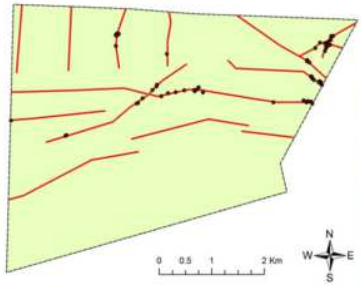

The conservation and management of the bilby (*Macrotis lagotis*) in the Pilbara

M. A. Dziminski and F. Carpenter

Annual Report 2017 - 18

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GOVERNMENT OF WESTERN AUSTRALIA

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Summary

The greater bilby (*Macrotis lagotis*) is a burrowing marsupial that was once widespread across most of mainland Australia. Since European colonisation, the introduction of the cat and fox, changed fire regimes, the degradation of bilby habitat through pastoralism, introduced herbivores, and clearing, the range and abundance of greater bilbies have contracted severely and bilbies have disappeared from at least 80 % of their former range.

Populations of bilbies still persist in parts of the Pilbara. The aim of this project is to improve our understanding of the distribution, and demographics of bilbies in the Pilbara, and provide information to environmental regulators and resource development companies that will allow appropriate management to ensure the persistence of this species in the Pilbara.

An extensive data set of bilby records in the Pilbara continues to be collated from existing sources and field surveys. So far 3222 plots have been surveyed across the Pilbara with bilby presence detected at 718 plots. The furthest, western-most currently known wild bilby population was documented 145 km SSW of Port Hedland. The standardised 2 ha Sign Plot technique was further developed and simplified, with new apps and datasheet made available.

In order to promote standardisation and comparability, draft guidelines based on best practice techniques used within Western Australia and nationally, have been developed for pre-clearing searches to locate resident bilbies and relocation of bilbies prior to vegetation clearing

These will guide more efficient, standardised and comparable techniques for bilby searches prior to vegetation clearing and best practice techniques for managing bilbies within areas of vegetation clearing.

The technique developed to monitor numbers of bilbies within populations by genotyping individuals using DNA extracted from scats has been developed in previous years. A calibration of this technique was undertaken to assess the accuracy in measuring numbers of individuals within populations. This study was undertaken within an exclosure that contained a known number of recently translocated bilbies. This study showed that the abundance monitoring technique reliably censuses individuals within populations.

Trial fire management was implemented at a bilby population which was assessed as under risk of being impacted by wildfire. A fire management plan was developed and the area of habitat of the bilby population was protected from wildfires by creating controlled burn and mineral earth fire breaks and grading tracks. This trial will provide information on protection of bilby populations from large, hot wildfires and a plan and technique developed to apply similar fire management at other bilby populations.

1 Introduction

The greater bilby (*Macrotis lagotis*) is a burrowing marsupial that was once widespread across most of mainland Australia (Marlow 1958; Southgate 1990a; Friend 1990; Gordon *et al.* 1990; Johnson and Southgate 1990; Abbott 2001; Abbott 2008; Bradley *et al.* 2015; Figure 1). The greater bilby is now listed as Vulnerable under the Commonwealth *EPBC Act* 1999 (EPBC 1999); Schedule 3 - Fauna that is rare or is likely to become extinct as vulnerable fauna, under the Western Australian *Wildlife Conservation Act* 1950 (Government of Western Australia 2015); and internationally listed as Vulnerable on the IUCN Red List of Threatened Species (IUCN 2014).

Since European colonisation of Australia, the range and abundance of greater bilbies have contracted severely (Southgate 1990a; Bradley *et al.* 2015; Figure 1). Since the late 1800s, greater bilbies have disappeared from at least 80 % of their former range (Southgate 1990a; Figure 1), and the lesser bilby (*Macrotis leucura*), a closely related species, has become extinct (IUCN 2008). The decline in bilbies has been attributed to a number of threats working directly or in combination with each other. These threats include predation by introduced cats and foxes (Paltridge 2002; Bradley *et al.* 2015), changed and inappropriate fire regimes (Southgate and Carthew 2006; Southgate and Carthew 2007; Southgate *et al.* 2007; Bradley *et al.* 2015), and the degradation of bilby habitat through pastoralism, introduced herbivores, and clearing (Southgate 1990a; Pavey 2006; Bradley *et al.* 2015; Department of Environment 2016).

The current distribution of the greater bilby (hereafter referred to as the bilby) is now restricted to the Tanami Desert, Northern Territory (Johnson and Southgate 1990), the Great Sandy and Gibson Deserts, parts of the Pilbara and Kimberley in Western Australia (Friend 1990), and an outlying population between Boulia and Birdsville in south-west Queensland (Gordon *et al.* 1990). In the Pilbara, bilbies occur approximately east of a line extending south of Karratha (Figure 1 and Figure 2). In WA, bilbies have been successfully reintroduced to Francois Peron National Park in Shark Bay, and Matuwa IPA (Lorna Glen) in the northern Goldfields.

From the literature summarized in Table 1, suitable habitat for bilbies can be defined as level or undulating plains including watercourses and dune systems, composed of cracking clay, soil or sand that allows burrowing, with vegetation consisting of open-tussock Mitchell grass (in SW Queensland) or hummock grassland (spinifex), with low shrubland, usually *Acacia* dominated. Habitat which is steep and/or rocky which does not allow burrowing may be used for foraging if it is adjacent to suitable burrowing habitat. The critical characteristic of suitable habitat for bilbies is the availability of a soil or sand substrate that enables the construction of burrows.

The aim of this project is to improve our understanding of the distribution, and demographics of bilbies in the Pilbara, and provide information to environmental regulators and resource development companies that will allow appropriate management to ensure the persistence of this species in the Pilbara.

Specifically, the objectives of this project are to:

1. Gather recent and historic records in order to understand and predict the distribution of bilbies in the Pilbara
2. Develop and implement a broad-scale survey technique
3. Develop a fine-scale population monitoring technique and implement long-term population monitoring
4. Understand the effects on demographics of bilby populations in the Pilbara

A draft recovery plan was prepared in 2006 (Pavey 2006), however, this was superseded by an interim conservation plan in 2015 (Bradley *et al.* 2015). The aim and objectives of this project are consistent with the goals and actions of the interim conservation plan (Table 2). In particular, this project addresses the goal to implement a program of priority research (Bradley *et al.* 2015).

In order to seek broad collaborative agreement on the research agenda, the Western Australian Department of Parks and Wildlife hosted a workshop where research priorities were identified through a facilitated process (Cramer *et al.* 2017). Five key areas for future research effort were identified:

1. Refine survey methods appropriate for all habitat types
2. Improve understanding of habitat use in relation to substrate type and food resources
3. Improve understanding of the genetic structure of (meta)populations
4. Improve understanding of the threat posed by introduced predators and herbivores
5. Improve understanding of how fire regimes affect bilby conservation

The aim and objectives of this project also align with the research priorities for the greater bilby in the north of Western Australia (Table 2; Cramer *et al.* 2017).

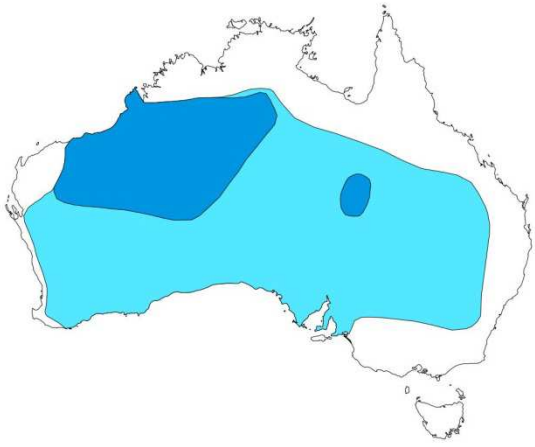

Figure 1. Current (■) and former (■) distribution of the greater bilby.

Table 1. Published accounts of suitable bilby habitat characteristics.

Substrate	Vegetation	Terrain	Area	Reference
Soils from 0.6 m depth to siliceous sands >2 m depth. Textures of soils from coarse sand to light medium clay. Uniform texture profiles, non-calcareous gradational soils and duplex soils	Woodlands of low (<10 m) trees with *Acacia* spp. rich understorey. Shrub steppe communities, to tussock/forb grasslands in SE Queensland.	Level plains to undulating plains and rises, gently inclined, slope never exceeding 6 %.	Central deserts and SE Queensland	Southgate (1990b)
Stone-free Cretaceous sediments of cracking clays, friable on the surface (usually 35 % clay) with a denser (45-70 % clay) subsoil	Grassland downs, Mitchell grass (*Astrebla pectinata*) and feathertop wiregrass (*Aristida latifolia*) in the form of open-tussock grassland, saltbush (*Atriplex* spp.) herblands and open succulent shrubland of Queensland bluebush (*Chenopodium auricomum*) and canegrass (*Eragrostis australasica*)	Adjacent to watercourses, not hilly.	SW Queensland	Lavery and Kirkpatrick (1997)
Sandy soils with rocky outcrops, laterite rises and low-lying palaeodrainage systems	Spinifex grasslands (mainly *Triodia basedowii*, *T. pungens* and *T. schinzii*) with low shrub cover of *Acacia* spp. *Melaleuca* spp. in palaeodrainage channels.	Rises and low-lying drainage systems	Tanami Desert, Northern Territory	Southgate *et al.* (2005)
Dune and sand substrate, laterite/rock features and drainage/calcrete substrates	Three spinifex or hummock grass species (*Triodia pungens*, *T. schinzii*, and *T. basedowii*), with an overstorey of scattered shrubs and trees; shrub species	Rises and low-lying drainage systems	Tanami Desert, Northern Territory	Southgate et al. (2007)
Cracking clays, sandplains, dunefields sometimes containing laterite, massive red earths.	Mitchell grass (*Astrebla pectinata*), hummock grassland (*Triodia* spp.) and *Acacia* shrubland.	Plains, dune fields.	Extant range	Johnson (2008)

Table 2. Alignment of this project with the goals of the interim conservation (Bradley *et al.* 2015) and research priorities for the greater bilby in the north of Western Australia (Cramer *et al.* 2017).

