nest box checks were undertaken.

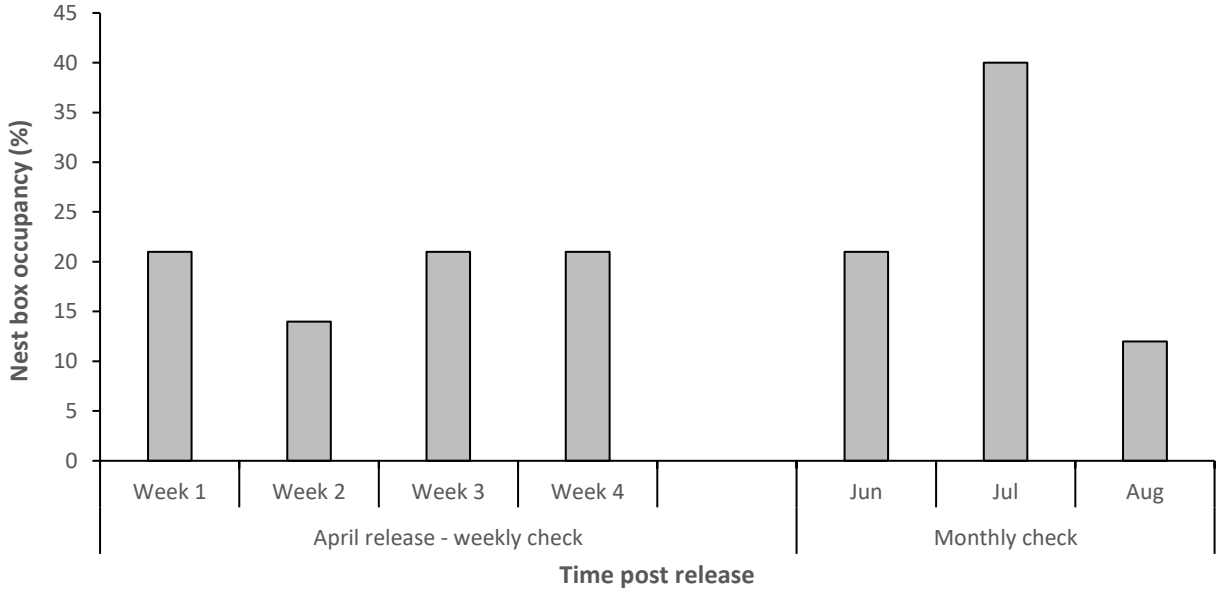

Figure 14. Use of nest boxes by Red-tailed Phascogales post-release. Only nest boxes used for releasing animals were checked in weeks 1-4, following which all nest boxes (52 spread throughout the Establishment Zone) were checked for signs of use.

A variable pattern of establishment was detected by the array of 119 camera traps in the Establishment Zone. Following the third release, occupancy rapidly increased from 9% in April to 48% in July, then declining to 13% in December (Figure 15).

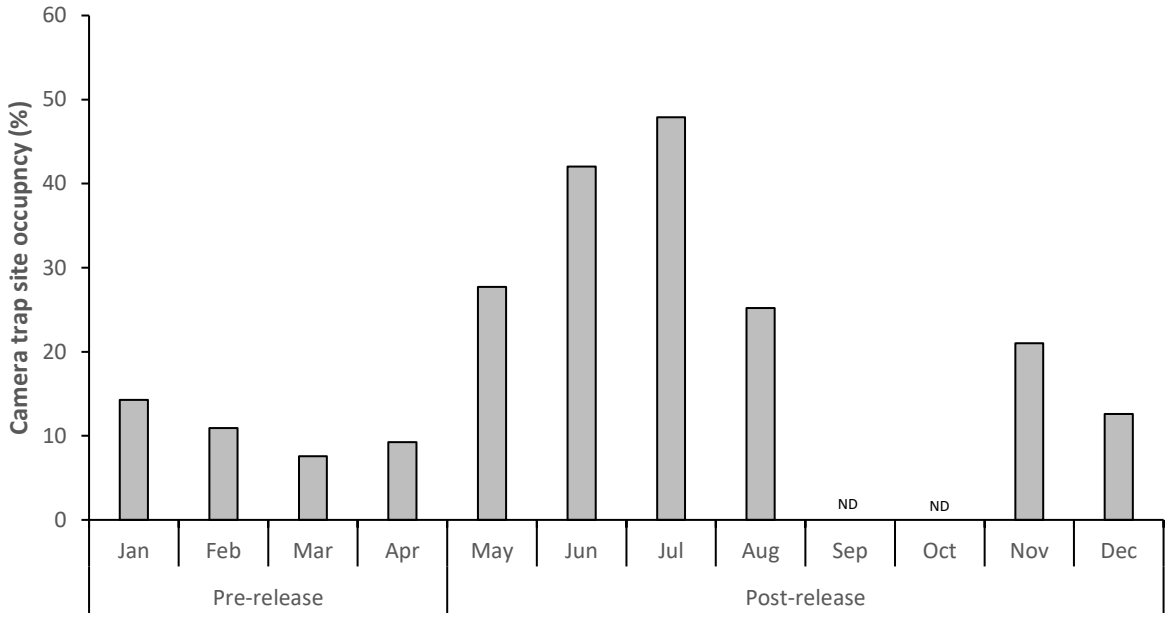

Figure 15. Proportion of camera trap sites occupied by Red-tailed Phascogale per month in 2021 following the release of the third tranche of animals. This data excludes detections made in the first 2 weeks post-release when camera traps were not lured. Data were not gathered in September and October. ND = no data.

The health check survey conducted of the reintroduced Red-tailed Phascogale population in May 2021 involved assessment of 7 individuals. Two individuals were caught from the April 2021 release cohort and 5 individuals from the November 2020 release cohort. No unmarked individuals were caught.

Brush-tailed Bettongs

Survival

Two cohorts of Brush-tailed Bettongs were released in August and October 2021 totalling 70 animals with 27 individuals fitted with radio-collars to monitor survivorship (cohort 1 n=15; cohort 2 n=12). Two individuals had their collars removed and one individual had been missing for 3 months before the end of 2021. At the end of December overall survivorship (excluding individuals that had collars removed or went missing) was 78% at 5 months post-release for cohort 1- and 3-months post-release for cohort 2.

