Project Plan SP 2016-030

Dirk Hartog Island National Park Ecological Restoration Project – fauna reconstruction

Animal Science

Project Core Team

Supervising Scientist	Saul Cowen
Data Custodian	Saul Cowen
Site Custodian	

Project status as of Nov. 16, 2020, 3:45 p.m.

Approved and active

Document endorsements and approvals as of Nov. 16, 2020, 3:45 p.m.

Project Team	granted
Program Leader	granted
Directorate	granted
Biometrician	granted
Herbarium Curator	not required
Animal Ethics Committee	granted

Dirk Hartog Island National Park Ecological Restoration Project – fauna reconstruction

Biodiversity and Conservation Science Program

Animal Science

Departmental Service

Service 7: Research and Conservation Partnerships

Project Staff

Role	Person	Time allocation (FTE)
Research Scientist	Saul Cowen	1.0
Technical Officer	Colleen Sims	1.0
Supervising Scientist	Lesley Gibson	0.2
Research Scientist	Kym Ottewell	0.5
Technical Officer	Sean Garretson	1.0
Technical Officer	Kelly Rayner	1.0
Technical Officer	John Angus	0.5
Research Scientist	Allan Burbidge	None

Related Science Projects

SP 2014-003 Cat eradication on Dirk Hartog Island (D Algar *et al*)

Proposed period of the project

July 1, 2016 – June 30, 2030

Relevance and Outcomes

Background

The Australian vertebrate fauna, particularly mammals, has undergone a significant decline since European settlement. Over the last 200 years, 29 mammal species have become extinct, and another 89 taxa are threatened with extinction (Woinarski *et al*. 2014). Many of these declines and extinctions have occurred in the semi-arid and arid areas of Australia (Burbidge and McKenzie 1989, Burbidge *et al*. 2008). Offshore islands have provided refuge for several mammal species that otherwise have declined or become extinct on the Australian mainland (Abbott and Burbidge 1995).

Dirk Hartog Island (DHI) is WA's largest island (58,640 ha) and lies within the Shark Bay World Heritage Area. In 1616 the Dutch navigator Dirk Hartog landed at the northen end of DHI and became the first European to land on the west coast of Australia. From 1860 - 2009 it was a pastoral lease supporting up to 20,000 sheep (*Ovis aries*) at a time. Goats (*Capra hircus*) were introduced to the island in the early 1900s following the construction and operation of a lighthouse at Cape Inscription, and they became feral soon after. Cats (*Felis catus*) are believed to have been introduced to DHI several times over the last 150 years and are now feral (Koch *et al.* 2015). House mice (*Mus domesticus*) have also become feral on the island, and horses (*Equus caballus*) and camels (*Camelus dromedarius*) were present on DHI as part of the pastoral operations (Burbidge and George 1978).

Thirteen species of native terrestrial mammal are known to have occurred on DHI (Baynes 1990, McKenzie *et al*. 2000), however all but three, smaller species have become extinct over the last few hundred years. This

project proposes to reconstruct the island's fauna assemblage by reintroducing 10 species of native mammal and one species of bird, and introducing two other threatened mammal species for conservation reasons, over a 12 year period. Eight of the species that are proposed for translocation to DHI are listed as threatened under the WA *Wildlife Conservation Act 1950* and Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*, and another two species are Conservation Dependent. Many of these species are now restricted to a few offshore islands, or fenced conservation enclosures.

The value of DHI to mammal conservation has been recognised for several decades. In 1975 the Conservation Through Reserves Committee (CTRC 1975) recommended that DHI be included in the conservation estate, but this was not achieved until 2009 when most of DHI became a National Park. In 1995, the pastoral lessee developed an environmental management plan that proposed the eradication of sheep, feral goats and feral cats, and the reintroduction of the native mammals that once occurred on DHI (Saunders 1995). Prior to this, in 1974-78 an attempt was made to establish a population of banded hare-wallabies (*Lagostrophus fasciatus*) on DHI (Prince 1979), but this failed due to drought, overgrazing by sheep and goats and an inability to effectively control feral cats (Short *et al.* 1992). In 2003, the Environmental Protection Authority (EPA) supported the use of Net Conservation Benefits (NCB) funds derived from the Gorgon Gas Development on Barrow Island to be used for the restoration of DHI and reconstruction of its mammal fauna. DHI is also within the Shark Bay World Heritage Property. One of the four criteria for which the Shark Bay area was listed as a World Heritage site was that the area supported important and significant natural habitats where threatened species of animals of outstanding universal value still survive. Reconstructing DHI's mammal fauna will further enhance the values of the World Heritage Property in respect of threatened fauna conservation.

NCB funding has allowed realisation of the vision of restoring DHI to a similar ecological condition to that which existed when Dirk Hartog landed on the island in October 1616. A proposal for the DHI National Park Ecological Restoration Project (DHINPERP) was submitted by the then Department of Environment and Conservation (now Parks and Wildlife) to the NCB Board in 2011 and proposed a two stage process for achieving this (DEC 2011). Stage One (2011-2018) has focussed on the eradication of sheep, feral goats and feral cats, the management of weeds, and implementing a biosecurity program for the island. This was to be followed by Stage Two (2018-2030) that would restore the native mammal species to the island. The DHINPERP was funded by the NCB in 2012 and work on Stage One commenced immediately. With the successful implementation of Stage One, planning is now underway for Stage Two to commence. This project will contribute significantly to the long-term conservation of several threatened species. In addition, by returning the mammal species that were once known on DHI, the ecosystem services provided by their digging, burrowing, grazing and browsing activities will assist in re-establishing the ecological processes to support plant communities. It will be the largest ecological restoration project undertaken in Australia, and possibly the world.

Stage One of the DHINPERP has progressed well and since 2010 over 7,000 sheep and feral goats have been removed from the island. As at June 2017, two radio-collared 'Judas' goats remained and these will be removed by November 2017. The island was split into two management areas by a cat-proof fence to facilitate effective cat eradication. Following baiting and trapping programs since 2014, good progress has been made with removing feral cats and eradication will be confirmed by September 2018. No black rats (*Rattus rattus*) have been detected, either on DHI, or in the broader Shark Bay area (Palmer 2017). Weed management is ongoing. Vegetation assessment by Landsat imagery has shown that there has been a 35% increase in vegetation cover, predominantly in the south part of DHI, since sheep and goat removal began (van Dongen and Huntley 2016).