Objectives of this project	Alignment with the interim conservation plan goals (Bradley *et al.* 2015)	Alignment with research priorities for the greater bilby in the north of Western Australia (Cramer *et al.* 2017)
1. Gather recent and historic records in order to understand and predict the distribution of bilbies in the Pilbara	5. Share, collate and report information effectively	2. Improve understanding of habitat use in relation to substrate type and food resources
2. Develop and implement a broad-scale survey technique	4. Agree and implement monitoring and survey methods	1. Refine survey methods appropriate for all habitat types 2. Improve understanding of habitat use in relation to substrate type and food resources
3. Develop a fine-scale population monitoring technique and implement long-term population monitoring	4. Agree and implement monitoring and survey methods	1. Refine survey methods appropriate for all habitat types 3. Improve understanding of the genetic structure of (meta)populations 4. Improve understanding of the threat posed by introduced predators and herbivores 5. Improve understanding of how fire regimes affect bilby conservation
4. Understand the effects on demographics of bilby populations in the Pilbara	1. Manage predators effectively 6. Manage appropriate fire regimes 7. Mitigate grazing and land-use issues	3. Improve understanding of the genetic structure of (meta)populations 4. Improve understanding of the threat posed by introduced predators and herbivores 5. Improve understanding of how fire regimes affect bilby conservation

2 Collation of current and historic distributional data

Current and historic records of bilbies in the Pilbara have continued to be accessed from the following sources:

- Published literature
- "Grey" literature (including consultants and CALM/DEC/Parks and Wildlife reports)
- Western Australian Department of Parks and Wildlife, Western Australian Museum (WAM) and other national databases
- Liaison with Parks and Wildlife staff, ecologists, consultants and land holders/users
- Field trips to the Pilbara region

To date 1724 records of bilbies have been collated and populated into the Pilbara Threatened Fauna Database (Figure 2) which is linked to display records through the Department's NatureMap portal (DBCA 2018). Records collated range from 1901 to 2018 and peak between 2010 and 2018 (Figure 3).

2.1 Management implications

- Better understanding of where bilbies are present in the Pilbara for environmental impact assessment (EIA) processes.
- Sufficient presence data now gathered to enable development and improvement of habitat suitability modelling for bilbies in the Pilbara (see Dziminski and Carpenter 2017).

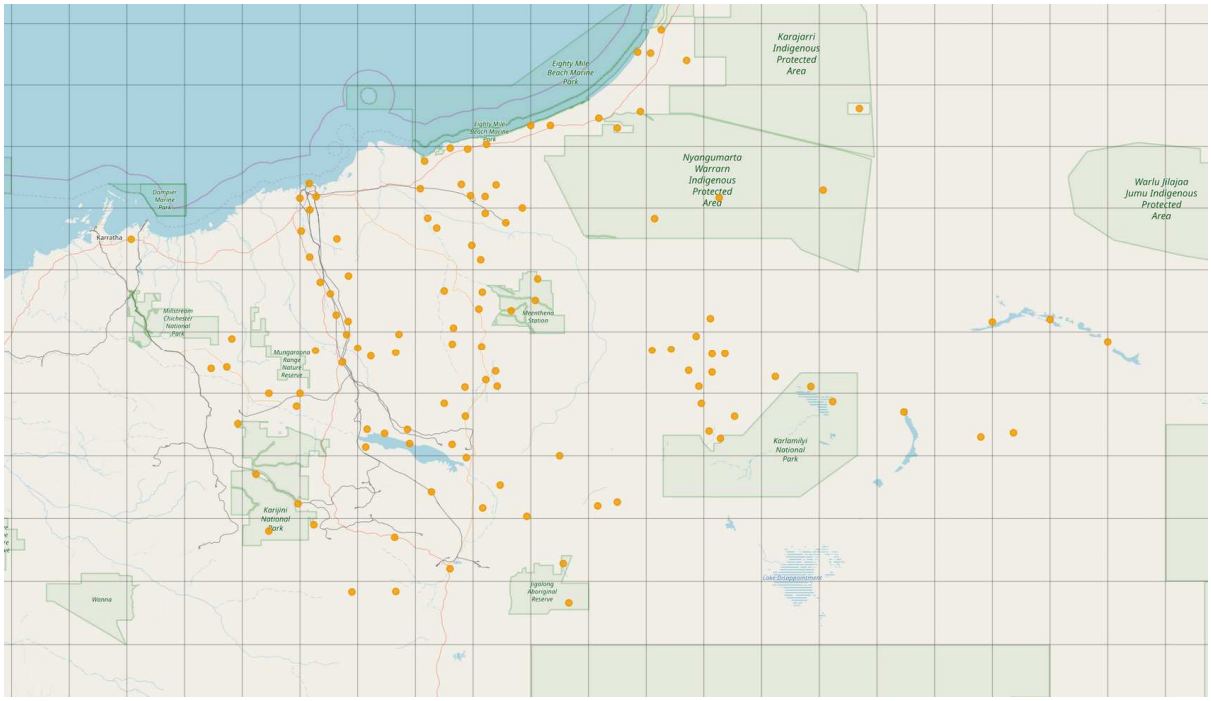

Figure 2. Bilby records (●) collated from the Pilbara region.

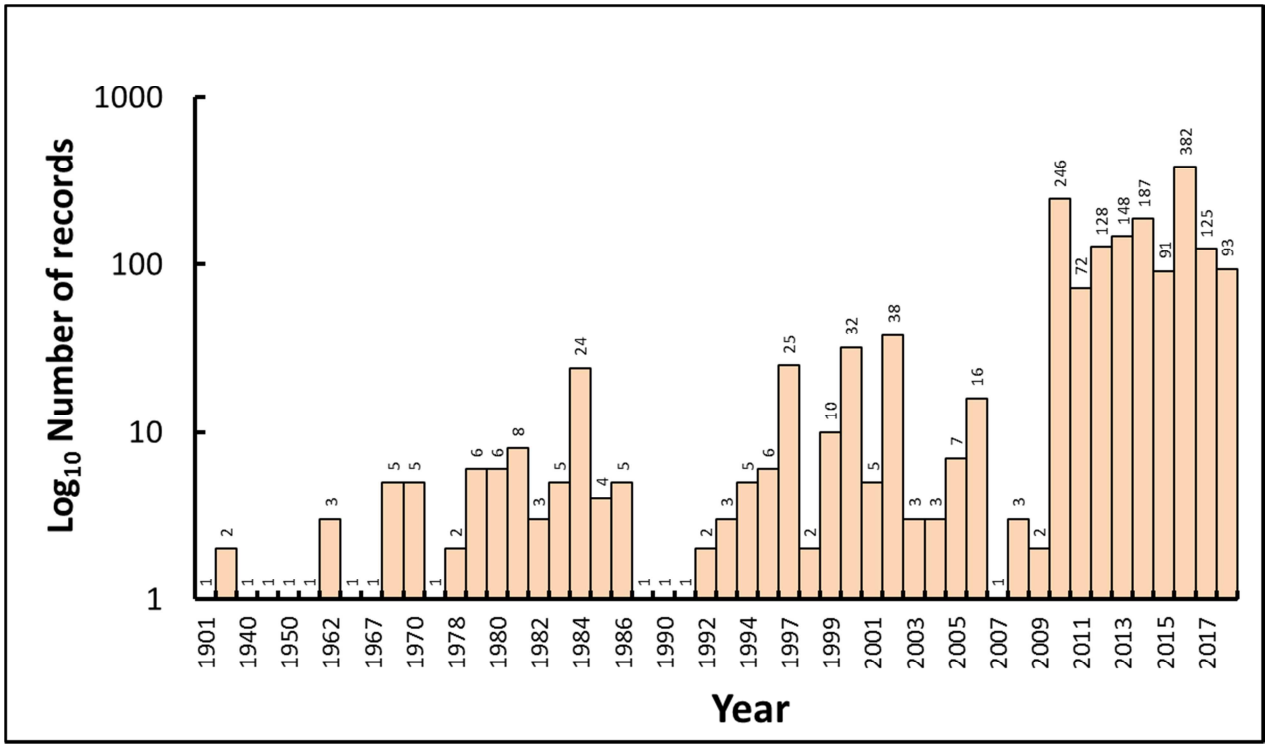

Figure 3. Frequency distribution of all collated bilby records from the Pilbara.

3 Presence/absence survey

3.1 Current survey

The current most effective and efficient methodology for on-ground survey for the presence/absence of bilbies without the use of aircraft is the 2 ha plot method described in Moseby *et al*. (2011) and developed by Southgate *et al.* (2005) and Southgate and Moseby (2008). This technique has subsequently been further developed (Dziminski and Carpenter 2017; Southgate *et al.* 2018). Only three types of sign provide definitive evidence of the presence of bilbies:

1. Tracks
2. Scats
3. Multiple diggings into the base of *Acacia* shrubs where grubs are accessed.

Burrows can easily be confused with varanid lizard or rabbit burrows by all but the most experienced observers, however, if there are occupied burrows then there will most likely be evidence nearby of at least one of the three signs described above. Descriptions and images of bilby sign can be seen in Appendix 2.

There are some limitations to this technique in the Pilbara region. In many areas in the Pilbara where bilbies are found, the substrate is not as sandy or soft, or may be covered by more leaf litter than in many of the desert areas. Therefore, bilby tracks may not be present in the frequency they are observed in desert areas, and the primary indicators of bilby presence within the 2 ha plots are scats and multiple diggings into the base of *Acacia* shrubs where grubs are accessed.

A further limitation of the 2 ha plot method is that the location of plots is usually limited to areas that can be accessed near vehicle roads and tracks. In October 2015 a quad bike was acquired for use in the Pilbara. The quad bike enables efficient ground access to establish plot surveys in areas not normally accessible on foot. As well as the advantage of accessing difficult to get to areas, the use of the quad bike has increased the number of plots surveyed per trip.

So far, 3222 plots in likely bilby habitat have been surveyed for the presence of bilbies across the Pilbara (Figure 4). At 718 of these plots, confirmed evidence of bilby presence was recorded (Figure 5). These data will be available through the Department's NatureMap portal (DBCA 2018).

3.2 Management implications

- Better understanding of where bilbies are present in the Pilbara for environmental impact assessment (EIA) processes.
- Sufficient presence data now gathered to enable development and improvement of habitat suitability modelling for bilbies in the Pilbara (see Dziminski and Carpenter 2017).