The health checks of the reintroduced Brush-tailed Bettong population were undertaken in September and November-December 2021 and involved assessment of 27 individuals from the August and October 2021 release, of which 21 were radio-collared.

Body weight

Weights of the Brush-tailed Bettong have remained stable with cohort 1 showing a slight increase in average weight (Table 8 and Table 9), and cohort 2 showing a slight decrease (6% loss) since translocation (Table 9). Both cohorts have maintained their average body weight within 20% of the release weight, indicating that the population is on track to meet short-term condition success criteria.

Table 8. Average weight (g) of adult Brush-tailed Bettongs captured during September health-check at Newhaven. These data only include cohort 1.

	Number animals	Translocation (g)	Health Check (g)	Weight Difference (g)	% Weight Difference
Males	9	1101	1122	21	2
Females	6	1058	1148	90	9
Females (NO PY)	1	840	1035	195	23
All	15	1084	1133	49	5
All (NO PY)	10	1075	1114	39	4

Table 9. Average weight (g) of adult Brush-tailed Bettongs captured during November-December 2021 health checks at Newhaven. C1 refers to Cohort 1 released in August 2021, C2 refers to Cohort 2 released in October 2021.

	Number animals		Translocation		Nov-Dec-21 Health Check		Weight Difference (g)		% Weight Difference	
	C1	C2	C1	C2	C1	C2	C1	C2	C1	C2
Males	7	4	1,151	1,170	1,190	1,126	39	-45	3	-4
Females	3	5	1,073	1,108	1,104	1,089	31	-19	3	-2
Females (NO PY)	0	1		1,105		935		-170		-15
All	10	9	1,128	1,136	1,164	1,105	37	-30	3	-3
All (NO PY)	7	5	1,151	1,157	1,190	1,087	39	-70	3	-6

Mala

The health check conducted of the reintroduced Mala population in August 2021 involved assessment of 18 individuals which represented 7 founders from Scotia and 2 founders from Watarrka, 8 Newhaven born Mala, 4 of which were new animals.

As a result of the above average rainfall in early 2021, conditions have been good and new individuals have been recruited into the population. At the August 2021 health check 88% of adult females were carrying pouch young (PY), an increase from the previous figure of 50% in September 2020 (Figure 16). This result shows that the success criteria set out in the Translocation Proposal (>50% female should be carrying pouch young 2 years post-release, presuming average rainfall or above) has been met.

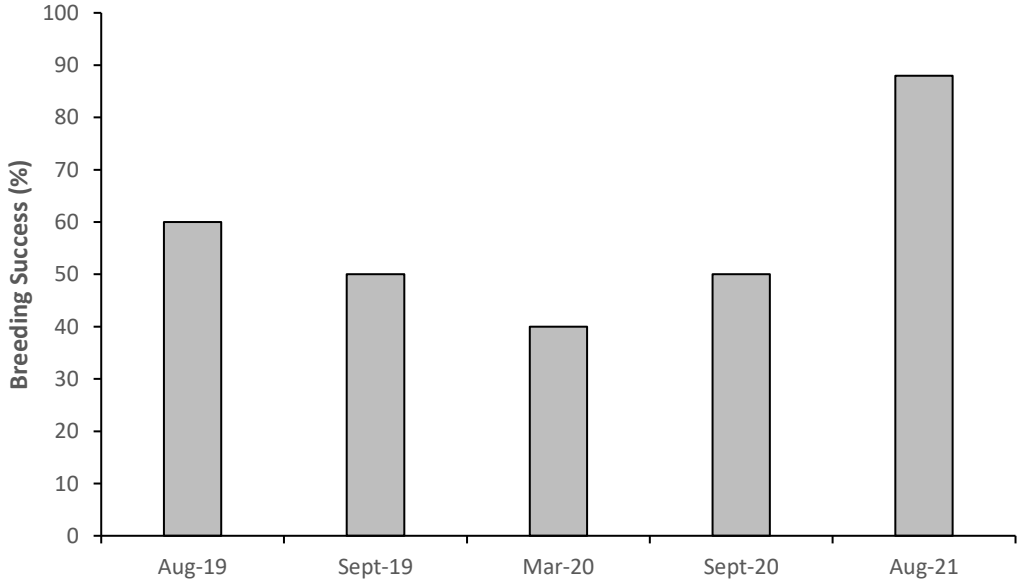

Figure 16. Proportion of adult females carrying pouch young in Mala health-checks, 2019-21.

Key threatened and iconic vertebrates

Brush-tailed Mulgara

Brush-tailed Mulgara occupancy data is collected during track plot surveys at Newhaven. The track plot surveys ran from 2008 to 2015 and cover the extent of Newhaven Sanctuary. The number of sites visited in any given year varied as a result of environmental factors affecting site access. Brush-tailed Mulgara are an eruptive species with occupancy linked to rainfall as can be seen from the large increase in occupancy in 2012 (Figure 17) following above average rainfall in 2010-2011 (Figure 4).

