



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

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Progress Report 2016

April 2016



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April 2016

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The recommended reference for this publication is:
Department of Parks and Wildlife, 2016, The conservation and management of the bilby (*Macrotis lagotis*) in the Pilbara: Progress Report 2016, Department of Parks and Wildlife, Perth.

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Summary

The greater bilby (*Macrotis lagotis*) is a burrowing marsupial that was once wide spread 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 has been collated from existing sources and field surveys. Bilbies in the Pilbara were found to be associated with stands of particular *Acacia* species which provide the major food resource for bilbies in the Pilbara in the form of cossid moth larvae (grubs) from their root systems. Remotely piloted aircraft were trialled in the field to detect bilby sign in inaccessible areas and to increase the speed and efficiency of presence/absence surveys. This technique showed potential and will be further developed.

A study of the effect of time on DNA degradation found that DNA exists on bilby faecal pellets for a long period of time and can be amplified with a high success rate and low error rates. A population monitoring technique to measure abundance has been developed using DNA extracted from scats quantitatively collected at populations in the field. We recommend this technique to be used as a standard method to monitor numbers of individuals within populations. Monitoring using this technique found that populations in the Pilbara are geographically isolated and consist of a small number of individuals. This means that they are likely to be very vulnerable to the threats described in Section 1 and any disturbance.

An ecological study examining the use of bilby burrows by other species found that both occupied and disused burrows are important for a range of other species. The disappearance of bilbies across at least 80 % of their former range, and thus the disappearance of their burrows as important structural resources in an often featureless and harsh environment, may have had important consequences for a range of species.

1 Introduction

The greater bilby (*Macrotis lagotis*) is a burrowing marsupial that was once wide spread 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 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).

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.* 2016). 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.* 2016).

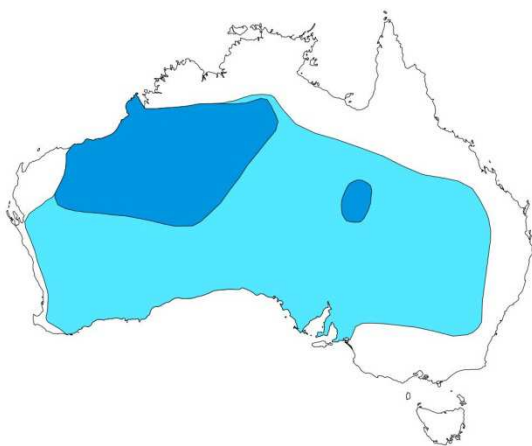


Figure 1. Current (■) and former (■) distribution of the greater bilby.

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 <i>Acacia</i> 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 (<i>Astrebla pectinata</i>) and feathertop wiregrass (<i>Aristida latifolia</i>) in the form of open-tussock grassland, saltbush (<i>Atriplex</i> spp.) herblands and open succulent shrubland of Queensland bluebush (<i>Chenopodium auricomum</i>) and canegrass (<i>Eragrostis australasica</i>)	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 <i>Triodia basedowii</i> , <i>T. pungens</i> and <i>T. schinzii</i>) with low shrub cover of <i>Acacia</i> species. <i>Melaleuca</i> spp. In palaeodrainage channels.	Rises and low-lying drainage systems	Tanami Desert, Northern Territory	Southgate <i>et al.</i> (2005)
Dune and sand substrate, laterite/rock features and drainage/calcrete substrates	3 spinifex or hummock grass species (<i>Triodia pungens</i> , <i>T. schinzii</i> , and <i>T. basedowii</i>), with an overstorey of scattered shrubs and trees; shrub species	Rises and low-lying drainage systems	Tanami Desert, Northern Territory	Southgate <i>et al.</i> (2007)
Cracking clays, sandplains, dunefields sometimes containing laterite, massive red earths.	Mitchell grass (<i>Astrebla pectinata</i>), hummock grassland (<i>Triodia</i> spp.) and <i>Acacia</i> 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.* 2016).

Objectives of this project	Alignment with the interim conservation plan goals (Bradley <i>et al.</i> 2015)	Alignment with research priorities for the greater bilby in the north of Western Australia (Cramer <i>et al.</i> 2016)
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)
- WA Department of Parks and Wildlife, 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 1059 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 (DPaW 2016). Records collated range from 1901 to 2016 and peak between 2010 and 2016 (Figure 3).

2.1 Management implications

- Better understanding of where bilbies are present in the Pilbara for environmental impact assessment (EIA) processes
- Enough presence data now gathered to enable accurate modelling of the distribution of bilbies in the Pilbara (see Section 6).

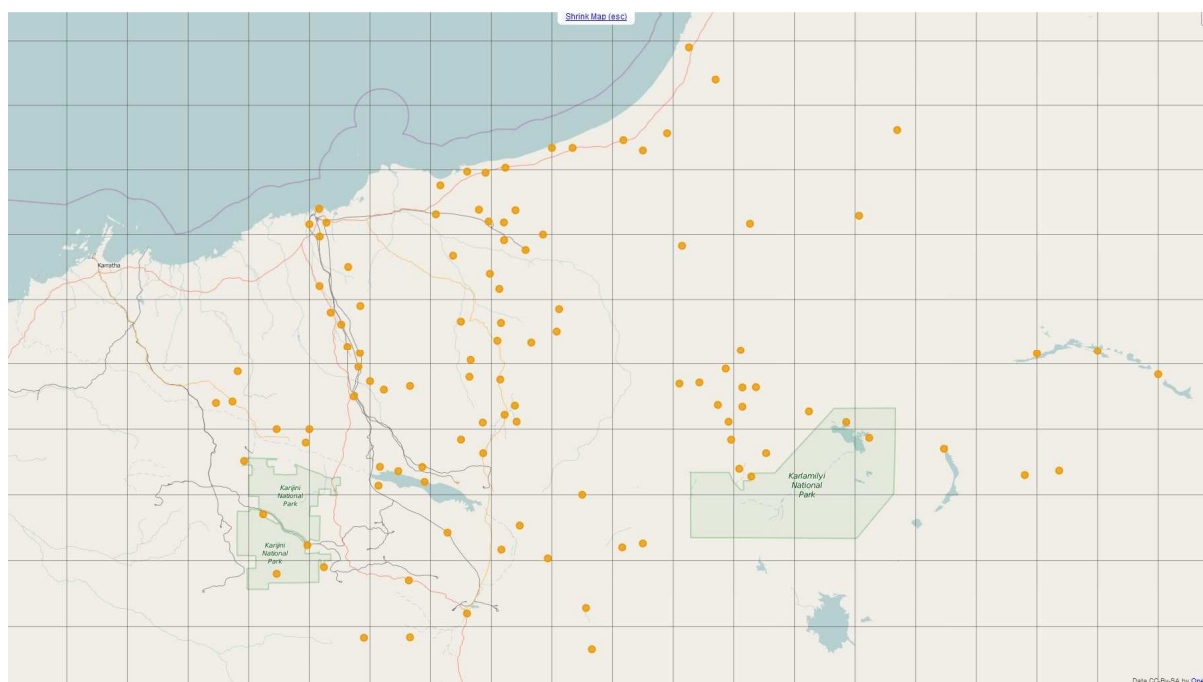


Figure 2. Bilby records (●) collated from the Pilbara region.