In anticipation of Stage Two of the DHINPERP proceeding, a strategic framework to guide the fauna reconstruction and conservation program on DHI 2017 - 2030 was prepared (Morris *et al.* 2017). This Project Plan provides details about planning and implementing the translocation program, the research required to support the translocation program, and the research that could be undertaken once fauna populations have been established on DHI.

It is proposed to undertake a trial release of 10-12 banded hare-wallabies and 10-12 rufous hare-wallabies (*Lagorchestes hirsutus*) in August / September 2017 to trial collection and transport techniques, and develop adequate monitoring protocols for use on DHI. Providing this trial is successful, 40-50 of each species will be translocated in September/October 2018 and 2019. Providing this translocation is successful, the translocation program for the other 10 mammals species and one bird species, as outlined in the Milestones and Tasks below, will be implemented over a 12 year period.

Aims

The aim of Stage Two of the DHINPERP is to re-establish up to 10 terrestrial native mammal species and one bird species on Dirk Hartog Island and establish up to two native mammal species that may have previously occurred there, along with healthy vegetation and ecosystem processes to sustain the islands biodiversity (Parks and Wildlife 2017).

Specifically this project aims to:

a) Identify the most suitable source populations to act as founders for new populations on DHI, using the criteria set out in the Strategic Framework (Morris *et al.* 2017).

b) Establish new populations of 12 mammal species and one birds species on DHI, using the species selection criteria set out in the Strategic Framework (Morris *et al.* 2017).

c) Confirm that the translocations are successful and that all new populations on DHI are healthy and self-sustaining, using criteria set out in the Strategic Framework (Morris *et al.* 2017) and approved Translocation Proposals.

d) Promote scientific research associated with the translocations, monitoring and establishment of fauna, and publish scientific findings.

Expected outcome

This project will achieve one of the key outcomes identified in the Wildlife strategic priorities in the Parks and Wildlife Strategic Directions document 2014-2017 - "With external partnerships, restore the original suite of native fauna to Dirk Hartog Island National Park".

Specifically, if successful, this project will significantly increase distributions and populations sizes of eight species of threatened mammal (rufous hare-wallaby, *Lagorchestes hirsutus;* banded hare-wallaby, *Lagostrophus fasciatus*; woylie, *Bettongia penicillata*; dibbler, *Parantechinus apicalis;* chuditch, *Dasyurus geoffroii*; western barred bandicoot, *Perameles bougainville*; heath mouse, *Pseudomys shortridgei*; and Shark Bay mouse, *Pseudomys fieldi*), two Conservation Dependent species (boodie, *Bettongia lesueur*; and greater stick-nest rat, *Leporillus conditor*), and a Priority species (mulgara, *Dasycercus blythi*). This will potentially lead to an improvement in conservation status for all of these species. The only island population of the desert mouse (*Pseudomys desertor*) will be established, and the return of the only bird species known to have become extinct on DHI, the western grasswren (*Amytornis textilis textilis*) will also be accomplished.

The re-establishment of medium-sized native mammals will also allow many of the ecological services that these diggers and burrowers provided, to be returned to the DHI ecosystem. In addition, opportunities for research at all stages of the translocation program will be provided resulting in a better understanding of fauna translocation processes and the values of fauna on ecosystem management.

Knowledge transfer

This will be the largest island fauna restoration project in Australia and possibly the world, and there will be global interest in the outcomes and the techniques used. Knowledge and technology transfer to other organisations contemplating fauna translocations to islands will be through reports, publication of peer-reviewed manuscripts and presentations at conferences. Communication of results to the Shark Bay community will be undertaken via the DHINPERP Community Engagement Strategy. Media statements will be issued via PICA to highlight significant events in the projects implementation.

Tasks and Milestones

2017 - Trial translocation of banded hare-wallabies and rufous hare-wallabies:

1. February-August : planning for fauna translocations (prepare SPP, undertake genetic audit, select source populations, prepare translocation proposals, AEC approvals, staff employment).
2. June-July: undertake site selection for release of hare-wallabies and dibblers.
3. August: monitor source populations on Bernier and Dorre Islands,
4. October: monitor rufous hare-wallabies on Trimouille Island and Shark Bay mouse on North West Island (Montebellos), collect further tissue samples for DNA analysis.
5. September-December: undertake trial translocations of rufous and banded hare-wallabies to DHI, monitor outcomes.

6. October-November: capture dibblers for captive breeding colony at Perth Zoo. Undertake monitoring of DHI small vertebrates in conjunction with Global Gypsies.

2018 - Translocations of banded and rufous hare-wallabies, and dibbler:

1. January-October: dibbler breeding program at Perth Zoo for release on DHI in October 2018.
2. February: prepare a publications schedule.
3. February-June: monitor hare-wallabies on DHI, obtain ecological and biological data.
4. March: report on 2017 monitoring source populations and trends, confirm sources of hare-wallabies for Sept/Oct translocations, prepare translocation proposal for dibblers, obtain AEC approvals.
5. June: report on 2017 trial translocations and monitoring of hare-wallabies and small vertebrates.
6. August-October: monitor source populations on Bernier and Dorre Islands, Salutation Island, and North West and Trimouille Islands.
7. September-December: undertake translocations of rufous and banded hare-wallabies (larger numbers), and dibblers (in early Oct using 2018 progeny), monitor outcomes.
8. October-November: capture dibblers for captive breeding colony at Perth Zoo (for June 2019 restocking), undertake monitoring of DHI small vertebrates.

2019 - Restocking of banded and rufous hare-wallabies and dibblers, reintroductions of boodies and western barred bandicoots:

1. January-March: capture dibbler founders for restocking release on DHI in April (females with young).
2. February-June: monitor hare-wallabies and dibblers on DHI, obtain ecological and biological data.
3. March: report on 2018 monitoring source populations and trends, confirm sources of boodies and western barred bandicoots for Sept/Oct translocations, prepare translocation proposals for boodies and western barred bandicoots, obtain AEC approvals.
4. April: undertake restocking of hare-wallabies, monitor outcomes.
5. June: undertake dibbler restocking with females and pouch young (early June), report on 2018 translocations and monitoring of hare-wallabies and dibblers, and small vertebrates.
6. August-October: monitor source populations on Bernier and Dorre Islands, Salutation Island, and North West and Trimouille Islands.
7. September-December: undertake translocations of boodies and western barred bandicoots, monitor outcomes.
8. October-November: undertake monitoring of DHI small vertebrates.