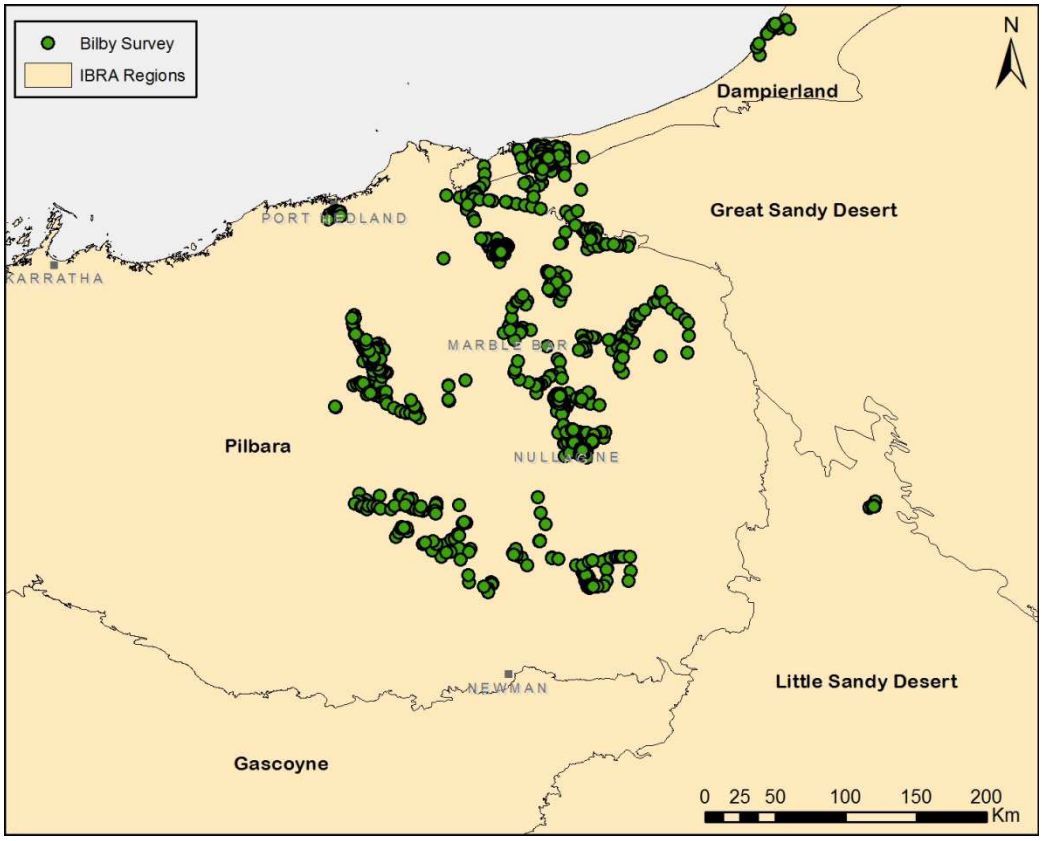

Figure 4. Plots surveyed for bilby presence across the Pilbara.

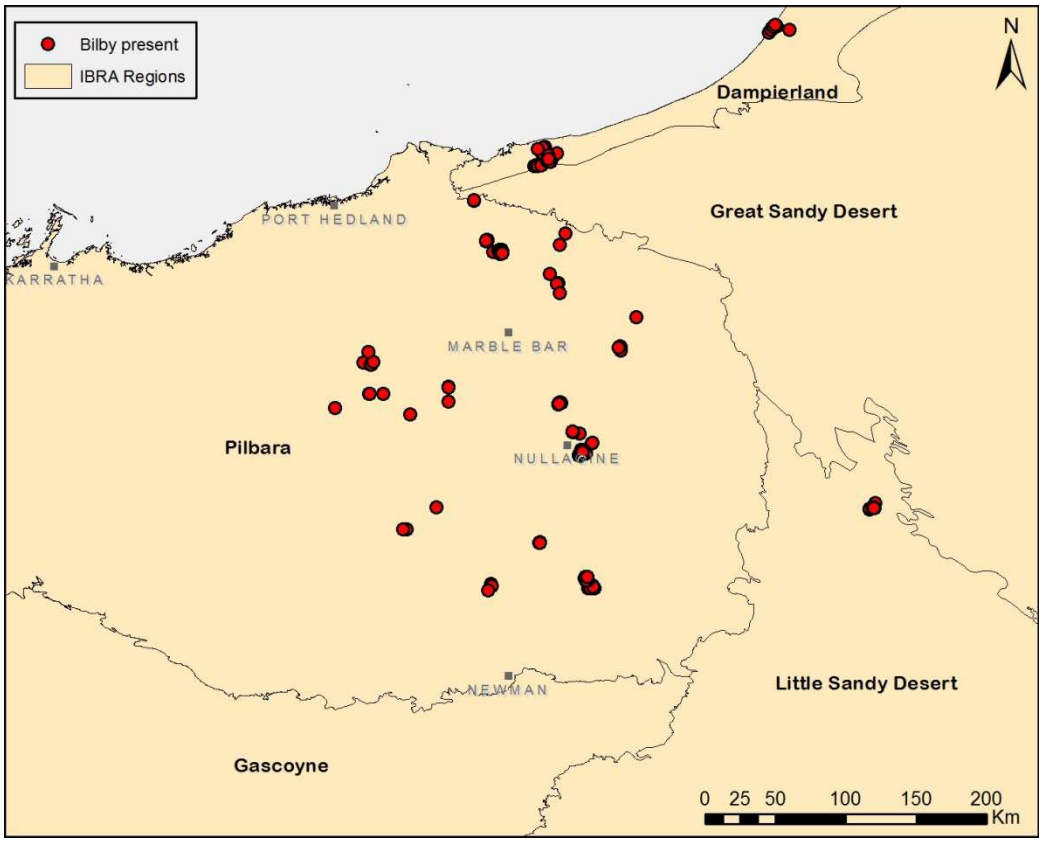

Figure 5. Bilby presence detected at survey plots across the Pilbara.

4 Improving survey techniques

4.1 Standardisation and development of best practice occupancy survey techniques

Various, incomparable presence/absence or occupancy survey techniques for bilbies are being used or being proposed to be used across Western Australia. In order to promote standardisation and comparability a set of guidelines based on best practice techniques used nationally have been developed and are described in Southgate *et al.* (2018), together with a protocol to assess potential bilby activity and verify bilby presence from sign.

4.2 Software and refinement of 2 ha sign plot data collection

In 2017 a standardised app was developed using Mobile Data Studio (MDS; Creativity Corp 2017), along with an equivalent paper version for collecting sign plot data. Advice from experts conducting bilby surveys across Australia was incorporated during development. Traditional Owner Rangers also developed this data template into a Fulcrum (2017) sequence.

The app and datasheet was optimised further by Department of Biodiversity, Conservation and Attractions staff and Traditional Owner Rangers during this project and others around Western Australia. Many fields have been simplified and unused data fields removed. We encourage all users (including Fulcrum users) to update devices to the latest version. The electronic MDS template (Figure 6) is available from the Department by request, and the paper version is attached at Appendix 3.

This standardised data collection template will continue to be used for all surveys, as well as other sign plot projects throughout Western Australia. We encourage all users to update devices to the latest version.

4.3 Management implications

- More efficient, standardised and comparable technique for occupancy surveys.
- Better understanding of what type of sign can be used for detection of bilbies in the Pilbara for Level 2 or targeted surveys.

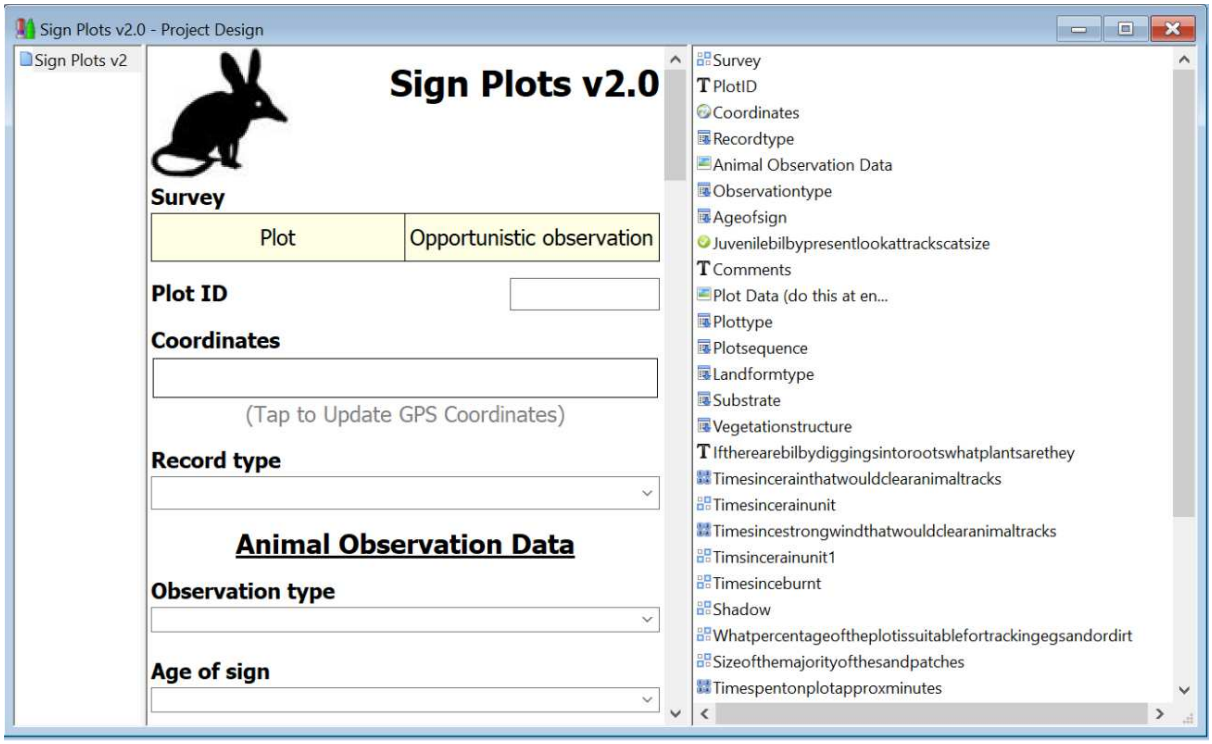

Figure 6. Screenshot from the standardised mobile data collection app.

5 Guidelines

In order to promote standardisation and comparability, draft guidelines based on best practice techniques used within Western Australia and nationally have been developed for:

1. Pre-clearing searches to locate resident bilbies
2. Relocation of bilbies prior to vegetation clearing

These are shown below in Box 1 and Box 2.

5.1 Management implications

- More efficient, standardised and comparable technique for bilby searches prior to vegetation clearing.
- Best practice techniques for managing bilbies within areas of vegetation clearing.

Box 1. Guidelines for pre-clearing searches to locate resident bilbies

Version 2 – September 2018

Scope

Where targeted surveys or other information indicate that bilbies (*Macrotis lagotis*) are likely to occur in a development footprint (vegetation clearing area and may include any additional disturbance areas), avoidance, displacement or relocation, and management are likely to be required.

This document provides guidelines aimed at locating bilbies (generally occupied burrows) in development footprints so that the animals can either be avoided, displaced or relocated to prevent mortality. Search design may need to be adapted to the habitat types present, and the size and shape of the project area and in response to the targeted search results (refer to the *Guidelines for Surveys to Detect the Presence of Bilbies, and Assess the Importance of Habitat in Western Australia* (DBCA 2017).

Pre-clearing searches, also referred to as clearance surveys, are required to be conducted in accordance with conditions of the development or clearing approval, an approved fauna management or relocation plan, and a licence to take fauna (which includes fauna disturbance). Other licenses or permits may be required.

These guidelines only apply to the on-ground searches to locate bilbies *in situ* to avoid direct impact and mortality.