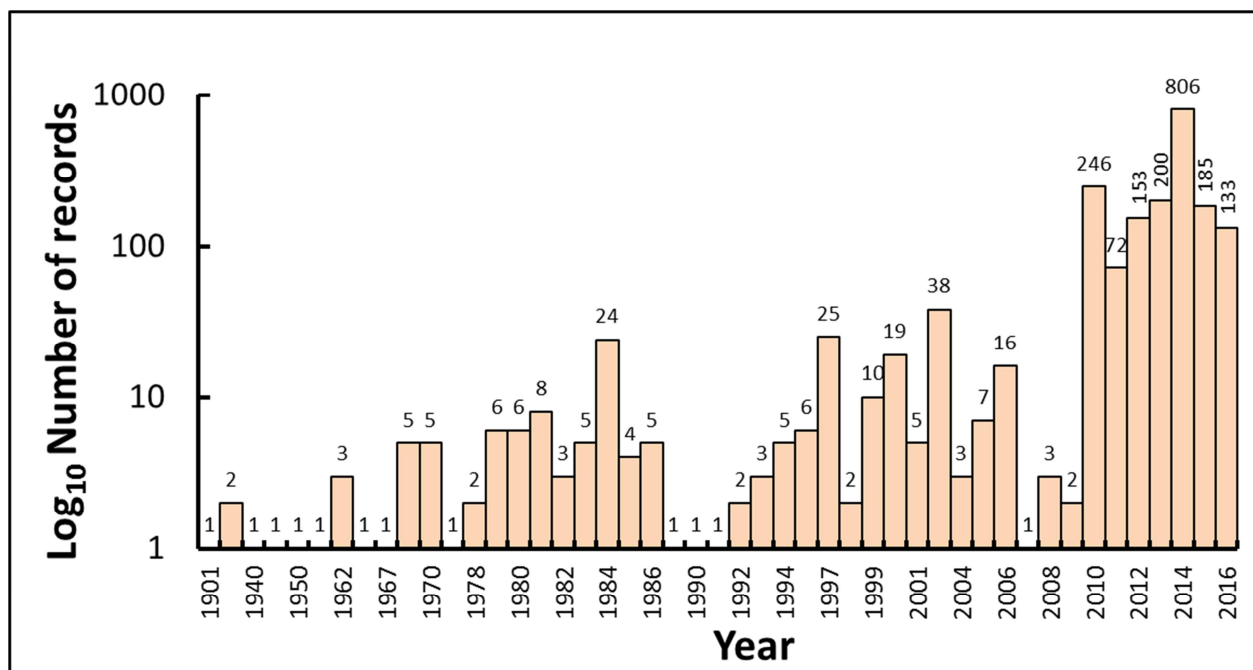


Figure 3. Frequency distribution of all collated bilby records from the Pilbara.

3 Population monitoring

3.1 Development of a population monitoring technique

To date, the most common techniques that are used to “monitor” bilbies only provide presence/absence data and no data on the actual abundance or numbers of bilbies at populations (Lavery and Kirkpatrick 1997; Moseby and O’Donnell 2003; Southgate *et al.* 2005; Bradley *et al.* 2015). Although **surveying** the presence/absence of bilbies is important to gain an understanding of their locations and patterns of movements across the landscape, abundance **monitoring** is needed to know information about actual numbers of bilbies within populations, to know what is happening at those populations. It is important to make the distinction between **survey** and **monitoring**, and monitoring numbers of bilbies within populations provides data on demographic fluctuations that can be caused by threats or changes in the surrounding environment.

Bilbies are trap-shy, are not consistently attracted to any form of bait, and reliably trapping an individual involves finding an occupied burrow and fencing it in with traps or digging traps into the burrow (Southgate *et al.* 1995; Lavery and Kirkpatrick 1997; Moseby and O’Donnell 2003). This technique involves a lot of effort and is a partially destructive method of sampling. Therefore, bilbies are not suitable for efficient mark-release-recapture studies.

The use of tracks is an unreliable indicator of numbers, especially when densities are high (Paltridge and Southgate 2001; Southgate *et al.* 2005). Some surveys have made use of burrow counts (eg Burrows *et al.* 2012), however the correlation between burrows and bilby numbers is poor and unreliable (Southgate *et al.* 1995; Lavery and Kirkpatrick 1997). A single bilby may use up to 18 burrows, sometimes up to 1 km apart, and may use up to 3 different burrows per night (Lavery and Kirkpatrick 1997; Moseby and O’Donnell 2003). Therefore, although burrows and tracks are a good indicator of presence, they are poor indicators of density.

Bilby scats are relatively easy to find, are distinctive and cannot be confused with the scats of other species by trained observers (Moseby *et al.* 2009). Simply counting scats is not reliable as there is no way of excluding recounts of individuals, and the use of distance sampling of bilby scats requires the scat deposition and decay rates to be accurately known (Lollback *et al.* 2015) to estimate the number of bilbies. These rates vary with location and season (Lollback *et al.* 2015). However, quantitatively sampling bilby scats, but coupling this with genotyping individuals using DNA from their scats, allows a more accurate calculation of bilby numbers within populations. Furthermore, a genetic snapshot of the population shows the relatedness of individuals as well as the relationship and connectivity with other nearby and distant populations or family groups. This non-invasive technique is the population monitoring tool that Parks and Wildlife have developed, recommend, and have implemented at monitoring sites across Western Australia.

Line transects 1-3 km and 50x50 m plots were tested to quantitatively collect scats. Scats were more reliably and efficiently collected from transects, which also had the

benefit of sampling across the home ranges of multiple individuals. A pilot trial of this monitoring technique was undertaken at Matuwa (Dziminski and Carpenter 2014). DNA was extracted from scats using a commercial stool DNA kit with some modifications to the process. Individuals were genotyped across seven polymorphic microsatellite loci (Moritz *et al.* 1997; Smith *et al.* 2009). To ensure DNA from scats can be used for monitoring individuals and to know the time duration that viable DNA is present on scats, an understanding of faecal DNA degradation is required. The effect of time on the degradation of faecal DNA from bilby pellets is described in Section 3.1.1 below.