2020 - Restocking of boodies and western barred bandicoots, reintroductions of Shark Bay mice and stick-nest rats:

1. February-June: monitor hare-wallabies, dibblers, boodies and western-barred bandicoots on DHI, obtain ecological and biological data.
2. March: report on 2019 monitoring source populations and trends, confirm sources of Shark Bay mice and stick-nest rats for Sept/Oct translocations, prepare translocation proposals for Shark Bay mice and stick-nest rats, obtain AEC approvals.
3. April: undertake restocking of boodies and western barred bandicoots, monitor outcomes.
4. June: report on 2019 translocations and monitoring of hare-wallabies, dibblers, boodies and western barred bandicoots, and small vertebrates.
5. August-October: monitor source populations on Bernier and Dorre Islands, Salutation Island, and North West and Trimouille Islands, Shark Bay mainland (grasswren) and south-west locations (woylie).
6. September-December: undertake translocations of Shark Bay mice and stick-nest rats, monitor outcomes.
7. October-November: undertake monitoring of DHI small vertebrates.

2021 - Restocking of Shark Bay mice and stick-nest rats, reintroduce western grasswren and woylie:

1. February-June: monitor hare-wallabies, dibblers, boodies, western-barred bandicoots, Shark Bay mice and stick-nest rats on DHI, obtain ecological and biological data.
2. March: report on 2020 monitoring source populations and trends, confirm sources of western grasswren and woylie for Sept/Oct translocations, prepare translocation proposals for western grasswren and woylie, obtain AEC approvals.
3. April: undertake restocking of Shark Bay mice and stick-nest rats, monitor outcomes.
4. May: survey for heath mice at Lake Magenta, south coast, Victoria; and Shark Bay area for western grasswren.
5. June: report on 2020 translocations and monitoring of translocated fauna, and small vertebrates.
6. July: capture heath mice and commence captive breeding program at Perth Zoo.

7. August-October: monitor source populations on Bernier and Dorre Islands, Salutation Island, and North West and Trimouille Islands, Shark Bay mainland (grasswren), south-west locations (woylie), and Matuwa (desert mouse).

8. September-December: undertake translocations of western grasswren and woylie, monitor outcomes.

9. October-November: undertake monitoring of DHI small vertebrates.

2022 - Restocking of western grasswren and woylie, reintroduce heath mouse and desert mouse:

1. February-June: monitor hare-wallabies, dibblers, boodies, western-barred bandicoots, Shark Bay mice and stick-nest rats, grasswren and woylie on DHI, obtain ecological and biological data.

2. March: report on 2021 monitoring source populations and trends, confirm sources of heath mouse and desert mouse for Sept/Oct translocations, prepare translocation proposals for heath mouse and desert mouse, obtain AEC approvals.

3. April: undertake restocking of western grasswren and woylie, monitor outcomes.

4. May: survey for desert mouse and mulgara at Matuwa.

5. June: report on 2021 translocations and monitoring of translocated fauna, and small vertebrates.

6. July: assess potential founder stock of heath mice available from Perth Zoo, provide additional founders if necessary for restocking in 2023.

7. August-October: monitor source populations on Bernier and Dorre Islands, Salutation Island, and North West and Trimouille Islands, Shark Bay mainland (grasswren), south-west locations (woylie), and Matuwa (desert mouse).

8. September-December: undertake translocations of heath mouse (captive stock) and desert mouse, monitor outcomes.

9. October-November: undertake monitoring of DHI small vertebrates.

2023 - Restocking of heath mouse and desert mouse, reintroduce mulgara:

1. February-June: monitor hare-wallabies, dibblers, boodies, western-barred bandicoots, Shark Bay mice and stick-nest rats, grasswren, woylie, heath mouse, desert mouse on DHI, obtain ecological and biological data.

2. March: report on 2022 monitoring source populations and trends, confirm sources of mulgara for Sept/Oct translocations, prepare translocation proposal for mulgara, obtain AEC approval.

3. April: undertake restocking of heath mouse (captive stock) and desert mouse, monitor outcomes.

4. May: survey for mulgara at Matuwa.

5. June: report on 2022 translocations and monitoring of translocated fauna, and small vertebrates.

6. August-October: monitor source populations on Bernier and Dorre Islands, Salutation Island, and North West and Trimouille Islands, Shark Bay mainland (grasswren), south-west locations (woylie), and Matuwa (desert mouse).

7. September-December: undertake translocations of heath mouse (captive stock) and desert mouse, monitor outcomes.

8. October-November: undertake monitoring of DHI small vertebrates.

2024 - Restocking of mulgara, reintroduce chuditch:

1. February-June: monitor hare-wallabies, dibblers, boodies, western-barred bandicoots, Shark Bay mice and stick-nest rats, grasswren, woylie, heath mouse, desert mouse and mulgara on DHI, obtain ecological and biological data.

2. March: report on 2023 monitoring source populations and trends, confirm source of chuditch for Sept/Oct translocation, prepare translocation proposal for chuditch, obtain AEC approval.

3. April: undertake restocking of mulgara, monitor outcomes.

4. June: report on 2023 translocations and monitoring of translocated fauna, and small vertebrates.

5. August-October: monitor source populations on Bernier and Dorre Islands, Salutation Island, and North West and Trimouille Islands, Shark Bay mainland (grasswren), south-west locations (woylie, chuditch), and Matuwa (desert mouse, mulgara).

6. September-December: undertake translocations of chuditch, monitor outcomes.

7. October-November: undertake monitoring of DHI small vertebrates.

2025 - Restocking chuditch, monitoring:

1. February-June: monitor hare-wallabies, dibblers, boodies, western-barred bandicoots, Shark Bay mice and stick-nest rats, grasswren, woylie, heath mouse, desert mouse, mulgara and chuditch on DHI, obtain ecological and biological data.