Protocol

Bilbies are cryptic and not easily observed or trapped. The most efficient and reliable technique to detect whether bilbies are present is the observation of sign by trained and experienced observers. A range of sign may be present, including scats, tracks, burrows and diggings.

Pre-clearing guidelines are very different in intent from targeted surveys as they aim to locate bilbies in impact areas (i.e. the disturbance footprint) as close as possible to the time of clearing. Bilbies are often sparsely distributed across large areas, and populations can move across the landscape, so a search to locate bilbies must be undertaken a close as possible to the clearing activity, at the most no longer than 2 weeks prior to commencement of vegetation clearing. Bilbies can move into an area within a short period therefore it is also recommended to have an experienced fauna spotter and a plan to manage situations that arise during clearing operations.

Graduated levels of intensity are recommended for these searches, effectively progressing from coarse to very fine scale searching in order to locate burrows:

- The initial approach is traversing transects in order to locate areas with bilby activity/sign. Transects must be spaced close enough together to ensure that bilby sign between transects will not be missed. This spacing will depend on visibility, for example, transects in recently burnt low open spinifex would be further apart than transects in thick Acacia shrubland which would need to be much closer together. Distance selected should be justified based on visibility and terrain at each site. These transects can generally be restricted to the area to be cleared or disturbed, unless the approval conditions specify otherwise.
- If evidence of bilbies is found during these initial transects, undertake more intensive searches where transects spacing ensures visibility of all ground between adjacent transects. Exact distances between transects depend on vegetation and terrain but are in the order of 20m spacing. The aim is to locate recent foraging sign, fresh tracks and scats. Even more intensive searches may be necessary to locate all occupied burrows.
- Once a burrow is located, clearly mark and record the location

A single bilby may have up to 18 burrows within its home range and can create new burrows or rework old burrows at any time. Not all burrows are occupied and the same burrows may not be occupied on successive nights. All burrows therefore need to be located, and then need to be examined for signs of occupancy. This can often be informed by fresh tracks and recent excavation, and the use of remote cameras is highly recommended. Many other animals use bilby burrows, so a burrow with fresh activity that does not show distinct bilby sign (ie clear bilby tracks or scats) may contain other animals rather than a bilby. This would need to be confirmed with remote cameras. Remote cameras need be located at burrow entrances for a minimum of three nights to confirm burrow use or if a bilby is not present in a burrow. A disturbed bilby could stay in a burrow for 24 hours. Careful consideration needs to be given to the positioning and angle of the camera. Consideration needs to be given to the brand and quality of cameras (many cheaper ones are unreliable) and the settings of the camera trigger. This information should be included in reporting. Because remote cameras are not always reliable and not always triggered, two cameras positioned at different angles could be used to ensure high confidence of burrow occupancy or vacancy.

Once occupied burrows are found, the pre-developed fauna management or relocation plan will dictate how to reduce, avoid or mitigate the direct impact to individuals (*Guidelines for relocation of billies prior to vegetation clearing are under development*). This may include relocation by displacement or trapping (capture and release), and these decisions are informed by surrounding land use, adjacent habitat quality, ability to undertake further

monitoring, etc. The fauna management plan must be developed in consultation with DBCA and endorsed prior to pre-clearing searches.

Important Principles

- Extensive searches are required to avoid, displace or relocate, and manage resident bilbies prior to clearing.
- The aim of these searches is to locate bilbies in impact areas (i.e. the disturbance footprint) as close as possible to the time of clearing.
- These surveys should be undertaken as close as possible to the clearing activity, preferably less than 2 weeks.
- Search intensity needs to progress from coarse to very fine searching in order to locate burrows.
- All burrows located need to be monitored to determine activity.
- Once occupied burrows are identified, undertake the actions set out in a pre-developed and endorsed fauna management plan, developed in consultation with DBCA.

Acknowledgements

These guidelines were prepared by DBCA with major contributions from Martin Dziminski, Amy Mutton, Kim Onton, Manda Page and Tracy Sonneman.

Box 2. Guidelines for relocation of bilbies prior to vegetation clearing

Version 1 – September 2018

Scope

The greater bilby (*Macrotis lagotis*) is a threatened species that may need to be relocated from a development footprint (i.e. vegetation clearing area including additional disturbance areas) to prevent mortality. This guideline recommends actions to be undertaken and incorporated in planning documents for the relocation of bilbies. These actions should be planned and implemented under the supervision of a suitably qualified and experienced zoologist/ecologist.

Pre-clearing surveys for bilby burrows within a development footprint must first be conducted as outlined in *Guidelines for pre-clearing searches to locate resident bilbies* (Department of Biodiversity, Conservation and Attractions 2018) to identify burrows and assess their occupancy before relocation options are considered.

The first approach to relocation is displacement where the animal is encouraged to move out of the footprint area on its own accord. This is the preferred course of action as it minimises direct trapping and handling of bilbies and reflects the behaviour of bilbies to use multiple burrows within their home range and their ability to rapidly excavate new burrows. The appropriateness and likely success of displacement will depend on the quality of the surrounding habitat and the long-term retention of adjacent vegetation. Displacement can only be used if the surrounding habitat is, and will remain, viable in the long term. Trapping and physical relocation should be only undertaken under circumstances where displacement has not been successful before clearing occurs, or if adjacent habitat is inviable.

NOTE: Ensure all applicable licenses, permits and approvals are in place prior to undertaking these activities. These recommended protocols should be incorporated into an approved Fauna Management Plan.

Protocol

The following sequence of events is recommended for bilby relocation:

- pre-clearance surveys to locate burrows,
- determine occupancy of burrows,
- fauna relocation;
  - by displacement – encouraging fauna to abandon burrows,
  - by capture and release,
- conduct vegetation clearing with a fauna spotter present,
- monitor displaced or relocated fauna activity after disturbance and mitigate threats.

Each stage should be consecutive, or concurrent where appropriate. Timing and surveillance are important to ensure that relocated fauna have no or limited opportunity to return to the impact area prior to disturbance.

Pre-clearing searches

Pre-clearing searches must be undertaken immediately before clearing, no more than two weeks prior to the clearing activity, and in accordance with *Guidelines for pre-clearing searches to locate resident bilbies* (Department of Biodiversity, Conservation and Attractions 2018). Searches need to consider the time required to

undertake any necessary fauna displacement or relocation but also limit the time available for fauna to move into the area between searches and clearing. A minimum of a week (3 nights for displacement, 4 nights for trapping) should be devoted to relocation if potentially occupied burrows are identified.

Determining burrow occupancy

The occupancy of each burrow that is located during pre-clearing searches needs to be determined. A single bilby may have up to 18 burrows within its home range and can create new burrows or rework old burrows at any time. Not all burrows are occupied and the same burrows may not be occupied on successive nights. All burrows therefore need to be located, and then need to be examined for signs of occupancy immediately before clearing.

Many other animals use bilby burrows, so a burrow with fresh activity that does not show distinct bilby sign (i.e. clear bilby tracks or scats) may contain animals other than a bilby. If there is any evidence that a burrow is potentially occupied, and the animal cannot be confirmed as a bilby, the protocols for 'occupied burrow' should be followed under the precautionary principle.

Unoccupied burrow

A burrow may only be considered unoccupied if:

- it has begun to collapse and no longer has a round entrance or cavity and would not enable a bilby to enter without additional digging, and there is no evidence that other vertebrates are making use of the burrow, or
- it has vegetation in the entrance and cob webs across the entrance and there is no evidence that any vertebrates are making use of the burrow.

In these circumstances, no further monitoring is required and the inactive burrow should be 'exposed' by using a shovel to dig it out to 1 m thus making it unsuitable for use by any vertebrates but enabling any remaining fauna to escape for at least one night before clearing activities commence. It should then be filled in to prevent fauna moving into the burrow before, during or after disturbance activities. Further inspection is recommended to ensure the burrow is not re-excavated and occupied.

If an unoccupied burrow is found in the vicinity, but outside of the development footprint, it should be left undisturbed as a potential refuge for fauna displaced from within the impact area.

Potentially occupied burrow: Monitoring

Monitoring of a burrow needs to be conducted if:

- the burrow is open (i.e. round entrance and depth characteristics adequate to house a bilby), with or without a sand apron, and/or
- fresh bilby sign is present at site.

Evidence of activity is the best way to assess burrow use or burrow vacancy and all monitoring techniques must be applied for a minimum of three nights and photographic records must be kept demonstrating the method and the number of nights of monitoring.

Monitoring using remote cameras is highly recommended. Remote cameras need be located at all burrow entrances for a minimum of three nights Camera type, settings and positioning should be selected to increase the likelihood of triggers by fauna. This information should be included in the fauna management plan and reporting. Careful consideration needs to be given to the positioning and angle of the cameras. Two cameras positioned at different angles will increase the confidence of determining burrow occupancy or vacancy.

If it is impossible for remote cameras to be used then all of the methods below should be used in combination:

- Signs: fresh scat, tracks and diggings at a bilby burrow may indicate recent use. Smoothing the burrow entrance to create a sand-pad and checking each morning for tracks may assist in detecting activity. Evidence needs to be fresh and clear, and observed by an appropriately experienced and skilled person to confirm occupancy by bilby, as other fauna species are known to use bilby burrows.
- Physically blocking entrance: very loosely block the entrance with small sticks or clumps of grass and check the location of the blockage each morning to assist in determining activity.
- Burrowscope: a burrowscope may be used to observe any fauna within the burrow. This method is the least reliable as effectiveness will be dependent on the length of the scope, and the burrow size and construction including the presence branching tunnels or blockages., and backfilling of tunnels.

If there is no evidence of fauna activity for at least three nights, then the burrow can be classed as unoccupied and actions described above undertaken immediately.

Occupied burrow: Displacement

If a burrow is determined to be occupied or remains potentially occupied or unknown following monitoring, then the following techniques for fauna displacement should be applied. However, displacement is only appropriate if

there is suitable adjacent habitat that will remain undisturbed and where threats to the bilby are managed. Displacement can only be used if the adjacent habitat is, and will remain, viable in the long term.

The displacement approach reflects the behaviour of bilbies to use multiple burrows within their home range and their ability to rapidly excavate new burrows, and is considered to be less-stressful, and more effective than a capture and release method.