After the initial pilot study, several trial monitoring sites were implemented across the Pilbara. These are described in Section 3.2 below. In 2015, the technique was tested over a much larger area at Matuwa (Figure 4) and preliminary results indicate 23 individuals detected from 215 scats collected from 66.3 km of transects across an approximately 4 000 ha area. These data are currently being further analysed and the monitoring and data analysis procedures are being refined to increase accuracy and efficiency.

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.

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

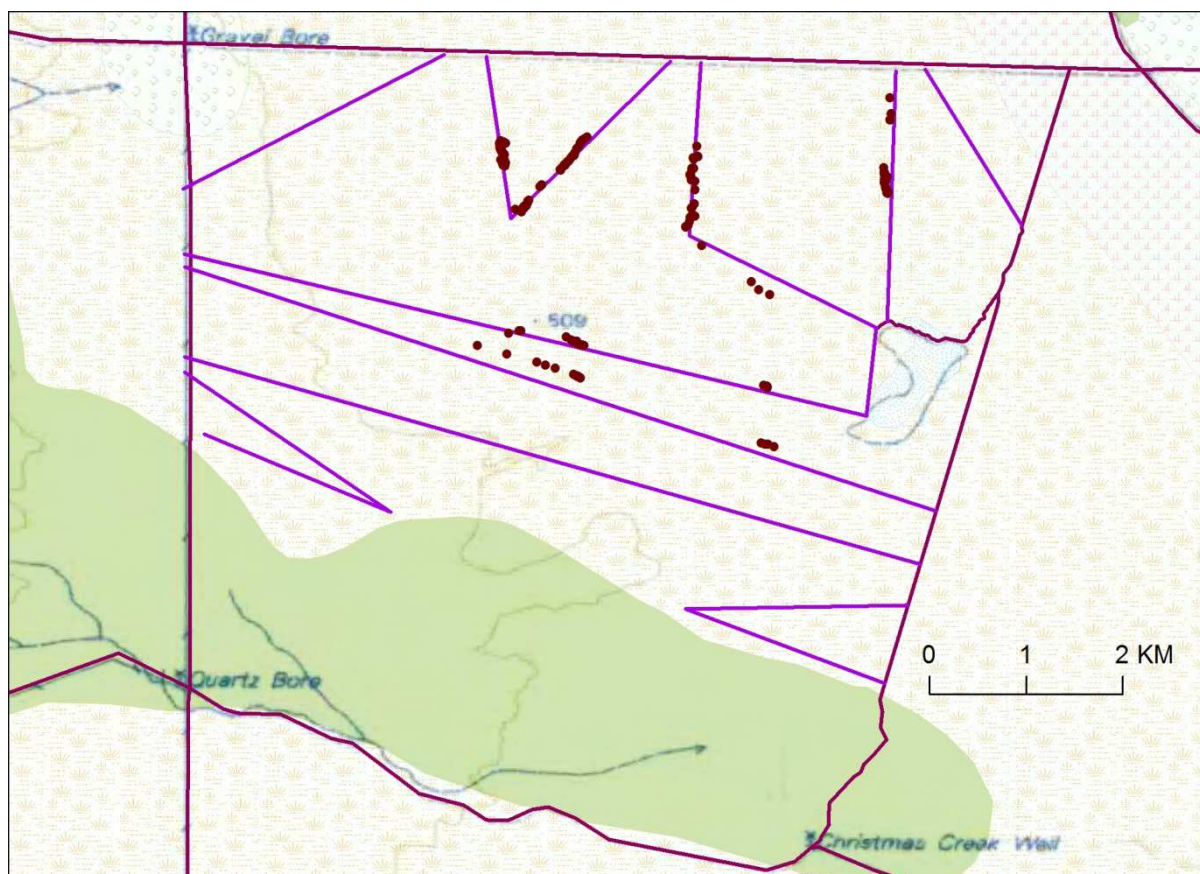


Figure 4. Transects (—) and points where bilby scats were collected (●) at an approximately 4 000 ha trial monitoring site at Matuwa.

3.1.1 Breaking down scats: degradation of DNA from bilby faecal pellets

To establish whether genotyping of threatened greater bilby (*Macrotis lagotis*) individuals from faecal pellets collected in the field can be useful for population monitoring, an understanding of the degradation rates of faecal DNA is necessary. The aims of this study were to determine the relationship between time and degradation of bilby DNA from faecal pellets and to assess the efficacy of whether a two-step elution process allows for better quality DNA with less inhibitors.

Faecal pellets were collected from captive individuals and maintained under semi-natural conditions in the field, then harvested at known time periods. DNA was extracted using a commercial stool DNA kit, with the addition of a two-step elution process to establish whether higher quality DNA could be obtained from a second eluate. Three polymorphic microsatellite markers were used to genotype samples.

We found that viable DNA exists on bilby faecal pellets for a long period of time and can be amplified with a 99% success rate and low error rates (less than 5% for both false alleles and allelic dropouts) up to 14 days after deposition (Figure 5). The amplification rate decreases, and the rate of allelic dropout increases gradually with time, but DNA can still be successfully amplified at rates above 80% and error rates below 11% at 30 days, and amplification rates above 60% and error rates below 15% at 90 to 180 days.

Amplification rates of bilby faecal DNA decreased and the proportion of allelic dropouts increased over time. We found that a second elution step at the end of the extraction process was unnecessary, with more DNA successfully amplified over a longer period of time using the first eluate. The implications of this are that DNA can be successfully amplified from bilby faecal pellets for a long period after deposition which is useful for obtaining genetic samples for population monitoring programs and studies on population genetics.