2. March: report on 2024 monitoring source populations and trends.

3. April: undertake restocking of chuditch, monitor outcomes.

4. June: report on 2024 translocations and monitoring of translocated fauna, and small vertebrates.

5. August-October: monitor source populations on Bernier and Dorre Islands, Salutation Island, and North West and Trimouille Islands, Shark Bay mainland (grasswren), south-west locations (woylie, chuditch), and Matuwa (desert mouse, mulgara).
6. September-December: monitor translocated fauna on DHI.
7. October-November: undertake monitoring of DHI small vertebrates.

2026 Monitoring, analyse data, publish results:

1. February-June: monitor hare-wallabies, dibblers, boodies, western-barred bandicoots, Shark Bay mice and stick-nest rats, grasswren, woylie, heath mouse, desert mouse, mulgara and chuditch on DHI, obtain ecological and biological data.
2. March: report on 2025 monitoring source populations and trends.
3. June: report on 2025 translocations and monitoring of translocated fauna, and small vertebrates.
5. August-October: monitor source populations on Bernier and Dorre Islands, Salutation Island, and North West and Trimouille Islands, Shark Bay mainland (grasswren), south-west locations (woylie, chuditch), and Matuwa (desert mouse, mulgara).
6. September-December: monitor translocated fauna on DHI.
7. October-November: undertake monitoring of DHI small vertebrates.

2027 - June 2030 Monitoring, analyse data, publish results:

1. January-December: analyse data, publish results
2. February-June: monitor translocated fauna on DHI, obtain ecological and biological data.
3. March: report on monitoring source populations and trends.
4. June: report on monitoring of translocated fauna, and small vertebrates.
5. August-October: monitor source populations.
6. September-December: monitor translocated fauna on DHI.
7. October-November: undertake monitoring of DHI small vertebrates.

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Study design

Methodology

1. Site Description

DHI is WA's largest island with an area of 58,640 ha (Abbott and Burbidge 1995). It lies at approximately 25°50'S 113°0.5'E (centroid) at the western edge of the Shark Bay World Heritage Area. The island is approximately 79km long and has a maximum width of 11km with its long axis in a south-east to north-west direction.

DHI is classified as a 'Coastal Dune' geomorphic district (Payne *et al*. 1987) and consists of coastal dunes and undulating plains of shallow calcareous sand over limestone or calcrete. Five land systems occur on the island, three of which (Coast, Edel and Inscription collectively form 99% of the island; Payne *et al*. 1987) and are described below:

Coast: occurs along the entire western side of the island and consists of large long-walled parabolic dunes and narrow swales, unstable blow-out areas and bare mobile dunes, minor limestone hills and rises and steep sea cliffs (41.9%);

Edel: occurs in eastern and south-eastern parts of the island and consists of undulating sandy plains with minor low dunes, limestone rises and saline flats (32.5%);

Inscription: is found in the north-east and central-east of the island. It consists of gently undulating sandy plains over limestone (24.3%);

The two remaining land systems are Birrida (0.7%) and Littoral (0.6%).

Vegetation on the island is generally sparse, low and open and comprises spinifex (*Triodia*) hummock grassland with an overstorey of *Acacia coriacea*, *Pittosporum phylliraeoides* over *Acacia ligulata*, *Diplolaena dampieri*, *Exocarpus sparteus* shrubs over *Triodia* sp., *Acanthocarpus preissii* and *Atriplex bunburyana* hummock grasses, chenopods or shrubs (Beard 1976). Adjacent to the exposed western coastline is a mixed open chenopod shrubland of *Atriplex* sp., *Olearia axillaris* and *Frankenia* sp. and slightly inland in more protected sites, *Triodia plurinervata*, *Triodia* sp., *Melaleuca huegelii*, *Thryptomene baeckeacea* and *Atriplex* sp.. There are patches of bare sand and several birridas (salt pans). On the east coast there are patches of mixed open heath of *Diplolaena dampieri*, *Myoporum* sp. and *Conostylis* sp. shrubs (Beard 1976). The overall height of the vegetation reduces towards the north of the island.

The climate of the region is 'semi-desert Mediterranean' (Beard 1976; Payne *et al*. 1987). The mean annual rainfall for Denham (recording station 006044, located 37km to the east of DHI) is 224mm (Bureau of Meteorology 2013; long-term records 1893-2013). The wettest month is June with an average of 55mm. February is the hottest month with a mean daily maximum of 31.8°C while July is the coolest month with a mean daily maximum of 21.7°C. Prevailing winds are southerly in the morning swinging to the south-west in the afternoon with the sea breeze (Bureau of Meteorology 2013).

Between the 1860s and 2009, DHI was managed as a pastoral lease and grazed by sheep (*Ovis aries*) and goats (*Capra hircus*). More recently, tourism has been the main commercial activity on the island. Cats were probably introduced by early pastoralists and became feral during the late 19th century (Burbidge 2001). Most of the island became a National Park in November 2009, and this provided the opportunity to reconstruct the native mammal fauna as had been proposed earlier (Saunders 1995). DHI could potentially support one of the most

diverse mammal assemblages in Australia and contribute significantly to the long-term conservation of several threatened species.

2. Translocation Proposals

The fauna translocations proposed for DHI will comply with the relevant Parks and Wildlife Corporate Policy and Guidelines (Parks and Wildlife 2015 a, b), and the *Animal Welfare Act 2002*. A Translocation Proposal (TP) will be prepared for each of the 13 species to be translocated to DHI. These will contain background biological and ecological information of the species being translocated, what source populations will be used and why, and how the founders will be captured and transported to DHI. Short, medium and long-term criteria for translocation success or failure will be established, and monitoring implemented to allow these to be assessed.

Founders will be released at pre-determined sites at dusk, usually within 24 hours of being captured. Methodologies for monitoring short - medium term survivorship (fate over time) for most mammal species will involve the use of either VHF or GPS telemetry attachments (collars or tail mounted transmitters). Longer term monitoring of survivorship will use trapping, camera traps and spotlighting techniques. Monitoring of the the translocated western grasswren will be through the use of coloured leg bands and field observations. Animal Ethics approvals will be obtained before translocations commence.

3. Genetic audit

a) Sampling and DNA extraction

Genetic samples will be taken from animals during each phase of the fauna reconstruction process, i.e. the initial audit of potential source populations, founder populations released onto DHI, and new recruits as part of the regular post-release monitoring.