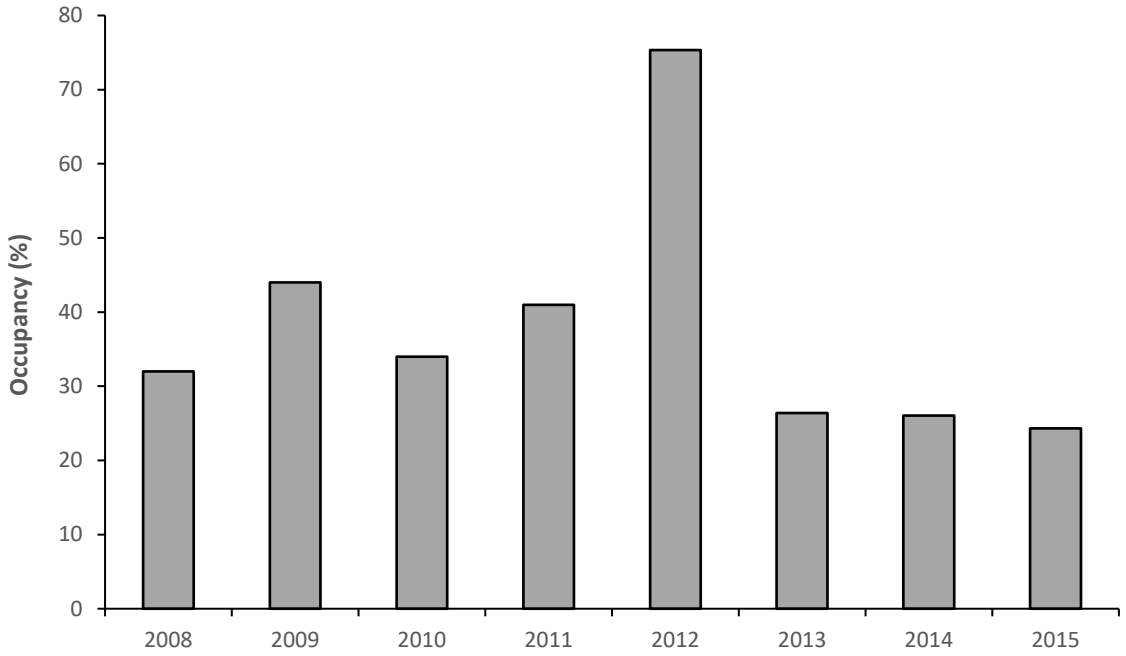

Figure 17. Brush-tailed Mulgara occupancy at Newhaven from track plot monitoring surveys 2008-2015.

Black-footed Rock-wallaby

In 2021 the Black-footed Rock-wallaby survey was undertaken in a modified form to collect scat samples for DNA analysis, with survey results not comparable to previous years. Results presented here are from 2015 to 2020. Overall, there was a substantial decline in activity of Black-footed Rock-wallabies on Newhaven over the period 2015-2020 (Figure 18). This decline is primarily driven by trends in the activity of adult wallabies. Encouragingly, the activity of adult rock-wallabies in the Wartikinpirri population (now within the fenced area) has increased since the fence was constructed in 2018. The activity of sub-adult rock-wallabies detected in scat plot surveys has generally been much less than that of adults (Figure 18 and Figure 19). There have been no clear trends in sub-adult activity over time, other than a spike in numbers in 2019. Whether this is a genuine result, or an artefact of sampling is unknown.

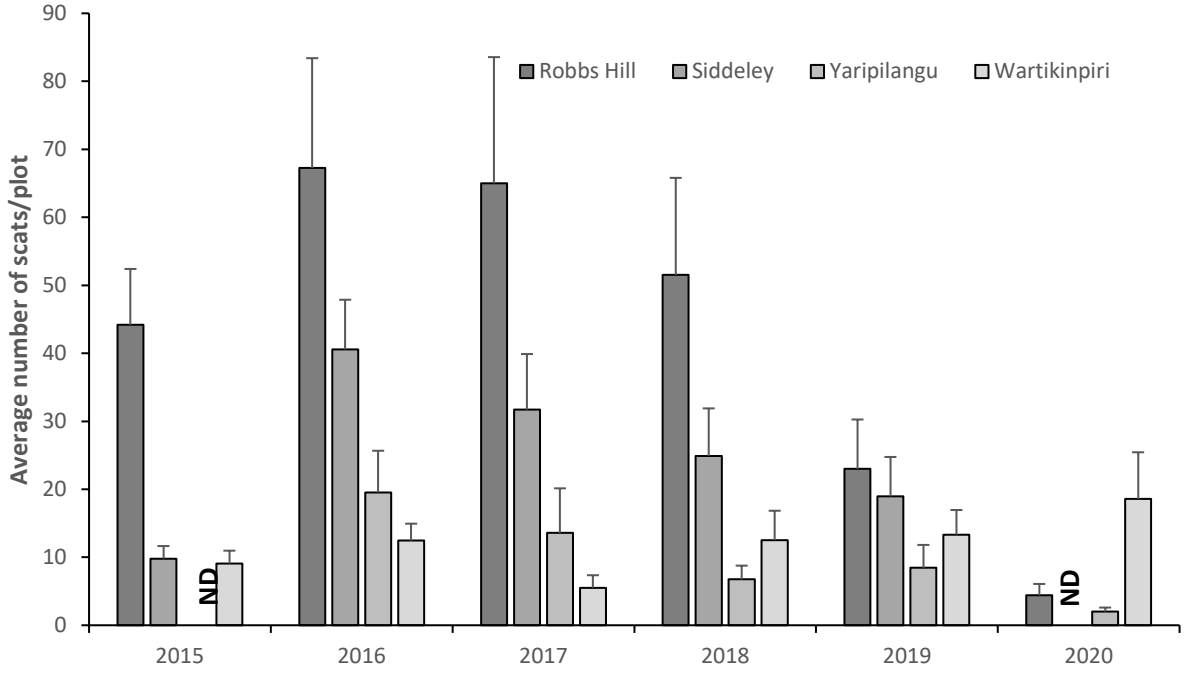

Figure 18. Adult Black-footed Rock-wallaby activity (average number of scats per plot, +/- SE), across each of 4 ranges on Newhaven, 2015-2020. ND = no data.