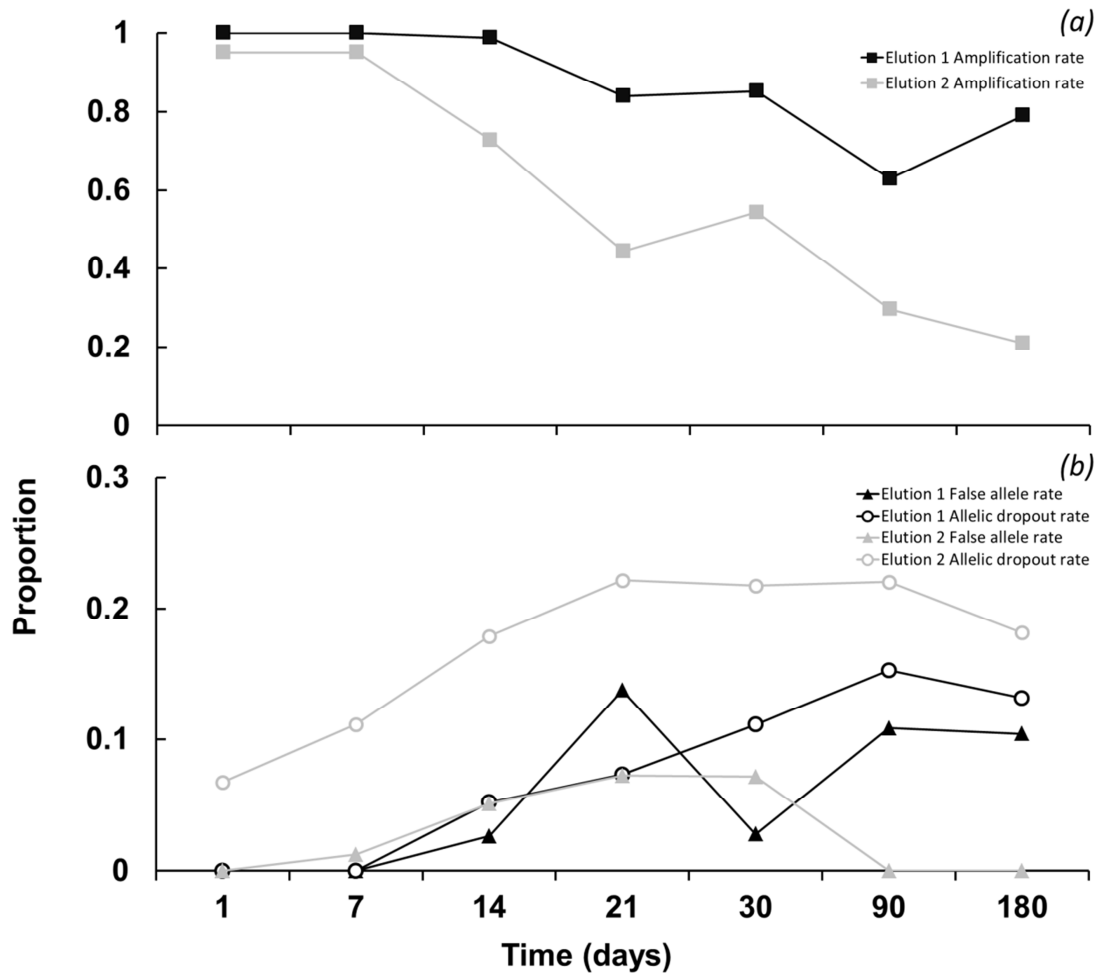


Figure 5. (a) The mean proportions of samples that amplified from DNA extracted using Elution 1 (■) and Elution 2 (■), (b) the mean proportion of false alleles from DNA extracted using Elution 1 (▲) and Elution 2 (▲), and the mean proportion of missing alleles from DNA extracted using Elution 1 (●) and Elution 2 (○), over time for three microsatellite loci on faecal DNA from greater bilbies (*M. lagotis*).

3.1.2 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 management of threats.

- Satisfies the needs for consistency with on-going bilby monitoring programs in the Pilbara and the Kimberley.

3.2 Implementation of population monitoring

As well as the trial site at Matuwa, population monitoring was undertaken at four populations in the Pilbara in 2015. As in 2014, population monitoring was undertaken in collaboration with FMG and *ecologia* at the Turner River and Hillside populations and with BHP and Biologic at the Yarrie population.

Unfortunately, at the Turner River and Hillside populations sampling was undertaken several days after a heavy rainfall event. As a result there were a very limited number of scats available for collection (Table 3) due to being washed away and/or disintegration from rainfall, particularly at the Hillside population. Because of this, the results from these two populations in 2015 should be interpreted with caution.

The Pardoo population was not monitored in 2015 due to only the tracks of one individual and one scat being found towards the end of 2014, with no other fresh evidence of any bilby presence. The area was searched in all directions out to 5 km on foot, and then out to 20 km by vehicle. No bilby evidence was found. Bilby populations in desert areas have been recorded moving up to 2.3 km per year and one population was recorded moving 10.5 km in 3 years (Southgate and Possingham 1995). This search was conducted over several days and was assessed to be thorough enough to detect the population if it had shifted. During the search at least four feral cats were observed jumping out of old disused bilby burrows. Furthermore, nearly the entire area had been burnt sequentially in 2012, 2013 and 2014 by large scale hot fires, and only several small patches of the once thick stands of *Acacia monticola* remain in the area. These *Acacia* stands provide the major food resource for bilbies in the area in the form of cossid moth larvae within the root systems.

In 2013, at least eight individuals were present in this area (Table 3), this population was confirmed as being in the same location since at least 2012 and there is anecdotal evidence from locals that bilbies were present at this location for up to 20 years. It is possible that the multiple large scale, hot fires have wiped out all the food resources for bilbies in the area, and coupled with an increase in cat predation, have caused bilby numbers to severely decline at this location. Further searches need to be conducted to confirm if bilbies are now absent from this area.

3.2.1 Management implications

- Provides baseline measures of abundance within populations in the Pilbara for future EIA processes
- Populations in the Pilbara are isolated and consist of a small number of individuals. This means that they are likely to be very vulnerable to the threats described in Section 1 and any disturbance.

Table 3. Numbers of individuals identified from scats collected along transects at monitoring sites.

Population	2013			2014			2015		
	Scats collected	Scats yielding DNA (% yielding DNA)	Individuals identified on transects	Scats collected	Scats yielding DNA (% yielding DNA)	Individuals identified on transects	Scats collected	Scats yielding DNA (% yielding DNA)	Individuals identified on transects
Pardoo	40	9 (23%)	8	1	0	-	-	-	-
Turner River	-	-	-	50	19 (38%)	2	19	6 (32%)	1
Hillside	-	-	-	49	16 (33%)	4	3	0	-
Nullagine	-	-	-	44	7 (16%)	2	46	28 (61%)	5
Yarrie	-	-	-	-	-	-	62	15 (24%)	10
Matuwa	-	-	-	-	-	-	215	118 (55%)	23