Ear biopsy samples will be obtained from mammals using a sterilised 1-2mm ear notching tool following standard operating procedures (Department of Parks and Wildlife, 2015). Tissue samples will be stored in 80-100% analytical grade ethanol under cool conditions before transport to the lab. Genomic DNA will be extracted from tissue samples using a standard 'salting out' protocol (Sunnucks and Hales, 1996) and stored at -20C until use. Where biopsy samples cannot be obtained, scats may be used as an alternative DNA source, though these can be less reliable than tissue. Scat DNA will be extracted using the Qiagen DNA Stool Mini-Kit following the manufacturer's protocol and stored at -20C until use.

For birds, blood or feather samples will be obtained and DNA extracted using the 'salting out' protocol (feathers) or Qiagen DNeasy Blood and Tissue kit (blood).

b) Genotyping

Different methods will be used to obtain genetic data from sampled animals dependent on (i) the choice of the most appropriate genetic marker type to address the research question, and (ii) the availability and need to integrate with existing data.

Microsatellites: For several species, microsatellite marker data are available from previously published studies. In cases where it is most efficient and informative to complement existing data to answer specific research questions we will utilise these existing markers. Microsatellite primers will be obtained from published studies and PCR amplified using the Qiagen Multiplex PCR kit following manufacturer's protocols. Microsatellite genotype profiles will be obtained through fragment analysis at the State Agricultural Biotechnology Centre (SABC) at Murdoch University.

RADsequencing: New genomic techniques such as RADseq offer a means of generating large numbers of informative markers relatively rapidly and cheaply, increasing the power of genetic analyses. RADseq will be used to provide genetic assessment of source populations and for genetic monitoring post-translocation. It is anticipated that RADseq data will be generated using a commercial service, Diversity Array Technologies (DART).

Exon capture: An alternative genomic approach, exon capture, may be employed when appropriate to address taxonomic questions (e.g. distinguishing sub-species of mala *Lagorchestes hirsutus*). Exon captures and sequencing will be performed at ANU as part of the Oz Mammal Genomics initiative.

c) Data analysis

Genetic assessment of source populations

To assess the genetic 'health' of source populations we will estimate genetic diversity using several metrics, (e.g. observed and expected heterozygosity, allelic richness), the level of observed inbreeding (F_{IS}) and the degree of relatedness (*r*). Genetic differentiation amongst source populations will be assessed by several metrics including the use of clustering approaches (e.g. STRUCTURE, PCA) and estimation of the fixation index, F_{ST}.

Where practical we will aim to source animals from populations with high genetic diversity, low inbreeding and to source animals from multiple populations to maximise genetic diversity represented in the translocated population on DHI. Mixing of divergent populations will be assessed against the framework proposed in Frankham *et al*. (2011) to minimise risks of outbreeding depression. Population viability analysis using VORTEX software (Lacy

and Pollack, 2014) and incorporating both genetic and demographic data will be used to inform translocations by estimating numbers of individuals required to maximise genetic diversity and genetic representativeness and assess mixing ratios where multiple source populations are used.

Genetic monitoring of translocated populations

We will assess the genetic 'health' of translocated populations on DHI at regular intervals, with tissue collection occurring during annual monitoring. It is anticipated that genetic analyses will be conducted at two year intervals for species with high breeding capacities, and three year intervals for species with a lower breeding capacity (see Table 1). At each interval we will estimate the population genetic diversity (observed and expected heterozygosity, allelic richness) and inbreeding/relatedness, and assess changes in these metrics over time. We will aim to sustain genetic diversity levels over the longer time frame at 95% that of the starting population; supplementations (genetic augmentation) may be recommended in order to maintain population genetic diversity and minimise inbreeding. Population viability models will be updated with genetic and demographic monitoring data to inform ongoing management activities, for example, the number and timing of supplementations (if required).

Table 1: Anticipated timetable for genetic analyses to monitor the genetic health of translocated populations on Dirk Hartog Island. T = translocation; S = supplementation (re-stocking); GA = genetic analyses.

Species	Breed	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
BHW	slow	T	T	S	GA			GA			GA			GA
RHW	slow	T	T	S	GA			GA			GA			GA
Dibbler	fast		T	S	GA		GA		GA		GA		GA	
Boodie	slow			T	S	GA			GA			GA		
WBB	fast			T	S	GA		GA		GA		GA		GA
SBM	fast				T	S	GA		GA		GA		GA	
GSNR	fast				T	S	GA		GA		GA		GA	
WGWren	slow					T	S	GA			GA			GA
Woylie	fast					T	S	GA		GA		GA		GA
HeathM	fast						T	S	GA		GA		GA	
DesertM	fast						T	S	GA		GA		GA	
Mulgara	fast							T	S	GA		GA		GA
Chuditch	slow								T	S	GA			GA

4. Monitoring source populations

a) Spotlight transects for mammals

Bernier and Dorre Islands

Bernier and Dorre Islands were divided into blocks of two or four transect lines, based on Short *et al.* (1989) and / or placed in proximity to safe landing points. Five blocks of four transects were established, 500m apart (total of 20 transects) running in an east-west direction and were marked for spotlighting on each island from 2006 to 2010. Transects were marked with a 1.8 m jarrah stake driven into the ground and marked at the top with reflective tape, with the start or finish of the transect set above high water mark or at a cliff-top. This was supplemented by reflective tape being placed on high vegetation such as *Acacia* spp. The spacing between the markers was variable but generally a few hundred metres and where possible placed on high points, but varied depending on terrain and vegetation. From 2011 to 2013 transect locations, number of transects (an additional seven transects were added) and survey frequencies were modified to meet Distance analysis requirements. The average transect length on Bernier Island is 4.8 km and on Dorre Island 5.4 km. Their locations have been mapped, and GPS coordinates recorded.

Between 2006 and 2013, the transects were walked by a team of two people at no faster that 3km/hr or less. One team member would use a 30w LightForce SL170 Striker spotlight to spot for animals and navigate by spotting the reflective tape on the markers. The spotter needed to maintain a line as close as possible to the transect line by navigating between the reflective markers. The other team member would walk behind the spotter and when an animal was sighted would take a GPS waypoint on the line where the spotter is, then go to where the animal was first sighted and either take another GPS waypoint or pace the perpendicular distance back to the transect line. The distance from the transect line would be calculated by either converting the recorders pacing distance to meters or subtracting the Northing of the animal location from Northing of the transect line.