1. Remote cameras previously installed to determine occupancy or potential occupancy should remain *in-situ* to continue monitoring fauna activity and confirm that fauna have left the burrow. Remote cameras, or other effective monitoring techniques must be deployed and remain *in-situ* during the displacement process. Successful displacement will likely take several days and nights to achieve and must be confirmed with evidence (see #3).
2. Some disturbance (i.e. partial excavation) of all burrow entrances within the development footprint may help make the burrows unattractive to the fauna and they may vacate the burrow and leave the impact area. Ensure that such disturbance does not prevent fauna from exiting the burrow. If abandonment of a burrow occurs and is confirmed (see #3), it is considered as displacement.
3. Time and date stamped images of fauna exiting a burrow and not returning, together with a lack of fresh sign (tracks on a sand-pad at the entrance), must be gathered to confirm successful displacement has occurred. Because remote cameras are not always reliable and not always triggered, two cameras positioned at different angles should be used to ensure high confidence of burrow occupancy or vacancy.
4. Once fauna displacement from a burrow has been confirmed, the burrow must be filled in immediately to prevent fauna moving in before, during or after vegetation clearing. The burrow should be carefully excavated by hand to verify that displacement has occurred. Ongoing surveillance is recommended (see #6).
5. Following displacement it is possible that new burrows will be created within the development footprint. A method of ongoing surveillance of the development area must therefore be incorporated into the program. Observations of fresh tracks and diggings may be followed to assist with this surveillance.
6. An animal may persist in using even a partly excavated or collapsed burrow, or try to re-excavate a burrow. Therefore, all burrows should continue to be monitored to ensure recolonisation does not occur up until clearing is undertaken.
7. If there is no confirmation that fauna have left an occupied or potentially occupied burrow, monitoring should continue for at least three nights until displacement is certain or capture and release is used.

In extreme circumstances, clearing up to the burrow, but no closer than 10m, can be used to help disturb and encourage displacement however a bilby is more likely to dig deeper and remain in the burrow than escape. In these circumstances clearing must be in a progressive manner from one direction, towards the closest adjacent intact vegetation. Surveillance and confirmation of displacement is still required (see # 3) and all further clearing must cease until displacement is confirmed.

Occupied burrow: Capture and Release

In instances where displacement of an occupied burrow has not been successful before clearing is scheduled to begin, or where there is not suitable adjacent habitat, capture and release may be appropriate. Bilbies can be difficult to trap and displacement is the preferred relocation method as it may create less stress on the animals than trapping. Capture and release should only be undertaken by personnel with appropriate skills and experience, licences, permits and approvals.

It is important that capture and release is conducted in accordance with the department's standard operating procedures (SOP) available at https://www.dpaw.wa.gov.au/plants-and-animals/96-monitoring/standards/99-standard-operating-procedures. In particular, the following SOPs are relevant:

- *Cage traps for live capture of terrestrial vertebrates*
- *Animal handling and restraint using soft containment*
- *Hand capture of wildlife*
- *Hand restraint of wildlife*
- *Transport and temporary holding of wildlife*
- *Care of evicted pouch young.*

Where capture and release is appropriate, the following information, techniques and protocols must be planned and documented prior to undertaking any activity, and may be required as part of the licensing process. Release sites must be identified and confirmed prior to any trapping commencing. It may be a requirement to document the location, quality of habitat and occupancy at release sites.

Trapping using free standing baited traps has not proved successful on wild bilbies. Instead, traps need to be placed in burrow entrances (burrow traps) or yard traps installed. Burrow traps take less time to install than yard traps but yard traps are particularly useful when:

- it is not feasible to fit a trap neatly into a burrow entrance (e.g. large termite mound),
- there are multiple entrances or pop-holes,
- there is evidence that the burrow may contain multiple individuals (e.g. mother and young), or
- a bilby has set off a burrow trap but was not captured.

Burrow traps

Cage traps with internal-opening doors (spring closing) are required. Hessian should cover the top and sides of the trap but not the end to enable a bilby to see out and also not the base. The sides of the burrow need to be carefully dug out using a small shovel to enable the trap to fit snugly inside the burrow, and deep enough so the treadle is just inside the burrow entrance (McGregor and Moseby 2014). Bait is unnecessary and is a detriment to the operation. Having no hessian on the base enables sand to bed between and obscure the wire mesh. However, the treadle needs to remain free and protected from sand build up from below. The treadle can be camouflaged by spraying water over the treadle, and then sprinkling sand on top to affix.

Yard traps

A yard is built around a potentially active burrow using 3-4 m panels of 25x25 mm square mesh (or finer), 900 mm tall with a hinged 300-400 mm footing (Southgate *et al*. 1995). The hinged footing can be attached with ring fasteners. A rod through ring fasteners attached to the end of each panels can be used to join additional panels. The panels need to encircle the burrow leaving about 1 m or more from the entrance. The footing needs to face inward toward the burrow entrance and can be cut to enable overlap and panels to curve around the burrow. The footing should be flat with the ground and covered with sand. Internally opening (spring closing) cage traps should be set inside the yard trap against the side of a panel and the wire mesh on the base obscured with sand. The top and sides of the traps should be covered with hessian but absent from the end. The yard traps should be free standing if relatively small radius. The panels of large radius traps may need support with attachment to external star pickets.

Trapping period

Traps need to be checked at sunrise each morning. A burrow trap that has been sprung by a bilby or another animal and not captured needs to be removed and replaced with a yard trap around the burrow.

A potentially active burrow should not be trapped using a burrow, yard or combination for more than for more than three consecutive nights. A burrow should then be fully excavated carefully (refer to appendix 1). Burrows should be excavated after trapping to confirm that all animals have been captured, then collapsed to avoid re-excavation of the burrow. Collapsed burrows should continue to be inspected to ensure re-excavation and recolonisation does not occur up until clearing is undertaken.

Handling protocols

All interactions with animals captured during this relocation program will be humane and ethical. It is essential that the animal handler/s is experienced in working with Greater Bilby to ensure the relocation program present limited risks to the animals. The length of time spent handling animals will be restricted as much as possible. Animals should be safely removed from traps and temporarily held following SOPs.

With the use of burrow traps and yard traps the likelihood of females ejecting pouch young is significantly reduced. However when removing animals from traps always check there are no ejected pouch young in or around the trap. Re-insert any ejected pouch young, tape and release together, following SOP.

Young-at-foot spend two weeks in a burrow before being left by their mother to become independent and at this stage are unlikely to survive if relocated. Such animals should be placed with a pre-determined licenced wildlife rehabilitator with experience with bilbies and the Department notified within 24 hours. If a lactating female is captured, hold the mother until burrow excavation is completed to attempt to retrieve the young and reunite (as per SOP).

All individuals captured should receive a general health check and sex determined. Check if females are lactating and retain until burrows are excavated to retrieve and reunite young with the mother. DNA samples may be required under a licence (refer to SOP), and temporary marking using non-toxic markers will enable individual identification of future camera images (refer to SOP).

Transport and release

Animals should be released at the pre-selected release site as soon as possible. If release cannot be undertaken immediately (early morning) store animals in dark, well ventilated, quiet and cool areas (less than 20^{o}C) in soft containment bags within petpacks. Animals should not be held for more than 14 hours. Transport protocols must follow SOPs.

Release sites must be identified and confirmed prior to any trapping commencing. It may be a requirement to document the location, quality of habitat and occupancy at release sites. Individuals should be moved further than 5 km away from the capture site to reduce the chance return to the operational area and to sites with existing evidence of bilbies. Habitat should be as similar as possible similar to the capture site

If possible locate a dis-used bilby burrow at the site for release. If a suitable burrow cannot be found an artificial burrow should be constructed. Artificial burrows are a pre-dug burrow oriented at approximately 30 degrees to a minimum depth of one metre. The roof of the hole is lined with a half cut PVC pipe (35-45 mm diameter) and the floor remains earth. Multiple burrows are recommended at the release site. Animals can be released directly into the entrance of the artificial burrow.

If releasing early morning, a yard trap can be constructed around the intended release burrow (dis-used or artificial) prior to release to contain the bilby in the event the bilby finds the burrow unsuitable and decides to re-emerge during day light. Individuals should be released during day light and encouraged to enter a burrow and remain there. The yard trap should be removed at dusk.

Monitoring relocated bilbies

Little is known about the response of wild bilbies following release so post release monitoring is recommended with the objective to determine whether the relocated bilby emerges in good health from the burrow, if the animal remains at the release site and to assess whether other individuals are present. Four days of monitoring using remote cameras set on burrows is recommended. Monitoring with more intensive methods like tracking require considerably more planning, resources, skills and approvals.

During vegetation clearing

If clearing is scheduled to commence and the displacement or relocation of fauna from occupied or potentially occupied burrows cannot be confirmed, clearing in the immediate area should be postponed and effort to relocation continued. If this is impossible, the burrow must be clearly marked, and clearing undertaken from one direction progressively toward the area containing the burrow. Before reaching the marked burrow, it must be carefully excavated by hand (appendix 1) as described above, to ensure animals are not buried and killed during clearing operations. This is an absolute last resort and only undertaken after all other methods above have been completed for a minimum of a week and clearing cannot be postponed.

Further, the following is recommended during clearing activities.

- A walk-through of the clearing area should be conducted immediately prior to clearing (either the day before or day clearing begins), to inspect previously filled burrows and ensure that no fauna has recolonised burrows, and no new burrows have been constructed.
- Clearing should commence at a maximum distance from any retained burrow and progressively work towards it and be conducted in a direction that allows fauna to move out of the impact area into adjacent vegetation that is not proposed to be cleared.
- A fauna spotter should be present during the clearing activities to observe any fauna leaving other refuge areas. The spotter can guide machinery operators to prevent fauna harm, injury or mortality.

It should be noted that fauna moving across cleared areas are exposed to a high risk of predation, therefore displacement during clearing operations is not appropriate and allowing at least a week to relocated animals prior to the commencement of clearing must be incorporated in to planning.

After vegetation clearing

After clearing the following points should be considered.

- Any remote cameras installed at burrows during the clearance surveys outside of the clearing area, within additional disturbance areas, or at release sites and/or buffer zones, should remain *in-situ* during the fauna displacement and clearing activities to monitor fauna movement. These burrows are potential refuge sites for fauna displaced from the impact area. Activity should be recorded.
- Secondary signs observed opportunistically within the area surrounding the development footprint should be recorded.
- The cleared area should be inspected periodically to determine if bilbies have recolonised the area, as bilbies often prefer loose and recently excavated soil to construct new burrows.
- Minimise areas of loose soil and soil piles, especially beside vehicle tracks, to discourage bilbies from constructing new burrows.
- If more than two weeks lapse between the fauna displacement and the clearing, or clearing stages, or after clearing and other activities commencing (i.e. construction), then additional pre-clearing searches and relocation may be required, as animals could recolonise the site.

Additional notes

The methods for relocation by displacement are also appropriate for mulgara (*Dasycercus* species). In locations where both bilby and mulgara occur, Elliott traps should be used for mulgara as mulgara are unlikely to trigger cage traps. The approval conditions often include the relocation of both species.

All fauna species may be relocated from an area prior to vegetation clearing, even if there are no specific conditions on the approval.

Appropriate methods for the relocation of other fauna species will be considered during the assessment of a licence application to take fauna. For further information on fauna licences visit https://www.dpaw.wa.gov.au/plants-and-animals/licences-and-permits.