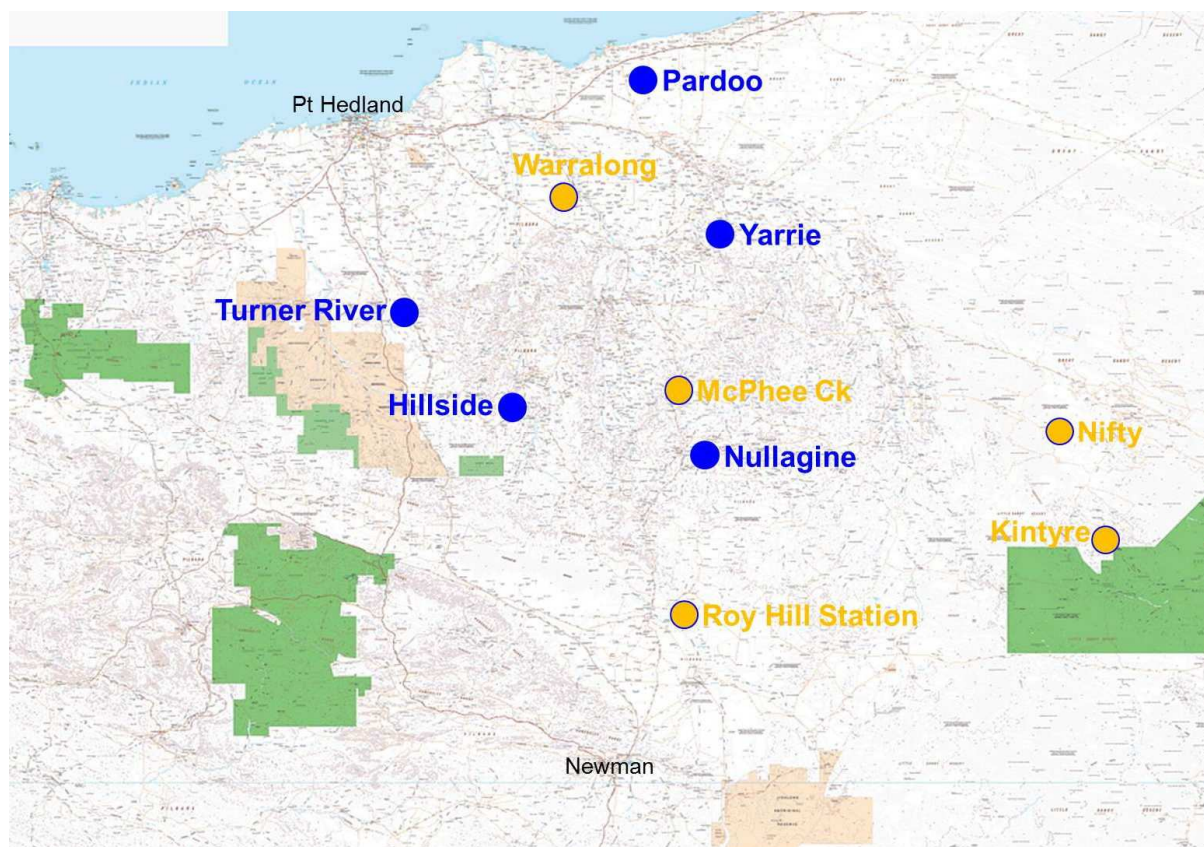


Figure 6. Current (●) and potential future (●) population monitoring sites.

4 Presence/absence survey

4.1 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 hectare plot method described in Moseby *et al.* (2011) and developed by Southgate *et al.* (2005) and Southgate and Moseby (2008) . Only three types of sign provide definitive evidence of the presence of bilbies:

1. Tracks
2. Scats
3. Multiple diggings into the bases 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 bases 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, off-road trailer for transport and a shipping container for storage were 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 1209 plots in likely bilby habitat have been surveyed for the presence of bilbies across the Pilbara (Figure 7). At 254 of these plots, confirmed evidence of bilby presence was recorded (Figure 8). These data will be available through the departments NatureMap portal (DPaW 2016).

Preliminary analyses have revealed that as well as always being found in areas where the substrate of sand, soil, sandy clay, or sandy gravel is suitable for burrowing, there is an association with particular *Acacia* spp. that bilbies use for food resources (Table 4). At sites where bilbies are found, these *Acacia* spp. typically form monospecific stands that provide resources in the form of cossid larvae (grubs) which is the major food resource for bilbies in the Pilbara.

4.1.1 Management implications

- Better understanding of where bilbies are present in the Pilbara for environmental impact assessment (EIA) processes
- Better understanding of the type of habitat and in particular vegetation that bilbies are associated with in the Pilbara for environmental impact assessment (EIA) processes and for Level 2 or targeted surveys
- Better understanding of what type of sign can be used for detection of bilbies in the Pilbara for Level 2 or targeted surveys
- Enough presence data now gathered to enable accurate modelling the distribution of bilbies in the Pilbara (see Section 6).