From 2016 onwards, each team of two were equipped with a Trimble Juno J41 Series 5 hand held computer, TruPulse 360B laser range finder (www.TechnologyOneCorp.com) and a Lightforce Striker 170 35w HID spotlight fitted with a Lithium Ferrous P04 9amp hour battery (www.lightforce.com). The Juno J41 Series 5 runs Trimble Terrasync (www.Trimble.com) mapping and GIS software and has all the required spotlighting transects for each island installed as shapefiles, as well as any other required or relevant GIS mapping information, i.e. landing points, island boundary shape files etc. The range finder connects wirelessly via Bluetooth to the Juno J41 Series 5 computer.

Teams walk at no more than 3km/hour. The team member operating the spotlight and rangefinder pinpoints the animal's location with the range finder. Navigation and data recording are undertaken by the other team member using the Juno computer, and the transect line is maintained by following the transect shapefile on the hand-held computer. When an animal is sighted the data recorder records the species, number sighted and location of the team. The spotter pinpoints the animal's location using the rangefinder, the location of the animal is then automatically transmitted to the hand held computer.

Trimouille Island

Mala on Trimouille Island are monitored using Distance sampling as per the 2016 methodology for hare-wallabies on Bernier and Dorre Island above. Trimouille Island has 10 transects running east west, and are 500m apart, covering the full length of the island. These have been mapped and their GPS coordinates recorded.

b) Trapping for mammals: Cage and Elliott traps

Bernier and Dorre Islands

Additional monitoring on Bernier and Dorre Islands using cage and Elliott trap grids is undertaken to target western barred bandicoots as they are likely not adequately monitored and/or potentially underestimated by Distance analysis alone due to their more cryptic nature and small size. Opportunistically, boodies are capture during these trapping sessions and are concurrently monitored in the process. Shark Bay mice are monitored on Bernier Island using Elliott traps alone as spotlighting does not adequately census this small species.

At White Beach (Dorre Island) a 7 x 7 trap grid with traps at 40m spacings has been established to the east of the dunes, covering a mixed habitat of travertine, *Scaevola* spp. and *Triodia* sp. vegetation. At each trap site, an Elliott and cage trap is set, baited with a mixture made up of rolled oats and peanut butter. Sardines are not used to reduce the likelihood of the traps being inundated by meat ants (*Iridomyrmex* sp.) which can be prolific in some areas of the islands and pose a risk to entrapped animals.

Two grids have been established on Bernier Island at Red Cliff Bay. One 7 x 7 grid (as above) has been established in suitable habitat, predominately of *Triodia* sp., *Scaevola* sp. and some fringing *Spinifex* sp. just west of the dunes, approximately 500m east of Red Cliff. A 7 x 3 grid to monitor Shark Bay mice has been established in suitable habitat (predominately *Spinifex* sp.) in consolidated dunes approximately 300m west south west of Red Cliff (Figure 4). Each trap site has an Elliott trap baited the standard bait (as above).

The locations of all the grids and traps on Bernier and Dorre Islands have been mapped and their coordinates recorded.

Standard morphometric measurements (pes length, head length, and scrotal width), weight and reproductive status of females recorded, and tissue samples for DNA analysis taken for each captured animal. Boodies are western barred bandicoots are permanently marked with Allfex Passive Integrated Implants (www.allflex.com.au), any captured rodents are marked using the standard ear clipping numbering system.

North West Island

A trapping grid has been established in *Spinifex longifolius* consolidated coastal habitat on North West Island, Montebello group, to monitor Shark Bay mice. The trapping grid is same layout as on Bernier Island so that capture rates can be compared. The grid location has been mapped and GPS coordinates recorded. Morphometric measurement, marking and tissue sampling are as above.

c) Hand netting of mammals

Morphometric and tissue samples are obtained from the two hare-wallaby species by hand-netting at night. A team of six people are required, made up of four runners/netters, one spotlighter and one equipment carrier. Two runners walk approximately 10m abreast both side of the spotter with the equipment carrier following up close behind. When an animal is sighted the spotlighter maintains the light on it while the runners move up slowly encircling the animal, generally the animal remains still and is easily netted. Animals that do move away can be chased down however, pursuits are restricted to no more than 100m to reduce stress to the animals and the possibility of females ejecting pouch young.

d) Mist-netting birds and field observations

It is anticipated that the founder western grasswrens will be sourced from the nearby Shark Bay mainland, possibly Peron Peninsula. A survey for potential source sites will be undertaken using experience ornithologists, and two - three source sites will be selected 12 months before grasswren translocations are planned. The

grasswren populations at these sites will then be monitored to obtain estimates of abundance. Mist nets will be used to capture a sample of the population, and captured birds will be weighed, sexed where possible, measured and marked with coloured leg bands. Swabs and blood samples for health screening and genetic analysis may be taken.

e) Data Analysis

Distance (Spotlighting)

Transect parameters and fauna observations are modelled using Distance 6.2 software (Thomas *et al.* 2010), to account for diminishing probability of detection with increasing distance from the transect line. The design of the analysis was a line transect 80m wide (40m each side of the transect), single observer and single observations of fauna at distances perpendicular to the transect. Conventional distance sampling was used to model the probability of detection as a function of the distance from the transect line via size bias regression and bootstrapped variance (Buckland *et al.* 1993; Buckland *et al.* 2001).

Akaike's Information Criterion was used to select the 'best' fitting models from amongst the following: uniform cosine, uniform simple polynomial, half-normal cosine, hazard rate cosine and hazard rate simple polynomial (see Buckland *et al.* 1993; Buckland *et al.* 2001 for more information). The best fitting models were used to estimate population sizes for the areas surveyed and these were extrapolated to estimate total population sizes for each Island. The data were log transformed to ensure they met the assumptions of the tests and *t*-tests were used to compare population sizes between islands.

Cage and Elliott Trapping

Spatially explicit capture-recapture (SECR) analysis of the cage and Elliott capture data is undertaken using Program Density 5.03 (http://www.otago.ac.nz/density). Estimates of population densities of western barred bandicoots, boodies and Shark Bay mice can also be derived using inverse prediction and/or maximum likelihood models to fit the data.