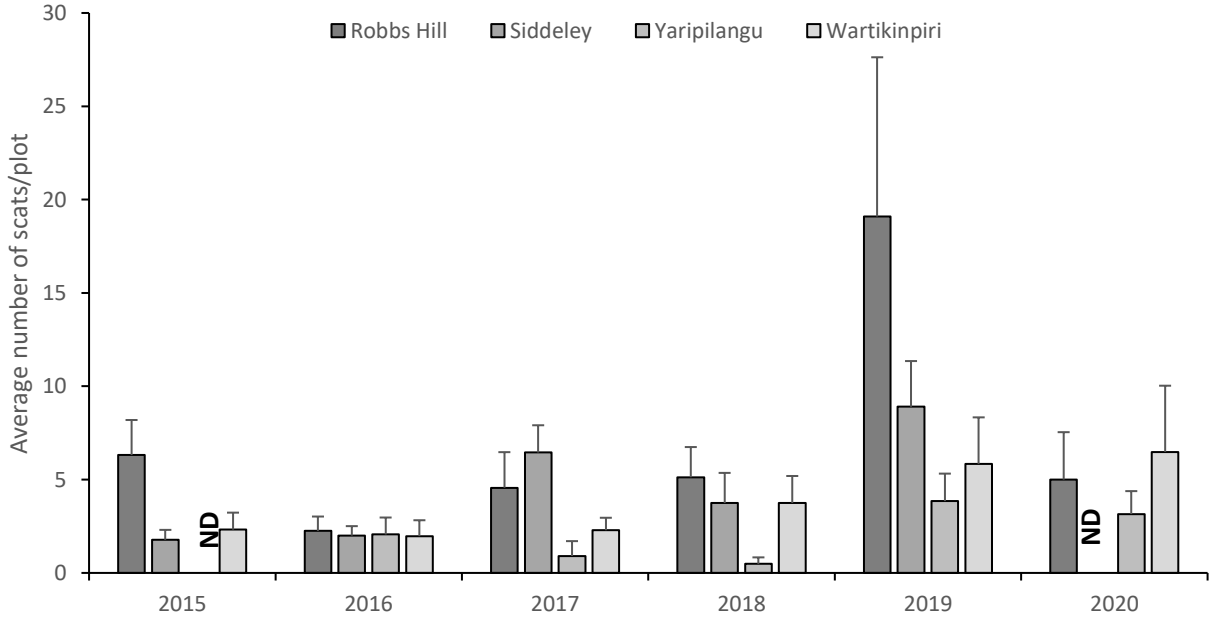

Figure 19. Sub-adult Black-footed Rock-wallaby activity (average number of scats per plot, +/- SE), across each of 4 ranges on Newhaven, 2015-2020. ND = no data.

The 2020 results (Figure 20) show the relatively high levels of activity of adult rock-wallabies in the Wartikinpirri Range population, compared with the 2 locations outside the fence.

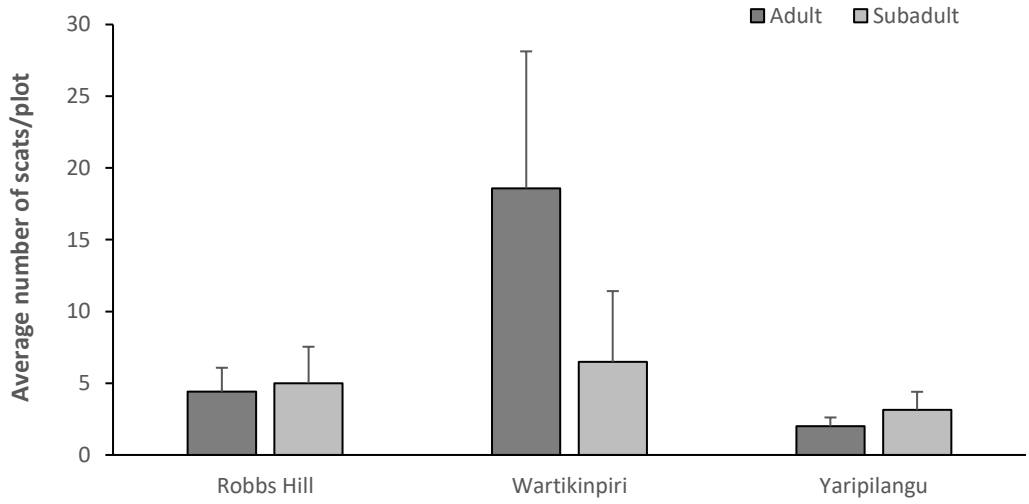

Figure 20. Black-footed Rock-wallaby activity (i.e. average number of scats per plot at each site, +/- SE), classified by adult and sub-adults, for the 3 ranges surveyed on Newhaven in 2020.

Occupancy data (i.e., the proportion of plots with scats) generally show similar patterns to the activity data presented above. There was a decline in the number of plots with adult rock-wallaby scats in 2020 compared with previous years (Figure 21). Nevertheless, in 2020, the population on the Wartikinpirri Range (within the fenced area) had the highest proportion of sites with evidence of adults (62%) and sub-adults (43%), well above figures for the 2 locations outside the fence (Figure 22).

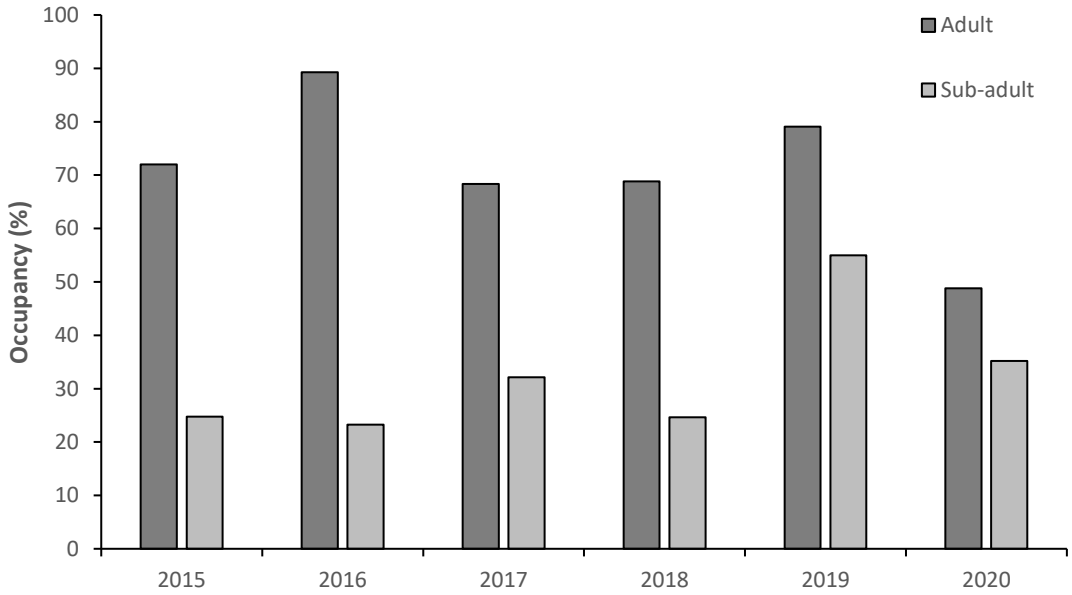

Figure 21. Sanctuary wide occupancy (i.e. proportion of plots with fresh scat) for Black-footed Rock-wallaby, categorised by age-class and year, 2015-2020.