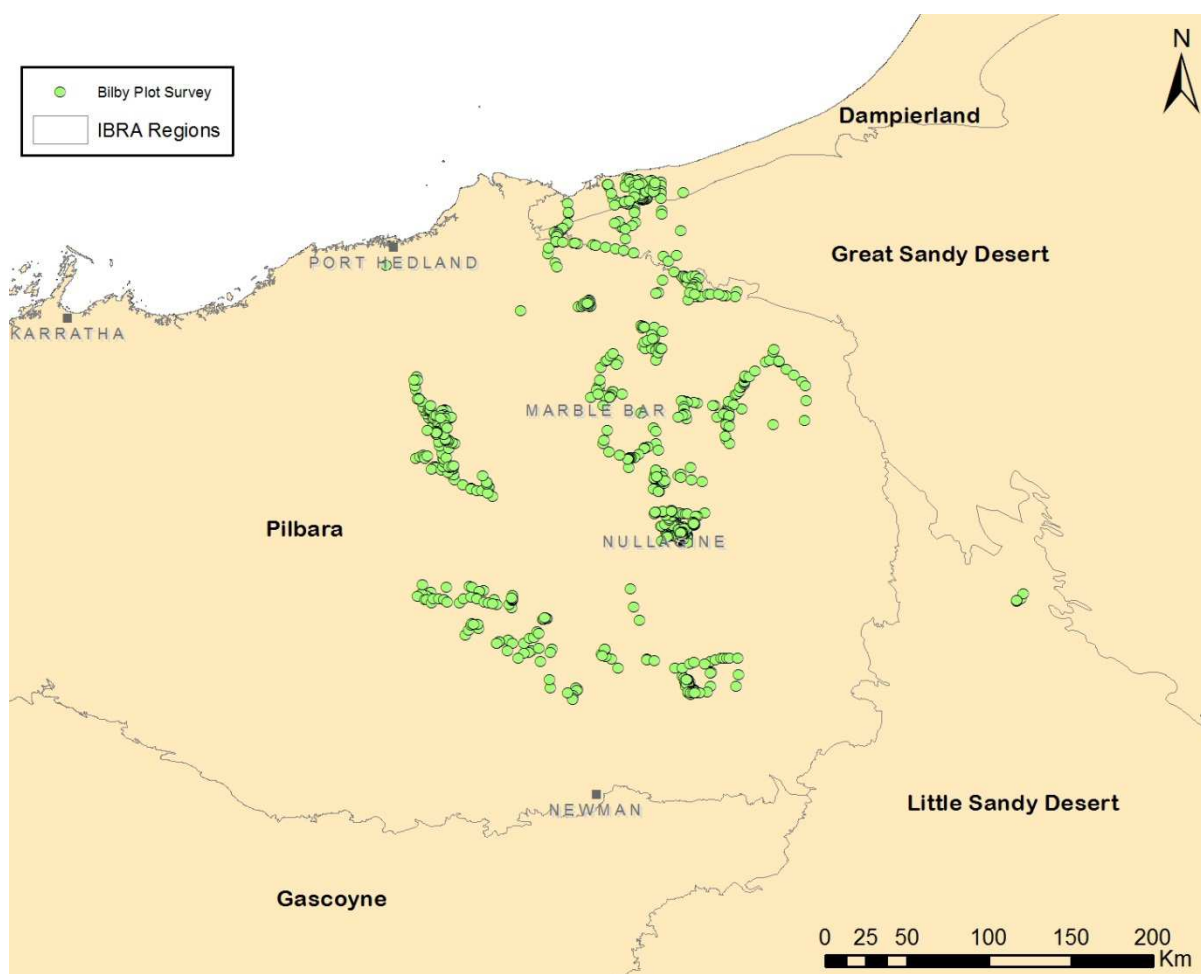


Figure 7. Plots surveyed for bilby presence across the Pilbara.

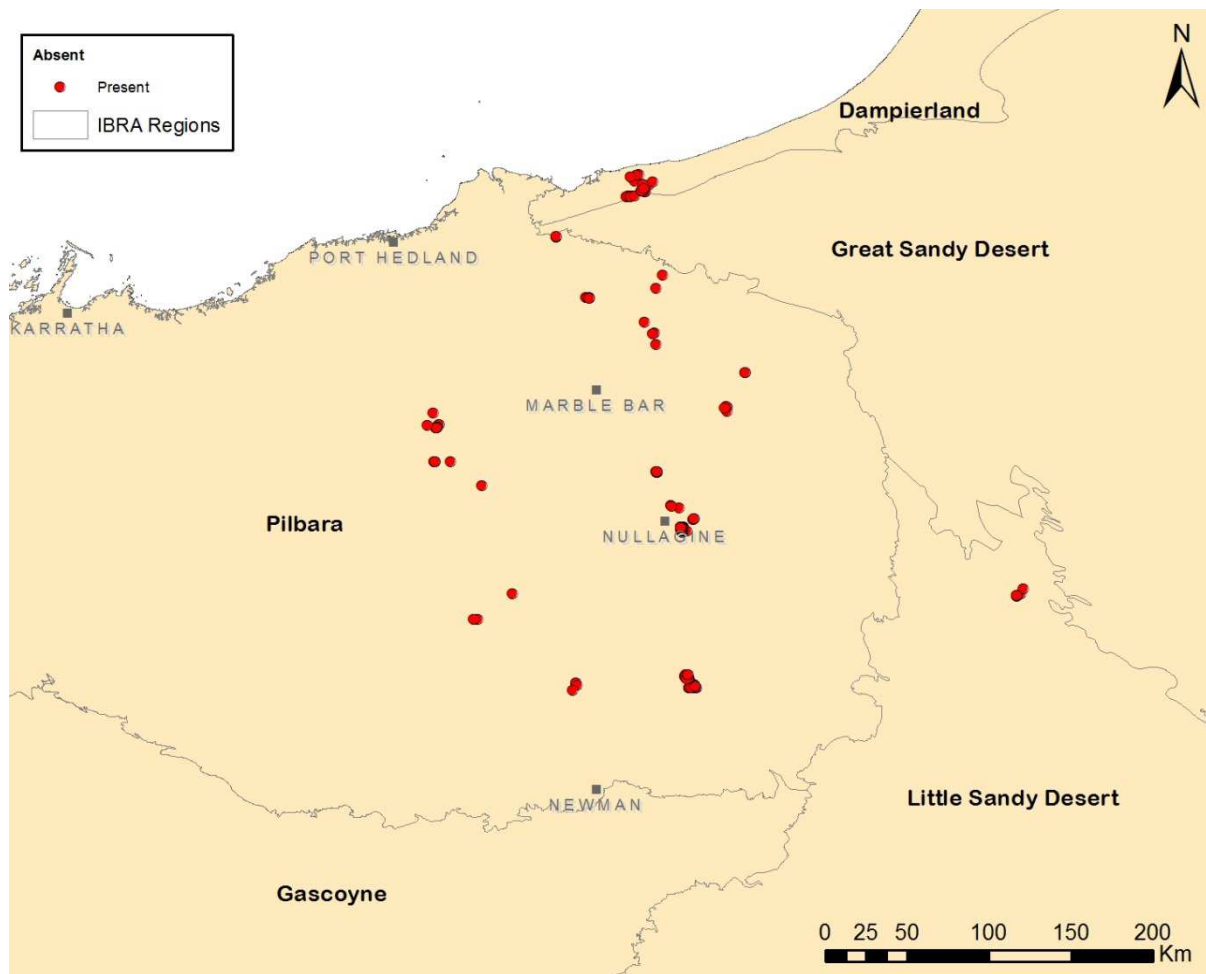








Figure 8. Bilby presence detected at survey plots across the Pilbara.

Table 4. *Acacia* associations at sites where bilbies were found in the Pilbara.

Area	<i>Acacia</i> association	Image
Turner River	Stands of <i>A. stellaticeps</i> and <i>A. bivenosa</i>	
Hillside	<i>A. trachycarpa</i> along drainage lines	
Nullagine	Stands of <i>A. trachycarpa</i> (dwarf form)	
McPhee Creek	Stands of <i>A. trachycarpa</i> (dwarf form) and <i>A. bivenosa</i>	
Warralong	Stands of <i>A. coleii</i>	
Roy Hill Station	Stands of <i>A. melleodora</i> and <i>A. dictyophleba</i>	

Pardoo

Stands of *A. monticola*



Yarrie

Stands of *A. stellaticeps*
and *A. trachycarpa* (dwarf
form)

Meentheena

Stands of *A. bivenosa*

Warrawagine

Stands of *A. colei*

Kintyre

Stands of *A. dictyophleba*



4.2 Improving survey techniques

Three survey techniques for detecting the presence of bilbies were tested for efficiency and reliability by Southgate *et al.* (2005). Their evaluation of transect, plot, and aerial survey techniques for detecting bilby sign (tracks, diggings and burrows) determined that aerial survey using helicopters was the most reliable, and cost- and time-efficient method of detecting the presence of bilbies.

Costs for helicopter use in remote areas is still very expensive, however emerging remotely piloted aircraft (RPA: drones or UAV) technology may prove an even more cost effective and practical technique for aerial surveys. Areas that are inaccessible to on ground plots may be surveyed by RPA to detect the presence/absence of bilby burrows using live-feed video imagery. Live-feed video imagery negates the need for lengthy post-processing, and provides immediate on-ground results.