5. Translocation Protocols

Animal capture

Founder mammals from source populations will be captured using the trapping and / or hand netting methods described above. Once captured the mammals will be marked, weighed, measured, and placed in black cloth bags and tagged with species and capture location. Data will be recorded either on standardised data sheets or into a hand held computer.

Founder grasswrens will be mist netted at the source sites. The nets will be erected at dawn, then checked and cleared before the heat of mid-morning. Nets will be dismantled or furled when not being attended. Captured birds will be weighed, measured, sexed where possible, fitted with coloured leg bands, and placed in calico bags in small, well-ventilated boxes.

Transport

Method of transport will be dependent on species being translocated at the time. Larger species will be individually bagged and placed in airline-approved pet carriers (K9 Pet Carrier 53 x 37 x 37 cm PP20). Bags will be secured within the pet carriers to the corners to prevent animals rolling on each other during transit. Due to their relative sizes, two hare- wallabies will be placed in each pet carrier, boodies and bandicoots can be transported in groups of up to four. Smaller species (smaller than western barred bandicoots) will be transported within Elliott traps placed within pet carriers. Depending on sea conditions, animals may need to be taken off the islands in water tight containers but should only be secured in these for the duration from transferring them from shore and to the charter vessel. Founder mammals will be transported to DHI either onboard a sea-going charter vessel, or an aircraft (fixed-wing or helicopter), or a combination of both.

Founder birds will be transported to release site(s) on DHI by either air-conditioned vehicles, or aircraft, or a combination of both. Birds will be released in the mid afternoon, within 6-8 hours of capture.

Stress and sedation: Rufous hare-wallaby / mala

Rufous hare-wallabies/mala are prone to capture myopathy, causing death, and there is anecdotal information than the Shark Bay sub-species may be more prone to capture induced stress than mala found on Trimouille Island (C. Simms, pers comm.).

It is recommended to inject rufous-hare-wallabies / mala (particularly Shark bay RHW) with Vitamin E to reduce the likelihood of capture myopathy. If it is used, Vitamin E injections should be given on initial capture to prevent possible capture myopathy from subsequent stress events such as transport. SelVit E (Ilium Selvite E, Troy, Australia) has been used in the past, administered intramuscular (IM) at a rate of 0.2ml/kg. However, this product is no longer sold in Australia. An alternative injectable prophylactic Vit E will need to be used.

To reduce the impact of additional stressors such as transport it may be necessary to sedate the animals. Veterinarian advice recommends the use of neuroleptic agents to induce a calm and tranquil state, and reduce stress. The following procedure is recommended to sedate the animals for transport:

- Initial use (as soon as possible after capture) of Diazepam at a lower dose rate (1mg/kg IM). Diazepam (Troy, Australia) will only provide sedation for up to a few hours (at most) and suggest combining it with a short-acting neuroleptic agent, Azaperone.
- An hour (approx.) after the Diazepam has been administered – administer the neuroleptic Azaperone (Stresnil®, Ausrichter, Australia) at a rate of 2 mg/kg IM which has a sedation duration of 3-8 hours.

Neuroleptic agents are less effective if the animal is already stressed when injected and less effective in creating a tranquil state. Therefore, it is important to give the Diazepam first (which is not affected in the same manner by the animal's state).

A decision on whether to use Vitamin e to reduce capture myopathy and / or neuroleptic agents to reduce stress will be made after further discussions with veterinarians and others who have translocated rufous hare-wallabies / male previously.

6. Release site selection

The release sites for the species to be translocated to DHI will be selected based on knowledge of their habitat and dietary preferences recorded in the published and unpublished literature. Release sites will also be selected using physical features (e.g. cat barrier fence, large, unvegetated sand dunes) to restrict wide-ranging movements in the early stages of translocations. Recorded interactions between translocated species (e.g. boodies and woylies) will also be taken into account when release sites are selected. The details of release sites and the reasons they were selected will be provided in the Translocation Proposals being prepared for each species.

The adequate availability and abundance of suitable invertebrate prey items is important for the success of dibbler translocations. A survey of prey items on DHI will be undertaken prior to dibbler releases in 2018 and 2019. This will involve the systematic sampling of litter for invertebrates > 3mm during periods of moist soil conditions (so the invertebrates are active). Litter samples will be collected, labelled and stored in plastic bags and the invertebrate fauna extracted using heat lamps. The location and vegetation association of each collection site will be recorded. Survey sites will be in the vicinity of the vehicle tracks on DHI, which offer transects in north-south and east-west directions.

7. Determining the success of translocations on DHI

The success of translocations will be assessed against short, medium and long term criteria which will be detailed in the Translocation Proposals for each species. These criteria will be based on survivorship, reproduction and recruitment, and occupancy and distribution. Monitoring using several techniques will be implemented to provide the information required to determine success / failure.

a) Radio Tracking

Short term monitoring of survivorship and habitat use will be undertaken using radio-telemetry. Before release on DHI, a proportion of founder mammals (up to 50%) will be fitted with either VHF mortality sensing radio-collars, or GPS radio-collars. As part of the pilot translocation of banded and rufous hare-wallabies in 2017, all of the founder hare-wallabies will be fitted with either a VHF Ultimate mortality sensing radio collars (Sirtrack, New Zealand) to provide information on survivorship, movements and refuge selection; or a FLR V GPS collar (Telemetry Solution, USA) to obtain finer scale movement information. All collars will have a degradable elastic insert to ensure collars breakaway over time.

Novel techniques using unmanned aeronautical vehicles (UAVs), or drones, as aerial platforms for radiotelemetry are currently being developed and there will be opportunities to use the DHI fauna translocations to develop these in collaboration with third parties.

Released mammals will be monitored intensively for the first 10-12 weeks post-release, then less frequently, depending on the outcomes of the intensive monitoring. It is anticipated that radio-collars will breakaway, or be removed after trapping the animals by six months post-release. GPS locations can be down loaded remotely from the FLR V collars as required.

b) Camera Traps

Once founder populations have established, medium to longer-term monitoring of relative abundance and habitat use will be achieved using camera traps, either in linear transects, or in grids.

c) Trapping

Longer term monitoring of population trends, demograhics and reproductive biology will be undertaken using trapping grids and transects.