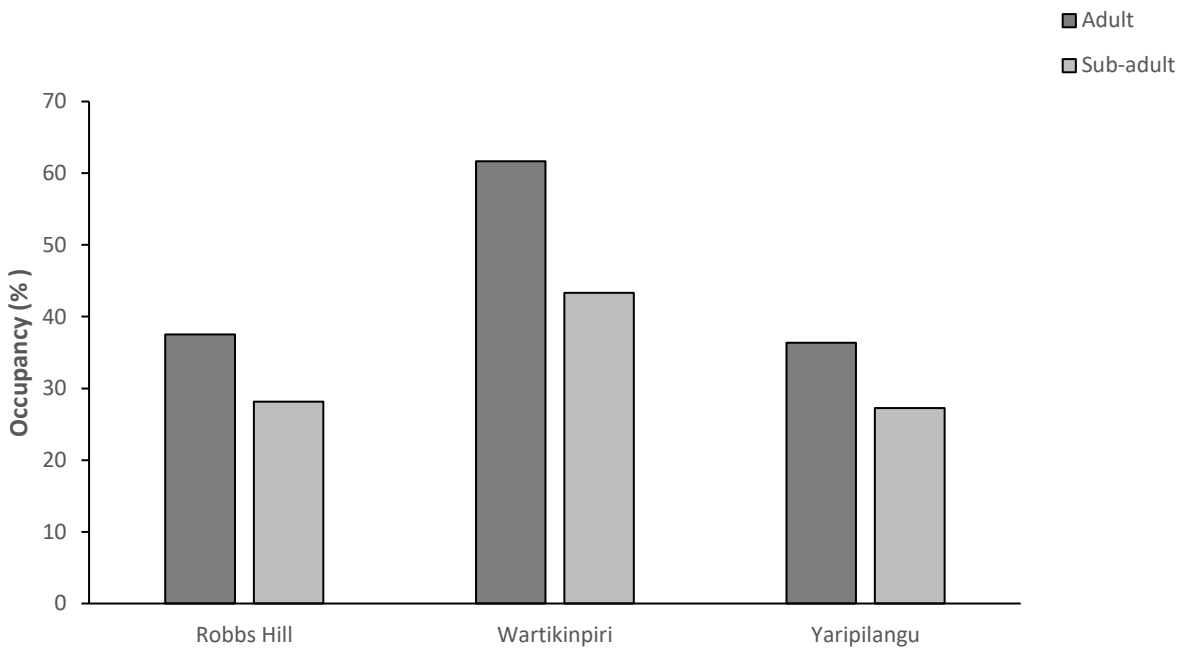

Figure 22. Occupancy at each range in 2020 for Black-footed Rock-wallaby adults and sub-adults.

Occupancy levels declined to very low levels in the outlying Mt Gurner population in 2017 (Figure 23); the population has not subsequently been monitored. On Robbs Hill, a small escarpment outside the fenced area, occupancy was high from 2015-18, but declined in 2019 and 2020 (Figure 23). Occupancy on the 2 other ranges – Wartikinpirri (within the fence) and Yaripilangu (outside the fence) both declined from 2019 to 2020 (Figure 23).

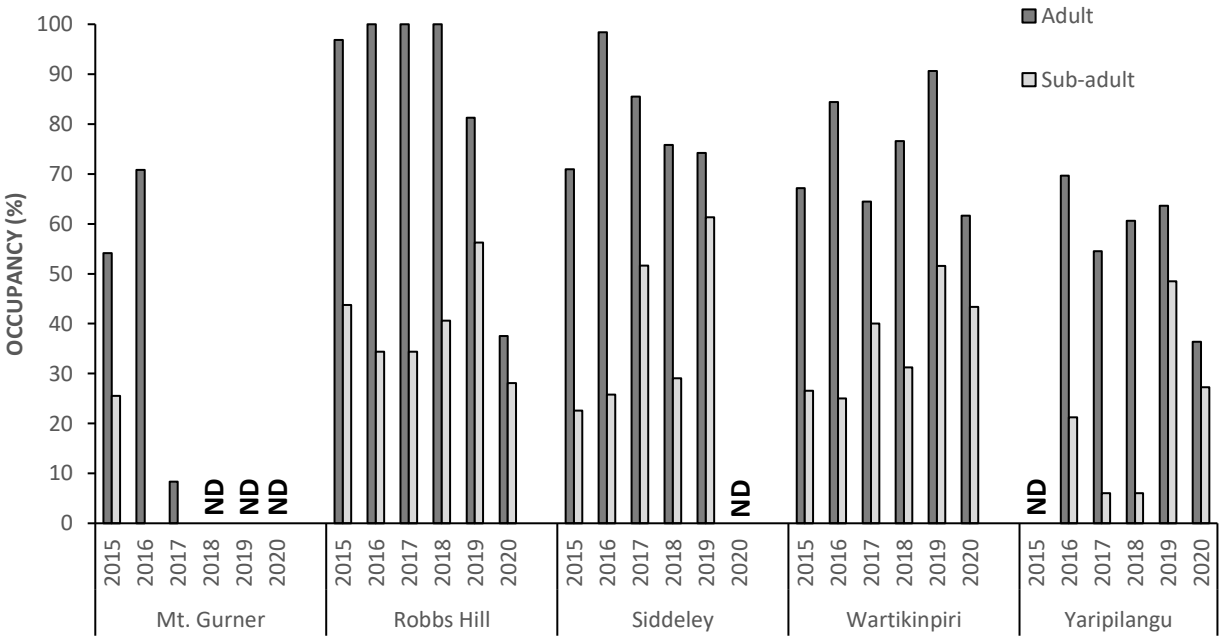

Figure 23. Occupancy of Black-footed Rock-wallaby by age class across each range, 2015-2020. ND = no data.