A short trial of this technique was conducted in the field using two rotary wing RPAs at Matuwa in 2015 (Figure 9). Locations where bilbies were known to be present were overflown using a live HD video feed. Recently burnt and unburnt areas were overflown. Bilby burrows and diggings were easily detected in recently burnt areas (Figure 10) and burrows were detected in unburnt areas (Figure 11) with success.

This method will need to be evaluated in the Pilbara where vegetation characteristics in areas occupied by bilbies may be different to the trial area. If vegetation in areas

that bilbies occupy is denser, it may reduce visibility and rates of detection of burrows from the air. Further research needs to be completed to determine optimal altitudes, velocities, camera angles and fields of view, atmospheric conditions (light levels, sun angle, shadows), and search patterns in a range of habitats to optimise this technology.

Two major restrictions of this technology were identified during these trials. The first was battery power – flight duration was typically between 15 to 20 minutes per battery depending on wind conditions. A stock of batteries needs to be constantly kept recharging either in a vehicle or from a generator to ensure sequential flight capability. However, with the current rapid increase in lithium ion battery technology, batteries will become better and flight duration longer.

The second major restriction is the current federal regulation that any use of RPA for gain requires an accredited and certified operator (CASA 2016a). Research is defined as a gain. Accreditation requires successful completion of basic RPAS training from a CASA approved organisation or successful completion of an aviation theory examination, manufacture training certificate and evidence of 5 hours logged time on type and furthermore, a minimum 80 day waiting period for processing applications. However, the good news is that the regulations are changing and as of late September 2016 operators of RPA under 2.5 kg will not require permits or accreditation (CASA 2016b).

4.2.1 Management implications

- Ability to survey previously inaccessible areas for bilby presence in the Pilbara for Level 2 or targeted surveys
- A more efficient, cost-effective survey technique allowing more area to be surveyed in less time for Level 2 or targeted surveys
- More data on bilby presence in previously inaccessible areas of the Pilbara for (EIA) processes
- A quicker method of identifying a population and defining the boundaries of occupancy prior to population monitoring (see Section 3.1).



Figure 9. The two rotary wing RPA and live HD video feed that was trialled in 2015.



Figure 10. Screen capture of burrows and diggings in a recently burnt area from the live HD video feed.



Figure 11. Screen capture of burrows in an unburnt area from the live HD video feed.

5 Greater bilby burrows: important structures for a range of species in an arid environment.

This project was undertaken by Lucas Hoffstede from Helicon Opleidingen Institute, Netherlands who completed a student internship with the Department of Parks and Wildlife in 2015.

Ecosystem engineers modify, create or destroy habitat. Greater bilbies have been described as ecosystem engineers and their burrows are significant structures across an often featureless and harsh arid landscape. We deployed remote cameras at 23 bilby burrows over 42 days to determine if bilby burrows were important structures for other species.

Cameras detected two mammal species, brush-tailed mulgara (*Dasycercus blythi*) and spinifex hopping mice (*Notomys alexis*) permanently occupying bilby burrows, and a further two species, short-beaked echidnas (*Tachyglossus aculeatus acanthion*) and sand goannas (*Varanus gouldii*) regularly using bilby burrows for shelter. An additional suite of 16 mammal, bird, reptile, amphibian and invertebrate species were detected interacting with bilby burrows (Table 5). Data gathered from studies in other parts of Australia identified a further six species using bilby burrows. There was no difference in the number of species using disused or occupied bilby burrows, indicating that even disused bilby burrows are an important structure for heterospecifics.

We show that bilby burrows support a range of species and are analogous to the traditional, mostly North American, and commonly provided text book examples of the gopher tortoise and kangaroo rat (Figure 12). The disappearance of bilbies across at least 80 % of their former range and thus the disappearance of their burrows as important structural resources in an often featureless and harsh environment may have had important consequences for a range of species.

5.1 Management implications

- Bilby burrows are important habitat for a suite of species
- Ensuring the persistence of bilbies where they still occur, and reintroducing bilbies back to areas they once occupied, may have positive effects on biodiversity

Table 5. Species observed occupying, regularly using and interacting with bilby burrows at Matuwa.

Mammals	Reptiles	Amphibians	Birds	Invertebrates
Species occupying bilby burrows				
Brush-tailed mulgara (<i>Dasyercus blythi</i>)				
Spinifex hopping mouse (<i>Notomys alexis</i>)				
Species regularly using bilby burrows				
Brush-tailed mulgara (<i>Dasyercus blythi</i>)	Sand goanna (<i>Varanus gouldii</i>)			
Spinifex hopping mouse (<i>Notomys alexis</i>)				
Short-beaked echidna (<i>Tachyglossus aculeatus acanthion</i>)				
Species interacting with bilby burrows				
Brush-tailed mulgara (<i>Dasyercus blythi</i>)	Sand goanna (<i>Varanus gouldii</i>)	Desert spadefoot toad (<i>Notaden nichollsi</i>)	Torresian crow (<i>Corvus orru</i>)	Common furniture beetle (<i>Anobium punctatum</i>)
Spinifex hopping mouse (<i>Notomys alexis</i>)	Mallee dragon (<i>Ctenophorus fordii</i>)		Splendid fairy-wren (<i>Malurus splendens</i>)	Migratory locust grasshopper (<i>Locusta migratoria</i>)
Desert mouse (<i>Pseudomys desertor</i>)	Blue-tailed finesnout ctenotus (<i>Ctenotus calurus</i>)		Crested bellbird (<i>Oreoica gutturalis</i>)	Spider (<i>unidentified</i>)
Short-beaked echidna (<i>Tachyglossus aculeatus acanthion</i>)	Lined firetail skink (<i>Morethia ruficauda</i>)		Willie wagtail (<i>Rhipidura leucophrys</i>)	
European rabbit (<i>Oryctolagus cuniculus</i>)	Bearded dragon (<i>Pogona minor</i>)			
Cat (<i>Felis catus</i>)	Mulga snake (<i>Pseudechis australis</i>)			