8. Data analysis

Morphometric measurements, age, sex and bodyweight data taken for all animals captured and translocated will be stored on an MS Access database. A body condition index will be derived for each mammal individual using a relationship between body weight and a measure of size such as pes or head length. Capture data from

monitoring sites will be analysed to detect population trends using Program MARK and used to assist population viability analyses using VORTEX software. Population estimates at potential source sites will be undertaken using Program DISTANCE where spotlighting transects are used and SECR where trapping is used. Estimates of population size and condition of translocated populations will be compared annually and reported.

Survivorship of translocated fauna will be determined using the Kaplan-Meier estimate based on knowledge of numbers of founders released alive and the number who subsequently die.

9. Other research

This project offers many research opportunities to improve conservation management of threatened species, and for assessing the impact of the removal of pest animal species, and the impact of re-establishing a suite of native fauna on a large island in a semi-arid environment. A framework to guide this research has been prepared (Morris 2017) and this identifies three broad research themes to focus research programs. These research themes are a) better planning, implementing and monitoring fauna translocations, b) understanding the role and impacts of translocated fauna, and c) understanding the ecology and biology of threatened species.

Currently two research projects are being planned.

a) Impact of pest species and translocated fauna on DHI ecosystems

Monitoring house mice and small vertebrates

The house mouse and small vertebrate fauna of DHI were monitored from 2008-2013 (prior to eradication of sheep, goats and cats, and translocations of native fauna) by Shark Bay District staff. Eight monitoring sites were established encompassing most of the major vegetation types on the island. Each site consisted of two paired parallel lines of pit traps (each line consisted of 3 x 20 L bucket alternated with 3 x 150mm diam PVC tube, 60 cm deep) approximately 30 m apart. In addition two parallel lines of six medium Elliott traps were set approximately 10 m from the pit lines. The beginning and end of each pit line was marked with a dropper post, and the first pit trap in each line marked on a GPS. Monitoring was undertaken annually (usually in October/November) with traps open for 4-5 nights for each trapping session. Animals captured were identified, weighed and measured, and released after being temporarily marked (e.g. with a permanent marking pen). Species lists and relative abundances have been prepared for each trapping site, and this equates to baseline data (pre-removal of pest species and before arrival of translocated species). These pit lines also offer the opportunity to sample and document the larger invertebrate fauna of DHI, which has not previously been undertaken.

These monitoring sites will be surveyed again in October / November 2017 and each year for at least the next seven years. Additional monitoring sites may be added in November 2017 to cover some vegetation types that are not adequately sampled at present (e.g. *Triodia* dominated sites, coastal sites). Animals captured will be processed as before and data recorded on datasheets. Animals that can not be confidently identified at site will be taken back to camp for identification using field keys. Some tissue (scale, tail tip etc) may be taken for DNA analysis. All animals will be released alive near the point of capture unless a new species for DHI is captured, in which case it will be either euthanased and preserved, or transported to Perth and provided to the WA Museum.

b) Better planning, implementing and monitoring fauna translocations

Prey abundance and release site selection for dibblers on Dirk Hartog Island National Park

The Endangered dibbler (*Parantechinus* apicalis) is one of the 10 species of mammal proposed for reintroduction to Dirk Hartog Island (DHI), in the Shark Bay World Heritage Area, as part of the DHI Ecological Restoration Project. If successful the establishment of a dibbler population on this 60 000 ha island would substantially improve its overall abundance and distribution and potentially lead to an improvement in its conservation status. One of the keys to the successful re-establishment of dibblers on DHI is their release in suitable habitat with adequate leaf litter and invertebrate food source. Assessments of these factors are recommended prior to any dibbler translocation.

Reintroduction of dibblers to DHI is planned for both October 2018 (sub adults) and May 2019 (females with pouch young). Prior to this DHI needs to be surveyed for a) leaf litter and ground debris, and b) medium-large invertebrates (> 3mm length) that would be suitable as a dibbler food source. The sampling survey would be based around the existing north – south track which runs for the length of the island (ca 80 km), some east – west tracks that cross the island (up to 15 km), and some other limited access tracks. Survey methodology would follow previous dibbler food availability assessments. It would include mapping areas of litter and rating these as good / abundant litter, moderate / adequate litter, and poor / little or no litter. Invertebrate sampling at a selection of good, adequate and poor sites would then be undertaken. There would be the opportunity to determine any trends in litter and prey abundance on DHI, and for comparison of results with other assessments (e.g. Jurien Bay islands and mainland sites). Parks and Wildlife researchers would use the results of this work to identify suitable dibbler release sites.

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Biometrician’s Endorsement

granted

Data management

No. specimens

None of the species targeted for translocation to DHI will be intentionally taken as specimens, unless they die unexpectedly. This may occur through the capture and transport process, the fitting of telemetry devices, or soon after release. Any unexpected deaths will be accurately recorded and reported to the Animal Ethics Committee.

Tissues taken for genetic analyses will be registered and stored in ethanol at the WA Conservation Science Centre.

Any individuals captured during the small vertebrate monitoring program, and thought to be new species for DHI will be taken as specimens for the WA Museum. These may be euthanased on site, or transported to the WA Museum alive.

Herbarium Curator's Endorsement

not required

Animal Ethics Committee's Endorsement

granted

Data management

Field data will be collected either on a pre-formatted PDA, or datasheets. It will be uploaded / input into either an MS Excel spreadsheet, or MS Access database. Data will be backed up on the Woodvale server. Translocation details will be added to the corporate translocation database, and trapping data incorporated into FaunaFile.

There will be a coordinated approach to link animal capture / sample collection data to genetic data and demographic data in one database location. A unique ID (potentially the PIT number) will be allocated to each specimen and this will be carried through on all data forms.

Budget

Consolidated Funds

Source	Year 1	Year 2	Year 3
FTE Scientist	0.50	0.50	0.50
FTE Technical			
Equipment			
Vehicle			
Travel			
Other			
Total	100,000	100,000	100,000

External Funds

Source	Year 1	Year 2	Year 3
Salaries, Wages, Overtime	325,000	561,900	578,800
Overheads	14,800	19,100	19,700
Equipment	27,000	25,000	27,000
Vehicle	30,000	33,000	35,000
Travel	30,600	36,500	37,300
Other	319,100	400,800	306,900
Total	746,500	950,200	1,004,700