Great Desert Skink

The Great Desert Skink survey was not undertaken in 2021. The results presented here are from 2015-2020. There was a generally increasing trend in the mean number of active Great Desert Skink burrows at monitored sites over the period 2015-20 (Figure 24). In 2020, across all 8 monitoring sites, 175 burrow systems were located, of which 49% were active, 14.3% inactive and 36% were no longer evident. Overall, 13 of the 175 burrow systems located in 2020 were new.

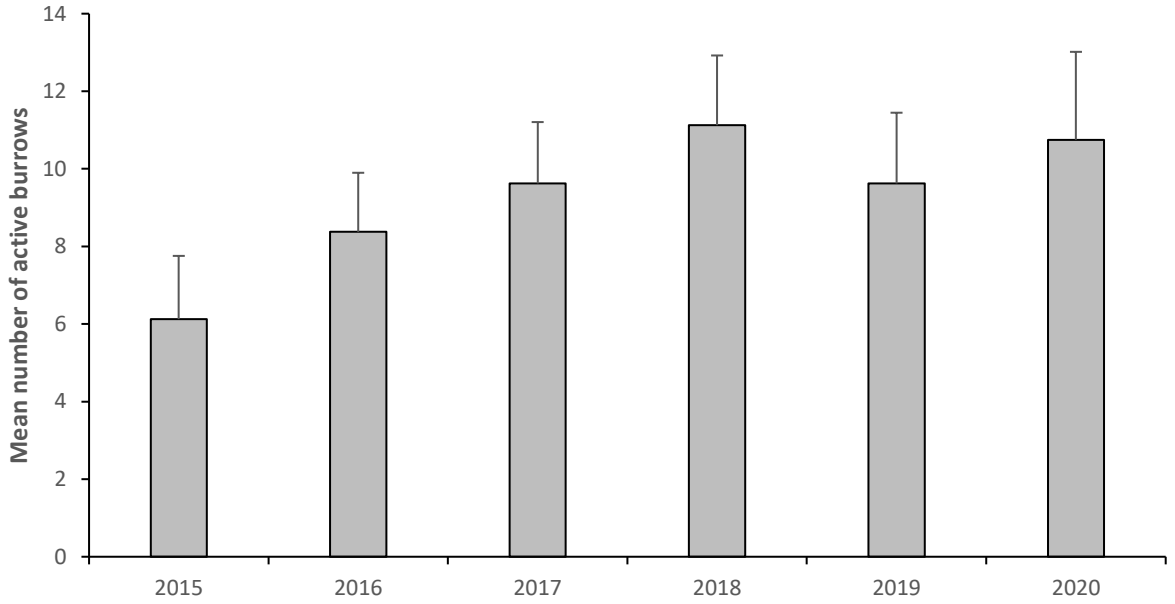

Figure 24. Activity (mean number of active burrows, +/- SE) of Great Desert Skink population, 2015-2020.

Data for trends in activity at each of the 8 monitoring sites are presented in Figure 25. Four of the monitored sites showed an increase in the number of active burrows, with Camel Bore South (CBS) and Honeymoon Lake (HL) experiencing the largest increase in Great Desert Skink activity for 2020, relative to 2019. Activity remained constant at 2 sites, and declined at the remaining 2.

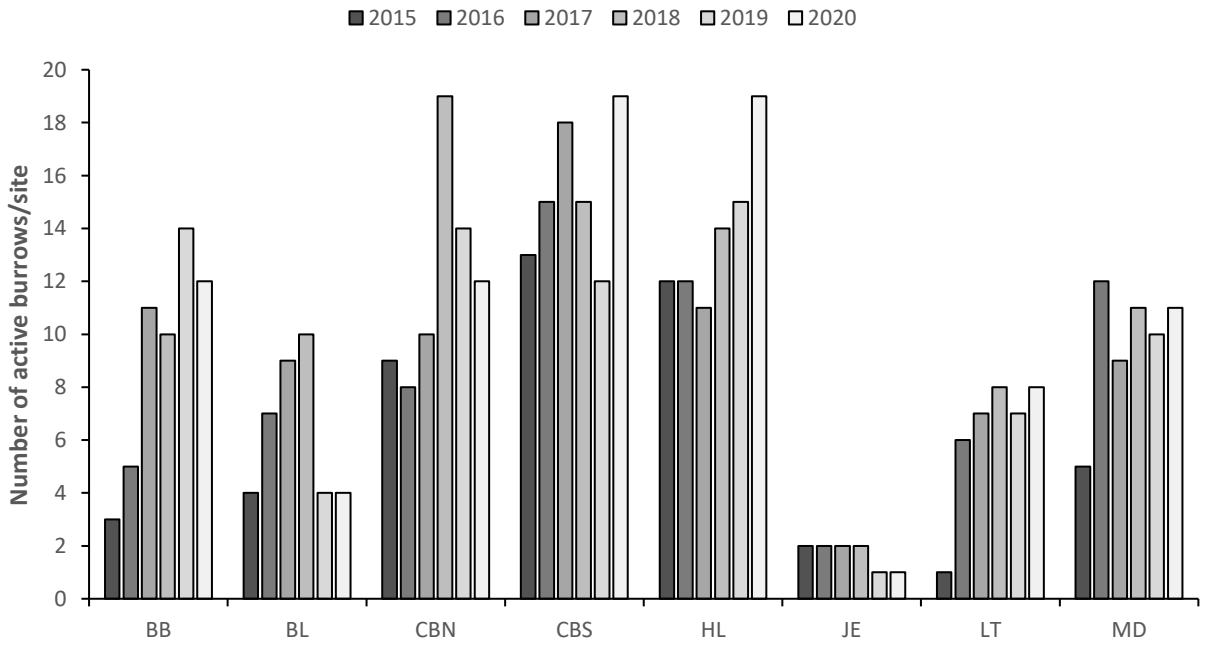

Figure 25. The number of active Great Desert Skink burrow systems at each site, 2015-2020.

The sites monitored for Great Desert Skinks are markedly different in levels of activity, suggesting a range of factors may influence activity, presumably including habitat suitability/ resource availability and predation, particularly by feral cats (Moore et al. 2017).