Important principles

- Prior to vegetation clearing, the occupancy of burrows identified during pre-clearing searches should be determined using remote cameras.
- Where occupancy is uncertain, the burrow should be considered as being potentially occupied and the protocols for 'occupied burrow' followed under the precautionary principle.
- Unoccupied burrows should be immediately filled in to prevent recolonisation.
- Displacement is the preferred fauna relocation method for occupied and potentially occupied burrows if suitable adjacent habitat is available.
- In instances where displacement of an occupied burrow has not been successful (or is not appropriate), capture and release may be applied. Capture and release should be undertaken in accordance with the department's standard operating procedures and by personnel with appropriate skills and experience.
- Burrows should immediately be filled to prevent recolonisation after displacement or relocation, and monitored to ensure recolonisation does not occur.
- If displacement of fauna from occupied or potentially occupied burrows is uncertain, clearing should approach in one direction and burrows hand excavated just prior to clearing.
- Additional pre-clearing searches and relocation may be required if more than two weeks lapses between the fauna displacement and the clearing, or clearing stages, or after clearing and other activities commencing (i.e. construction).
- Monitoring of displacement or release areas should be undertaken during and after clearing activities have concluded.
- Threat mitigation should be applied to displacement or release sites.

References and further reading

Hofstede, L., and Dziminski, M. A. (2017). Greater bilby burrows: important structures for a range of species in an arid environment. *Australian Mammalogy* **39**, 227–237. doi:10.1071/AM16032

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Southgate, R. I., Christie, P., and Bellchambers, K. (2000). Breeding biology of captive, reintroduced and wild greater bilbies, *Macrotis lagotis* (Marsupialia : Peramelidae). *Wildlife Research* **27**, 621–628. doi:10.1071/WR99104

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Southgate, R., and Possingham, H. (1995). Modelling the reintroduction of the greater bilby *Macrotis lagotis* using the metapopulation model analysis of the likelihood of extinction (ALEX). *Biological Conservation* **73**, 151–160. doi:10.1016/0006-3207(95)00052-6

Department of Biodiversity Conservation and Attractions Standard Operation Procedures (https://www.dpaw.wa.gov.au/plants-and-animals/96-monitoring/standards/99-standard-operating-procedures):

- *Cage traps for live capture of terrestrial vertebrates*
- *Animal handling and restraint using soft containment*
- *Hand capture of wildlife*
- *Hand restraint of wildlife*

- *Transport and temporary holding of wildlife*
- *Care of evicted pouch young.*

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Burrow Excavation

- Two individuals, each with a blunt-nosed shovel and/or garden trowels are required for burrow excavation. It may take up to several hours to excavate a bilby burrow, depending on its length and other characteristics.
- To maintain sight of the burrow, place the shovel handle down the burrow entrance as far as possible.
- Slice away the ceiling with the second shovel or trowel, removing sides and surrounding soils as required.
- Continue to slide the first shovel down into the burrow chamber so the burrow is not lost during excavation.
- Remove the soil with the second shovel or trowel as excavation proceeds and repeat.
- Excavate the burrow slowly and carefully and stop often to see if a bilby is within reach or the end of the burrow is visible (a torch maybe required). Be aware that other species maybe utilising the burrow.
- Do not collapse the burrow ahead of the shovel or trowel inside the burrow. Feel the shovel contact the other shovel with each stroke to avoid striking a bilby.
- Always excavate the burrow to its absolute end – be aware of forks, branches and plugged chambers and ensure all are excavated and inspected.
- If a fauna species is observed, it may be either displaced or captured. Note venomous species maybe present in burrows.
- If a juvenile bilby is captured, then reunite with mother if possible by direct insertion into the pouch and taping (refer to SOPs).
- After excavating the burrow, fill it in the remaining hole.

6 Population monitoring

A technique developed to monitor numbers of bilbies within populations has been developed (Dziminski and Carpenter 2017). This technique involves genotyping individuals using DNA extracted from scats. Individuals are genotyped across eight polymorphic microsatellite loci (Moritz *et al.* 1997; Smith *et al.* 2009). Viable DNA can reliably be extracted from scats that were deposited up to two weeks prior to collection (Carpenter and Dziminski 2017). This technique has been trialled to monitor populations in the Pilbara and elsewhere in Western Australia (Dziminski and Carpenter 2017; Dziminski *et al.* 2018).

The technique involves:

1. Identifying a population and defining the boundaries of occupancy or alternatively defining a portion of a continuous area that is occupied by bilbies.
2. Overlaying transects to evenly sample the defined area.
3. Traversing the transects, collecting scat samples and recording positional data.
4. Extracting DNA, PCR, fragment analysis and genotyping individuals from scat samples.
5. Analysis of spatial and genetic data and abundance.

In order to maximise the efficiency of the technique and increase the quality of the data the following recommendations are provided:

- Only fresh scat samples up to two weeks old should be collected (Carpenter and Dziminski 2017). Although determining the age from the look of scats can be difficult unless they are crumbling or falling apart, the digging associated with the scat can be used to determine freshness. If the spoil of the associated digging is degraded, weathered, hardened and flattened then it is likely very old. If the spoil looks recently dug and is still a different colour it is likely fresh.
- Samples should not be collected if there has been rain at the site during the past two weeks. Rain degrades the DNA on scats (Piggott 2004; Brinkman *et al.* 2009) and many will not yield viable DNA. It is best to time monitoring with a window of at least 2 weeks of no prior rain.
- Scats should be stored in tubes with silica gel beads with a cotton wool ball separating the sample from the beads (see Section 6.1.2).

DBCA Bilby Research Team staff can provide advice and assistance to set up and implement monitoring sites in collaboration with local partners. This will be a consultative process where DBCA staff will teach and assist partners in setting up the monitoring site, with the goal of all the on-ground work and future monitoring events being undertaken by the partner. DBCA can undertake molecular work and analyses as a service (Dziminski 2015a; Dziminski 2015b; Dziminski 2015c).

Utilising scats as opposed to sourcing tissue or blood for DNA samples has the benefit of reducing direct impacts to the species being studied (Murphy *et al.* 2000; Piggott and Taylor 2003; Vynne *et al.* 2012; Ramón-Laca *et al.* 2015). This is

particularly useful in the case of threatened species, such as bilbies, which are likely vulnerable to disturbance (eg Puechmaille and Petit 2007; Baldwin *et al.* 2010).

6.1 Calibration of the abundance monitoring technique

In 2017 a calibration of the technique was undertaken to assess the accuracy in measuring numbers of individuals within populations. This study was undertaken at the Australian Wildlife Conservancy (AWC) Sanctuary, Mt Gibson, Western Australia.

6.1.1 Background

Sixteen bilbies were released into a fenced exclosure in December 2016. Of these, 10 were female, and some of these were confirmed to be carrying young. The abundance sampling was undertaken 25-28 April 2017. The pouch period for bilbies is around 80 days, the gestation period 14 days, and litter size 1-2. The period between translocation and sampling provided sufficient time for some recruitment, therefore there is potential for new individuals to be detected.

6.1.2 Field sampling

A sampling area of 2379 ha at the northern end of the exclosure was defined for the pilot study (Figure 7). This area was selected since animals were released in this area, and most subsequent detections of individuals occurred here (Volck and Thomaz 2018: Figure 9). A total of 85 scats from 27.085 km of transects were collected by DBCA staff (Figure 8). Samples were stored dry, at room temperature, in 30 ml tubes, approximately 1/3-filled with silica gel beads and cotton wool, until DNA extraction was undertaken. Tissue samples from the 16 founding individuals were also provided by AWC.

6.1.3 Laboratory analyses

DNA extractions were undertaken over 5 days on 10-25 May 2017 following the protocol in Carpenter and Dziminski (2017). Extractions for the tissue samples were undertaken on the 22 August 2017. DNA was screened using seven highly polymorphic microsatellite markers. The PCR product was then analyzed on an ABI3730XL Sequencer, sized using Genescan-500 LIZ internal size standard, and genotyped using Genemapper software (version 5).

6.1.4 Genotyping analyses

Allele matching was completed using the R package '*AlleleMatch*' (Galpern *et al.* 2012). Unclassified samples and samples that matched multiple unique genotypes were examined manually and excluded if they could not be matched or classified as new unique genotypes. Any remaining mismatched alleles were flagged and examined to determine if they were genotyping errors. Genotypes identified along transects only provide information on the number of individuals detected specifically on transects, and further analysis is required to calculate the number of individuals within the extent of the population.

Of the 85 scat samples, 61 samples yielded DNA and 57 amplified at enough loci to include in identity analysis. All of the tissue samples were successfully genotyped across all loci. Genotyping identified 16 distinct individuals present across and along surveyed transects. Of these, nine were from the founder population and seven were new individuals indicating that recruitment is occurring.

The average genotyping success rate of 67 % is considered high compared with other completed site monitoring which is likely attributed to the freshness of the scats collected in the field (Carpenter and Dziminski 2017).

6.1.5 Abundance analyses

Spatially explicit capture-recapture analyses (SECR: Efford 2004) were used to calculate densities and numbers of animals. Maximum likelihood SECR analyses were undertaken using the R package '*secr*'. Spatial analyses were completed using ArcGIS (Esri®) and QGIS software.

All samples were grouped into a single sampling session and occasion. Two models were compared; one using polygon detectors and another using transect detectors. Polygon detectors (Figure 9) were generated by creating a buffer of 50 m around transects. The maximum distance a sample was detected from a transect was 49 m, therefore 50 m was chosen as the buffer. For transect detectors (Figure 10), the position of each sample was collapsed onto the nearest point on the transect line.

The habitat mask ("sampling area" in Figure 7) was constructed by generating the integration mesh using a buffer of $4\times\sigma$ and clipping with the "sampling area" polygon (Figure 9 and Figure 10). The hazard halfnormal (HHN) detection function and Nelder-Mead maximisation method were used in both models. Models were compared using sample size-adjusted Akaike's Information Criterion (AIC_c).

Both models yielded extremely similar results (Table 3: values identical due to rounding), with the model using transect detectors having a higher AIC_c. Maximum likelihood SECR analyses revealed a population of 19 (± 5) individuals within the sampled 2379 ha area.

This study showed that the abundance monitoring technique reliably censuses individuals within populations.