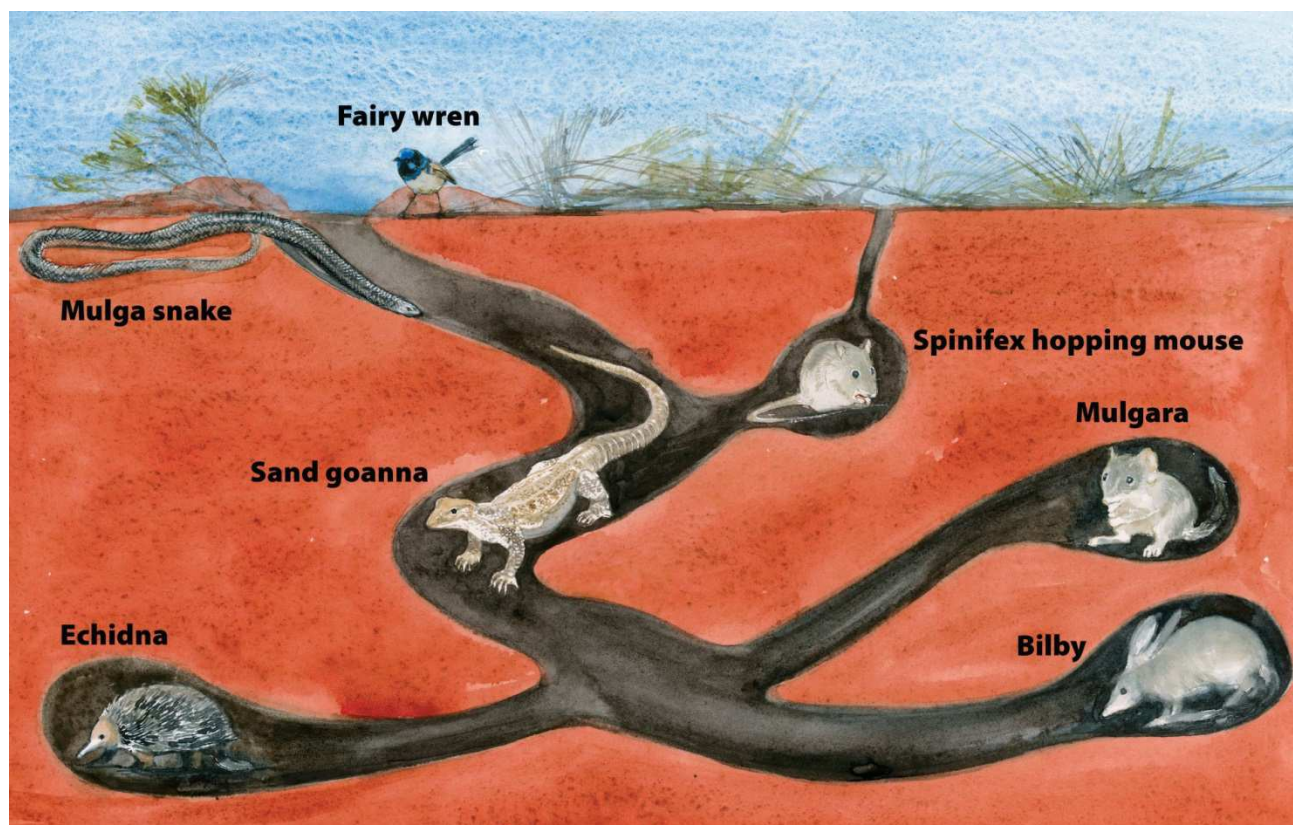


Figure 12. Example of a typical bilby burrow and some of the species that occupy and use bilby burrows. Burrow structure drawn from Smyth and Philpott (1968) and observations from this study. Illustration by Gooitzen Van Der Meer.

6 Ongoing work

The following ongoing work is planned to continue in 2016 and beyond:

- Continuing 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
- Using presence data, model the distribution of bilbies in the Pilbara – this was delayed until sufficient presence records were obtained during 2015 to enable accurate modelling of the distribution of bilbies in the Pilbara
- Continue survey of the Pilbara using the existing 2 ha plot methodology when possible
- Progress testing of RPA technology to survey for bilbies in the field
- Implement monitoring at more populations, aiming for community engagement and involvement in population monitoring
- Commence an experiment testing the performance of three different methods of storing scats to preserve DNA – desiccation with silica gel beads, freezing and dry envelopes.
- Initiate population genetics project using existing bilby DNA library collected from population monitoring and opportunistically collected scats
- Initiate diet analysis of surplus scats collected during population monitoring and opportunistically collected scats

Acknowledgments

Global Gypsies – Lorna Glen trial transects
Martu - Traditional Owners of Matuwa
Nullagine Community School and Community
Roy Hill Station
Yarrie Station - Annabelle Coppin
Pardoo Station
Millennium Minerals – Chris Goti
Aditya Birla Nifty – Michael Robinson
Cameco – Tim Duff
Rangelands NRM Western Australia
Paul Gioia – NatureMap Theme (Department of Parks and Wildlife)
Roy Hill
ecologia
Biologic
Rangelands NRM WA Throssell Coordinating Group
Frank Morris
Neil Thomas
Rebecca Coppen
Christina Koproicz
Andrew Moore
Lucas Hoffstede - Helicon Opleidingen Institute, Netherlands
Gooitzen Van Der Meer for the illustration of the bilby burrow

Offset Funding

Fortescue Metals Group
Millennium Minerals

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.

Carpenter, F., and Dziminski, M. A. (2016). Breaking down scats: degradation of DNA from greater bilby (*Macrotis lagotis*) faecal pellets. *Wildlife Research* Submitted.

Cramer, V. A., Dziminski, M. A., Carpenter, F., Ellis, R. J., and van Leeuwen, S. (2016). Research priorities for the greater bilby (*Macrotis lagotis*) in the north of Western Australia. *Australian Mammalogy* Submitted.


Hofstede, L., and Dziminski, M. A. (2016). Greater bilby burrows: important structures for a range of species in an arid environment. *Austral Ecology* Submitted.

Appendix 2 Bilby Poster


The poster below can be requested by contacting threatenedfauna@dpaw.wa.gov.au or by phone on (08) 9405 5100.

Bilby


Macrotis lagotis




Bilby



Bilby burrow: note the high, dome shape.



Bilby diggings at the base of Acacia bushes exposing roots.



Bilby diggings at the base of Acacia bushes exposing roots.

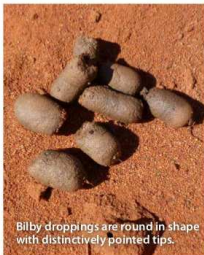
The bilby is a nocturnal, burrowing marsupial with large ears, soft, blue-grey fur, a long pointed snout and a black tail with a white tip. Body size can be up to 55cm long with a tail up to 29cm long.

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.

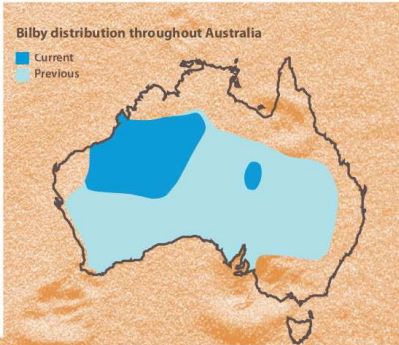


Bilby droppings are round in shape with distinctively pointed tips.




Bilby tracks have three very distinctive toe marks.


Bilby distribution throughout Australia



Legend: ■ Current, ■ Previous



Department of
Parks and Wildlife



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

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