Assemblages and surveillance species

The annual Standard Trapping Survey for small mammals and reptiles, and the Standard Bird Survey were not undertaken at Newhaven in 2021 thus only assemblage richness has been reported upon.

Mammals

During the period 2008-2019, 11 species in this guild were recorded from 12 known or likely to occur. During the last survey period, in 2019, 9 species in this guild were recorded, from 12 known or likely to occur. Missing species included several irruptive small mammals (dasyurids and rodents) typically only recorded after sustained high rainfall.

Reptiles

From 2008-2019, 70 species in this guild were recorded from 74 extant species known or likely to occur at Newhaven. Missing species were fossorial, and cryptic, requiring targeted search methods.

Birds

From 2007-2019, 156 species in this guild were recorded from 175 extant species known or likely to occur at Newhaven. Missing species were largely irruptive/ nomadic species, usually detected only after substantial rainfall.

Threat indicators

Rabbits

As a result of above average rainfall following 3 years of drought conditions there was an increase in rabbit density in 2021 (Figure 26), with a mean of 0.57 rabbits/ ha recorded. The increase in density is still below the high of 1.05 rabbits/ ha recorded in 2015.

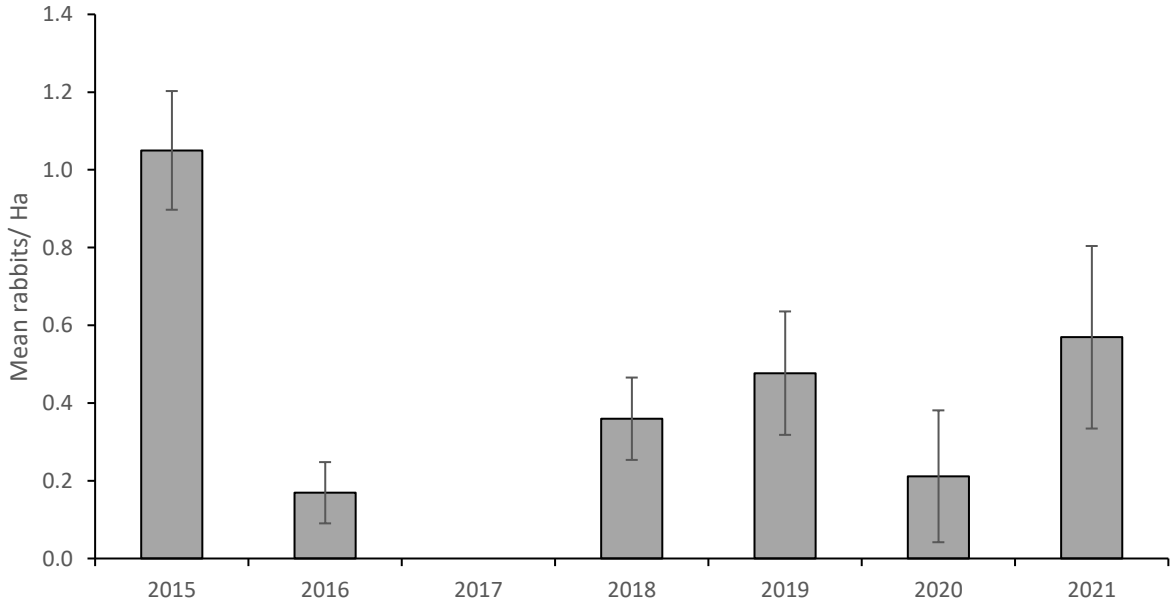

Figure 26. The mean number of rabbits/ ha across area surveyed on Newhaven. The fenced area remains rabbit-free.

Fire

In 2021, with 458 mm, Newhaven had above average annual rainfall after 3 dry years. Much of this rain fell in March (129 mm), resulting in limited success in the prescribed burns in April, May and June. That is, lots of effort was expended with fires not really carrying as conditions were still quite green from the rain and vegetation patchy from the 3 dry years. Conditions in July and August were much better for prescribed burns, with conditions becoming unfavourable in September. In all, 901 ha were burnt during the prescribed burn program and 48% of burn plan objectives completed. Another 24% of objectives were attempted with limited success. A total of 3,088 ha burnt in October 2021 in the western part of Newhaven as a result of deliberately lit fires around 2 broken down vehicles and very strong winds.

Table 10. Fire metrics for Newhaven for 2021.

Indicator	Metric	Baseline	Management Targets	2021 Results		Performance/ comments
1. Fire extent	Proportion (%) and area (ha) of property burnt by:					
	1a. winter fire		n/a	**0.4%**	**901 ha**	Green conditions and patchy vegetation meant fires did not carry well and only a short window for prescribed burns
	1b. prescribed summer fire		n/a	**0%**	**0 ha**	
	1c. summer fire		n/a	**1.2%**	**3,088 ha**	Wildfire in the east of the property in 2021
	1d. all fire types		n/a	**1.6%**	**3,989 ha**	
2. Fire severity	Proportion (%) of: 2a. total annual fire scar caused by severe fires (non-prescribed summer fire)	75.4% (1991-2006)	< 30%	**1.2%**		**On target**
	2b. fire sensitive vegetation communities burnt in severe fires (non-prescribed summer fire)	2.6% (1991-2006)	0%	**2.7%**		**On target**
3. Long unburnt vegetation	3a. Proportion (%) of long unburnt spinifex dominated vegetation communities (10+ rainfall-periods since fire)	51.9% (1998-2006)	25-35%	**28.6%**		**On target**
	3b. Mean distance to long unburnt (10 rainfall periods) vegetation (km)	0.7 km (2001-2006)	n/a	**0.7 km**		**On target**
4. Diversity of age classes in spinifex vegetation communities	Proportion (%) of spinifex dominated vegetation communities within defined age classes:					
	4a. 0 to <3	16%	25-35%	**6.5%**		Outside target

Indicator	Metric	Baseline	Management Targets	2021 Results	Performance/ comments
		(1990-2006)			
	4b. 3 to <10	15.1% (1998-2006)	35-45%	**64.8%**	Outside target
	4c. 10 to <30	No data	15-25%	**21.3%**	**On target**
	4d. 30+	No data	5-15%	**7.3%**	**On target**

Discussion

Prior to 2021 Newhaven had experienced three years of drought conditions. As a result of the La Niña climate cycle there was above average rainfall in 2021. This had a positive impact on the condition, reproductive success and occupation of sites of key species.