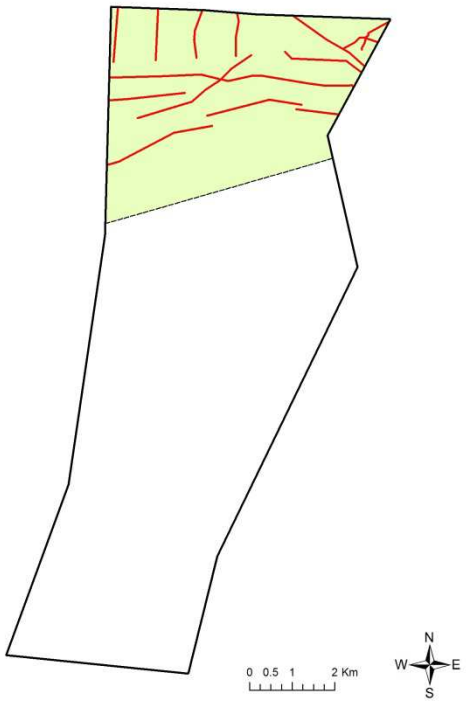

Figure 7. Sampling area (shaded) and transects (red) at the Mt Gibson Sanctuary exclosure.

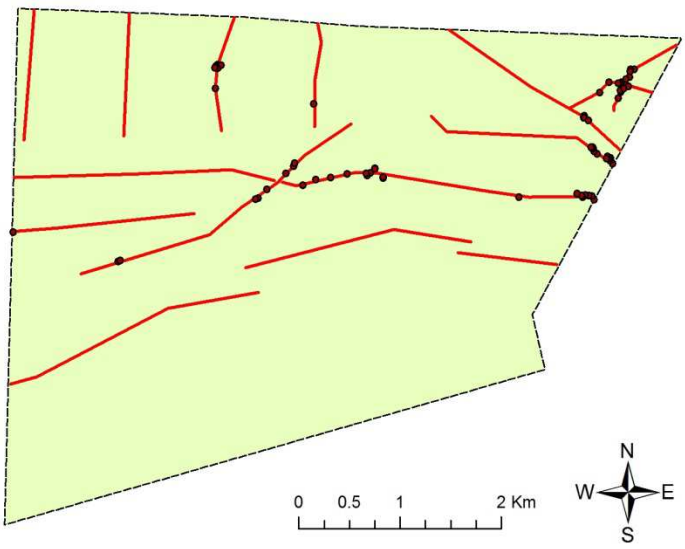

Figure 8. Collected scats.

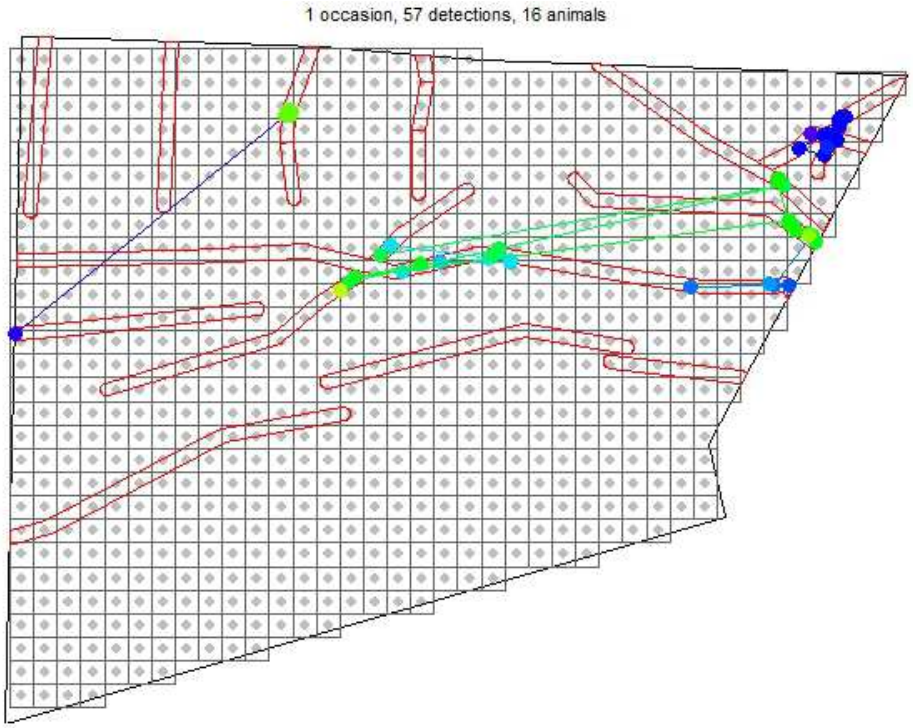

Figure 9. Polygon detectors (red), habitat mask and integration mesh (grey) and detections of individuals (coloured) with “recaptures” adjoined by lines.

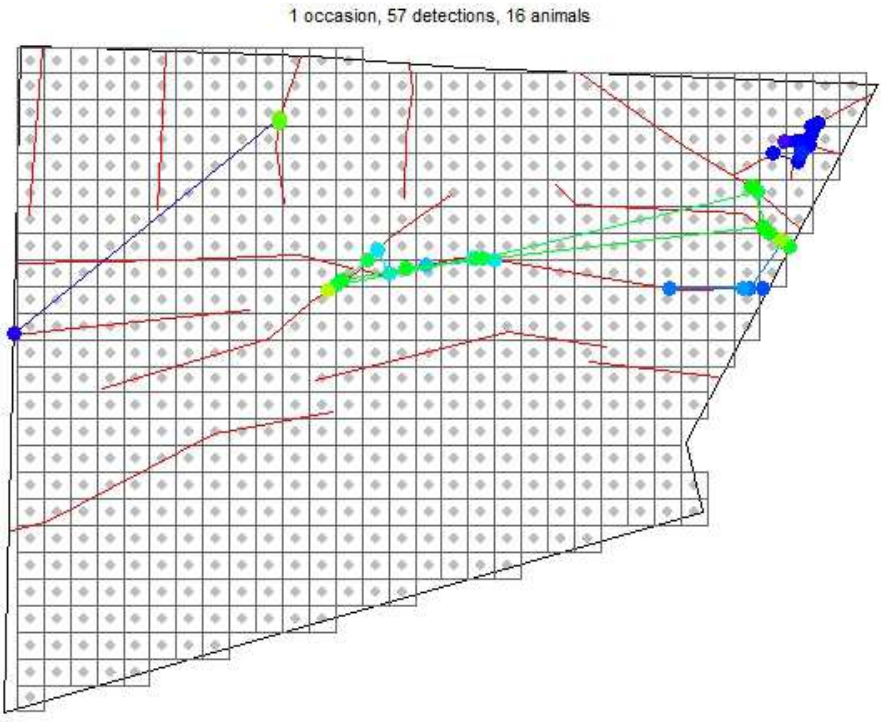

Figure 10. Transect detectors (red), habitat mask and integration mesh (grey) and detections of individuals (coloured) with “recaptures” adjoined by lines.

Table 3. Abundance and densities of bilbies derived from maximum likelihood SECR analyses.

Model	Number of individuals (± SE)	5-95% CI	Density (individuals ha^{-1} ±SE)	5-95% CI	AIC_c
Polygon detectors	19 (± 5)	12 - 31	0.008 (± 0.002)	0.005 - 0.013	1647.5
Transect detectors	19 (± 5)	12 - 31	0.008 (± 0.002)	0.005 - 0.013	1138.7

6.2 Management implications

- A reliable technique for abundance measures for bilby populations.
- Provides a standard technique for monitoring populations for EIA processes and determining the effects of threats and success of threat management activities.
- Satisfies the needs for consistency with on-going bilby monitoring programs in Western Australia.

7 Implementing fire management at bilby populations

The loss of several bilby populations in the Pilbara after extensive, large, hot wildfires has been documented (Dziminski and Carpenter 2017). These wildfires burnt the entire area and surrounding landscape of affected populations.

In 2017, trial fire management was implemented at the Nullagine bilby population which was assessed as under risk of being impacted by wildfire. With the support of Millennium Minerals a fire management plan was developed. Initial activity was focussed on protecting the area of habitat that the bilby population utilises by creating controlled burn and mineral earth fire breaks and grading tracks (Figure 11). In total:

- 5.5 km long and 50 m wide (27.5 ha) fire break was created by controlled burning
- 325 m long and 5 m wide mineral earth fire break was graded
- Approximately 7.5 km of track was graded

This trial will aim to protect the Nullagine population and future fire management will focus on maintaining this protection as well as implementing burnt patches within the protected area to create a fire mosaic. Feral predator management is planned to be implemented in conjunction with future fire management.

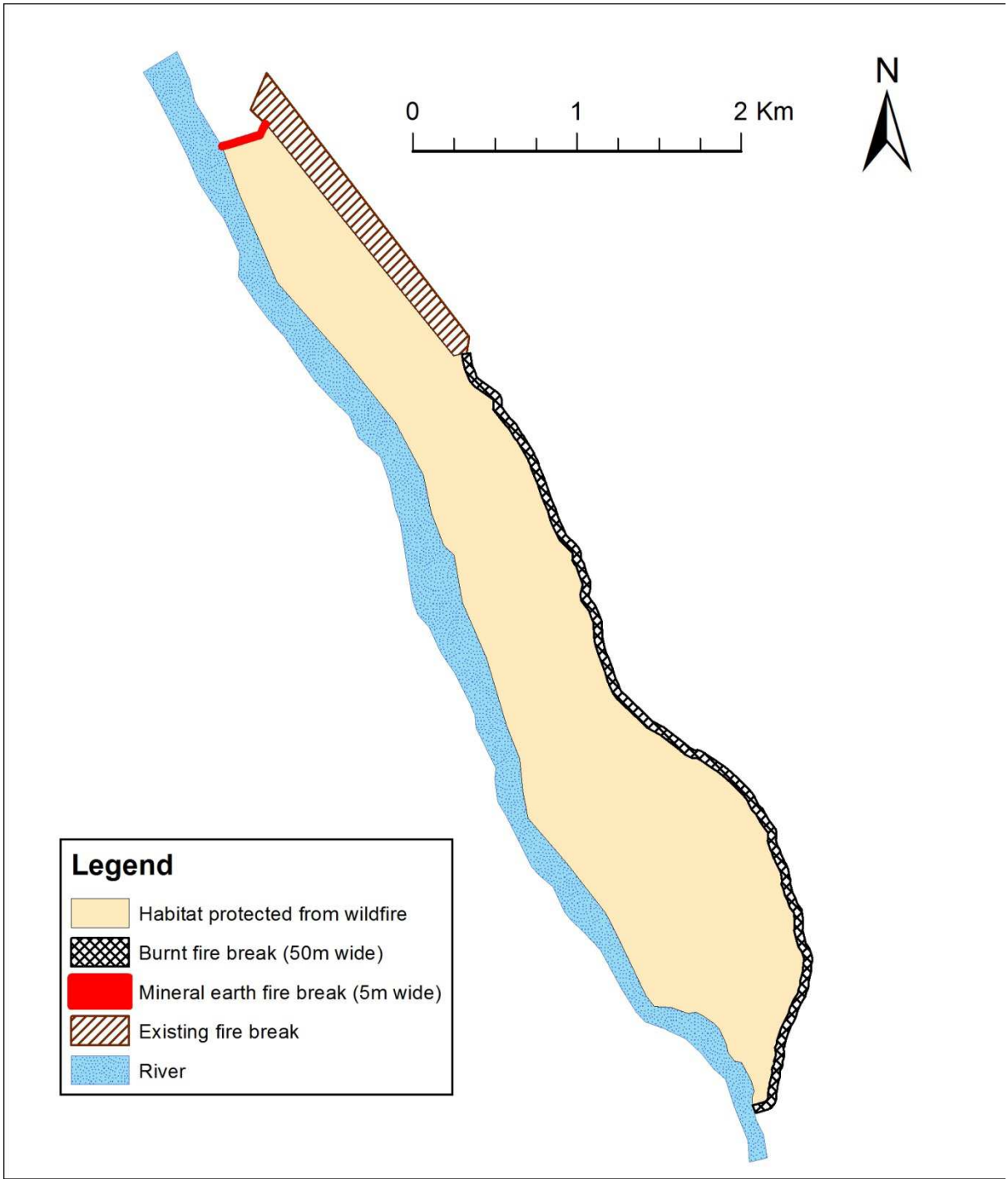

Figure 11. Fire management undertaken in 2017 at the Nullagine bilby population.

Figure 12. Fire management at the Nullagine bilby population.

Figure 13. Fire management at the Nullagine bilby population.

Figure 14. Fire management at the Nullagine bilby population.

Figure 15. Fire break three months post burning.

7.1 Management implications

- Protection of bilby populations from large, hot wildfires.
- Plan and technique developed to apply similar fire management at other bilby populations.

8 Ongoing work

The following ongoing work is planned to continue in 2017 and beyond:

- Continue collation of records from external sources.
- Maintenance of the Pilbara Threatened Fauna Database and websites.
- Maintain public awareness of bilbies in the Pilbara Region through continuation of media engagement, public seminars/presentations and distribution of posters.
- Continue work on modelling the distribution of bilbies in the Pilbara and ground-truth sites to validate the resulting models.
- Continue survey of the Pilbara using the existing 2 ha plot methodology when possible, focusing on unsurveyed areas identified from distribution modelling.
- Continue experimentation of RPA technology to survey for bilbies in the field.
- Continue monitoring populations, aiming for community and stake holder engagement and involvement in population monitoring.
- Continue implementation of threat management with initial focus on fire management at selected populations with community and stake holder engagement and support.

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Roy Hill

ecologia

Biologic

Throssell Coordinating Group - Rangelands NRM Western Australia

Offset Funding

Fortescue Metals Group

Millennium Minerals

Roy Hill

Appendices

Appendix 1 Publications

The following publications have been produced from this research:

Bradley, K., Lees, C., Lundie-Jenkins, G., Copley, P., Paltridge, R., Dziminski, M., Southgate, R., Nally, S., and Kemp, L. (2015). 2015 Greater Bilby Conservation Summit and Interim Conservation Plan: an Initiative of the Save the Bilby Fund. IUCN SSC Conservation Breeding Specialist Group, Apple Valley, MN.

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Appendix 2 Bilby Poster

The poster below can be requested by contacting threatenedfauna@dpaw.wa.gov.au or by phone on (08) 9219 9000.

Bilby

Macrotis lagotis

Bilby burrow: note the high, dome shape.

Bilby.

Bilby diggings at the base of *Acacia* bushes exposing roots.

Bilby diggings at the base of *Acacia* bushes exposing roots.

The bilby is a nocturnal, burrowing marsupial with large ears, soft, blue-grey fur, a long pointed snout and a black tail with a white tip. Body size can be up to 55cm long with a tail up to 29cm long.

Once found across most of arid and semi-arid Australia, the bilby is now only found in the Pilbara, Kimberley, north-western deserts in Western Australia and Northern Territory, and an isolated population in south-west Queensland.

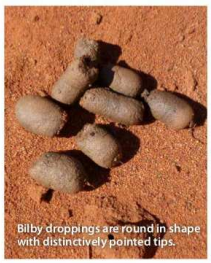
The presence of bilbies can be identified by large, high-arched burrows, distinctive tracks and scats, as well as diggings that are usually at the base of Acacia (wattle) shrubs to access grubs in the roots.

Parks and Wildlife is undertaking research on bilbies in the Pilbara. This research aims to survey where bilbies are in the Pilbara, and to develop long-term monitoring of populations.

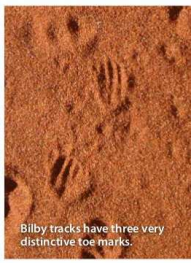
If you see bilbies or their signs, or have historical information, visit **naturemap.dpaw.wa.gov.au/threatenedfauna** and upload your records, locations and photos. Alternatively, email **threatenedfauna@dpaw.wa.gov.au** or phone **(08) 9405 5100**. Your contribution will help in the conservation of this species.

Department of Parks and Wildlife

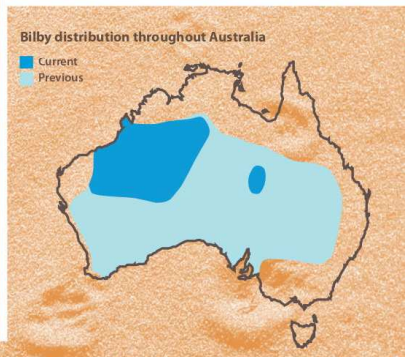
For more information visit:
naturemap.dpaw.wa.gov.au/threatenedfauna



Bilby droppings are round in shape with distinctively pointed tips.



Bilby tracks have three very distinctive toe marks.



Appendix 3 Standardised data sheet for 2 ha Sign Plots

The data sheet below can be requested by contacting threatenedfauna@dpaw.wa.gov.au .

Department of **Biodiversity, Conservation and Attractions**

GOVERNMENT OF WESTERN AUSTRALIA

2HA SIGN PLOT DATASHEET v1.4

FOR OCCUPANCY SURVEYS

1. RECORD LOCATION AT THE START

Site Name/Location/Plot ID_____

GPS:Lat/Easting_____Long/Northing_____ Date _____/_____/_____

Ranger group _____Time started_____Time finished_____

Team members_____

2. TEAM SPLIT UP EVENLY AND WALK A 2HA AREA FOR APPROXIMATELY 20 MINUTES
(Approximately 200m x 100m area)

3. INSPECT 100M OF THE ROAD FOR SIGN (ensure to tick "on road" for this sign)

4. RECORD ANIMAL DATA (tick boxes in table below ✓)

5. RECORD AGE OF SIGNS AT END OF WALKING 2 HA PLOT (1,2 or 3 in last column below)
Age of Sign: 1. Fresh 1-2 days old 2. Older, 3 days to 1 week 3. In hard mud/substrate or >1week

Species (add if not listed) All species prelisted	Tracks	Scats	Burrow	Digging	Digging into roots of plants	Tracks or sign on road	Other (eg sighting, remains, nest, resting place etc – add)	Juveniles present?	Age of most recent sign (1,2,3)
Bilby									
Bandicoot									
Bettong									
Dingo									
Echidna									
Euro									
Hopping mouse									
Kangaroo Red									
Kangaroo unknown									
Kangaroo W Grey									
Large rat									
Marsupial mole									
Mouse / Small Rodent / Dunnart									
Mulgara/Ampurta									
Possum									
Quoll									
Wallaby Agile									
Wallaby Hare									
Wallaby - Northern Nailtail									
Wallaby - Spectacled Hare									
Wallaby - unknown									
Lizard - Blue tongue									
Lizard - Goanna large									
Lizard - Goanna small									
Lizard - Great Desert Skink									
Lizard - Medium									
Lizard - Small									
Lizard - Thorny devil									
Sand slider (Lerista)									
Snake - other									
Snake - Python									
Bird - Curlew									

Department of **Biodiversity, Conservation and Attractions**

GOVERNMENT OF WESTERN AUSTRALIA

2HA SIGN PLOT DATASHEET v1.4

FOR OCCUPANCY SURVEYS

Species (add if not listed) All species prelisted	Tracks	Scats	Burrow	Digging	Digging into roots of plants	Tracks or sign on road	Other (eg sighting, remains, nest, resting place etc – add)	Juveniles present?	Age of most recent sign (1,2,3)
Bird - Emu									
Bird - Hopping									
Bird - Quail									
Bird - Turkey (Bustard)									
Bird - Walking									
Insect									
Other									
Cat									
Camel									
Cow									
Donkey									
Fox									
Goat									
Horse									
Pig									
Rabbit									

6. WHEN FINISHED WALKING RECORD THE FOLLOWING

Plot type

☐ Random ☐ Targeted at habitat ☐ Known location of target species

Plot sequence

☐ First time ☐ Repeat survey ☐ Unknown

Landform type

☐ Drainage line ☐ Dune or dunes ☐ Other (type in below)

☐ Salt lake system ☐ Hill or higher area _____

☐ Plain (flat low ground)

Soil type (substrate)

☐ Sand ☐ Soil/clay ☐ Gravel

Vegetation structure

☐ Shrubland ☐ Open woodland ☐ Dense woodland ☐ Open grassland

Vegetation thickness

☐ Open (easy to walk through) ☐ Thick (very hard to walk through)

If there are bilby diggings into roots what plants are they? _____

What percentage of the plot is suitable for tracking (eg sand or dirt)**?**

☐ To ¼ (0-25%) ☐ To ½ (25-50%) ☐ To ¾ (50-75%) ☐ Up to all (75-100%)

Department of **Biodiversity, Conservation and Attractions**

GOVERNMENT OF WESTERN AUSTRALIA

2HA SIGN PLOT DATASHEET v1.4

FOR OCCUPANCY SURVEYS

How big are the majority of the sand patches?

☐ less than 1m in width ☐ 1-3 m in width ☐ more than 3 m in width ☐ No sand patches

Shadow (look at own shadow

☐ Distinct shadow ☐ Slight shadow ☐ No shadow

Time since rain that would clear animal tracks (enter number) ☐ Days ☐ Weeks ☐ Months

Time since strong wind that would clear animal tracks (enter number) ☐ Days ☐ Weeks ☐ Months

Time since burnt (if known)

☐ <1 month ☐ <1 year ☐ >1 year

Photos of habitat taken? Y / N (if yes –list photo file names) _____

_____

_____

[OPTIONAL] If bilby burrows are found GPS the location of each one:

GPS Location (lat, long)	**Any notes - location (e.g under log or tree), sensor camera number if placed**

Any other comment/ notes:

Please submit datasheets to:

Department of Biodiversity, Conservation and Attractions - threatenedfauna@dbca.wa.gov.au, Woodvale Wildlife Research Centre, Bilby Research, Locked Bag 104 Bentley Delivery Centre WA 6983. (08) 9405 5105

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