The two species of locally-extinct mammals reintroduced to the fenced feral predator-free area on Newhaven in 2021 have met success criteria. With 55% survivorship of radio-collared Red-tailed Phascogales in the first two weeks following release and with nearly half of all camera trap sites occupied across the establishment area during the peak of the breeding season. The generally low occupancy of nest boxes by Red-tailed Phascogales is similar to results obtained for AWC's reintroduction of the species to Mt Gibson (WA), where natural nest sites (e.g., tree hollows, under bark) were likely used in preference to nest boxes. The good levels of occupancy across the establishment area in June and July reflect a level of activity that could be expected during the short Red-tailed Phascogale mating season when males will move widely to increase mating opportunities. This increase in occupancy also indicates that Red-tailed Phascogales are persisting in the establishment area.

Brush-tailed Bettongs met their survival success criteria at 3 months post-release and health check data show that body weight is being maintained at the same levels as at release. Overall mortality following release was relatively low, with 78% survivorship. A proportion of the mortalities occurred within the first two weeks following release, which can be attributed to animals not adapting to the conditions at Newhaven. The other mortalities occurred two to three months post-release, with many of the individuals moving large distances from what were stable home ranges prior to death. It was also observed that several of these individuals had taken up residency on the quartzite range that bisects the fenced area. It is postulated that animals settled on the range due to an abundance of new vegetation that grew in response to the above average rainfall that Newhaven received in early 2021. These resources could have become depleted during the later part of the year before the next good period of rainfall, prompting animals that were possibly underweight to search for new foraging areas. A strong male bias in the mortality rate was observed with 5 out of 6 mortalities were males.

Mala, the first species reintroduced into the fenced area, are showing signs of population increase following favourable weather following drought conditions from release date in 2019 to 2020. Over 80% of adult females were recorded carrying pouch young during the health check and has continued to improve year on year.

The Black-footed Rock-Wallaby and Great Desert Skink surveys did not take place in 2021. New survey methodologies are being developed for these species in 2022 to assist in ascertaining population estimates to better monitor the impact of introduced predators and changed fire regimes. The 2020 Black-footed Rock Wallaby survey result, together with data on trends in activity over time, suggest that the fenced area is helping conserve rock-wallabies on the Wartikinpirri Range, with numbers increasing in that population even through the drought.

In relation to threats, AWC's management of fire on Newhaven has resulted in several targets being met relating to fire extent and seasonality, and the relative distribution of vegetation age-classes (time since fire). While rabbits have increased slightly as a result of the above average rainfall, they have not reached levels that are a cause for concern. A Calicivirus release program was undertaken in 2021 to control the population at selected warrens.

The analysis of fire patterns on Newhaven from the past 30 years highlights that AWC's prescribed burning program has led to changes in these patterns. There has been an increase in the proportion of the property burnt by winter burns and a decrease in the impact on the property by hot summer fire. A small proportion (2.7%) of fire sensitive communities was burnt in summer wildfires in 2021. A finer mosaic of spinifex patches at varying ages has been achieved, and the maximum distance to long-unburnt spinifex has been reduced. The proportion of long unburnt vegetation has been reduced and now falls within management targets, reducing the potential for extensive severe fire.

Acknowledgments

AWC acknowledges the Ngalia-Warlpiri and Luritja people, the Traditional Custodians, of the country on which Newhaven resides. We also acknowledge their continuing connection to land, culture and community. We pay our respects to Ngalia-Warlpiri and Luritja Elders past present and emerging.

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References

BOM (2021a) Climate Data Online - Temperature Station ID 015528 - Bureau of Meteorology (bom.gov.au)

BOM (2021b) Climate Data Online - Monthly Rainfall Station ID 015611 - Bureau of Meteorology (bom.gov.au)

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

Collett R, Kemp L, Anson J, Foulkes J, Kanowski J (2020) *Reintroduction of the Red-tailed Phascogale to Newhaven Wildlife Sanctuary: Translocation Proposal.* 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, Roshier D, Kemp L (2018b) *Translocation of Mala (Lagorchestes hirsutus) from Scotia Wildlife Sanctuary, NSW to Newhaven Wildlife Sanctuary, NT*. Australian Wildlife Conservancy, Perth, WA.

Kanowski J, Skinner K, Anson J, Pierson J, Crisp H, Pierson J (2021a) *Reintroduction of the Brush-tailed Bettong (Bettongia penicillata) to Newhaven Wildlife Sanctuary: Translocation Proposal*. Australian Wildlife Conservancy, Perth, WA.

Latz P, Paltridge R, Holmes J (2003) Vegetation survey of Newhaven Reserve. Unpublished report to the Australian Wildlife Conservancy by Desert Wildlife Services, Alice Springs, NT.

Moore D, Kearney M, Paltridge R, McAlpin S, Stow A (2017). Feeling the pressure at home: predator activity at the burrow entrance of an endangered arid zone skink. *Austral Ecology* 43, 102-109.

Schubert A, Latz P (2015) *Vegetation communities of the central-northern section of Newhaven Wildlife Sanctuary.* Unpublished report to the Australian Wildlife Conservancy by Desert Wildlife Services, Alice Springs, NT.

Schofield J, Cullen D, Moore D (2015) *Newhaven Wildlife Sanctuary Black-footed rock-wallaby (Petrogale lateralis) distribution and activity monitoring protocol*. Australian Wildlife Conservancy, Perth, WA.

Thackway R, Cresswell ID (1995). *An Interim Biogeographic Regionalisation for Australia*. Australian Nature Conservation Agency, Canberra.

Webb T, Diete R, Moore D, Schofield J, Crisp H, Kanowski J (2022) *Newhaven Wildlife Sanctuary: 2021 Fire Pattern Analysis*. Australian Wildlife Conservancy, Perth, WA.

Williams K, Parer I, Coman B, Burley J and Braysher M (1995) *Managing Vertebrate Pests: Rabbits,* Bureau of Resource Sciences and CSIRO Division of Wildlife and Ecology, Canberra.

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