

Range of the greater bilby (*Macrotis lagotis*) in the Pilbara Region, Western Australia

MARTIN A. DZIMINSKI^{1*}, FIONA M. CARPENTER¹ & FRANK MORRIS²

¹Biodiversity and Conservation Science, Department of Biodiversity, Conservation and Attractions, Government of Western Australia, Locked Bag 104, 6983 Bentley Delivery Centre, Western Australia, Australia

²PO Box 611, 6959 Fremantle Western Australia, Australia

*Corresponding author: ✉ martin.dziminski@dbca.wa.gov.au

Abstract

Threatened greater bilby (*Macrotis lagotis*) populations in the Pilbara Region, where their distribution has been poorly documented, represent the extreme north-western extent of the species. We generated an accurate range of the bilby in this region from confirmed recent and historical records and identified areas of uncertain status. Their range covers approximately the eastern half, or 48%, of the Pilbara IBRA bioregion and 52% of the wider Pilbara Region (bioregion plus a buffer of 300 km). The western boundary of this range stretches south-east from approximately 50 km west of Port Hedland to about 350 km beyond Newman. Their range extends east and south-east into the Great Sandy, Little Sandy and Gibson Deserts, as well as northwards into the Kimberley. This study provides an accurate range for impact assessment and management decisions, and confirms the Pilbara Region as an important area for the persistence of wild bilby populations. Areas to the west and south-west of the confirmed range have unreliable or older records of bilbies and require further targeted surveys to confirm their absence in these areas.

Keywords: burrowing, critical weight range, occupancy, Matuwa, Lorna Glen, mammal, marsupial

Manuscript received 20 May 2020; accepted 4 August 2020

INTRODUCTION

The greater bilby (*Macrotis lagotis* Reid; hereafter referred to as the bilby), is an iconic burrowing marsupial in the Family Thylacomyidae and is of significant conservation and cultural value. It is an important ecosystem engineer (James & Eldridge 2007; Newell 2008; Read *et al.* 2008; James *et al.* 2011; Chapman 2013; Fleming *et al.* 2014; Hofstede & Dziminski 2017; Dawson *et al.* 2019) and an indicator species of environmental conditions (Southgate 1994). It is listed as 'vulnerable' under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, the Western Australian *Biodiversity Conservation Act 2016*, and by the International Union for the Conservation of Nature (2020). As well as having legislated protection, this species is important taxonomically, culturally to traditional owners (Paltridge 2016; Walsh & Custodians of the Bilby 2016) and is regarded as a national icon (Bradley *et al.* 2015). Once widespread across most of mainland Australia (Marlow 1958; Friend 1990; Gordon *et al.* 1990; Johnson & Southgate 1990; Southgate 1990a; Abbott 2001; Abbott 2008; Bradley *et al.* 2015), their range has contracted to approximately 20% of that prior to European settlement. The species is now found in the Pilbara, Kimberley and central deserts of Western Australia and the Northern Territory, and as an isolated population in south-western Queensland (Southgate 1990a; Bradley *et al.* 2015). Threats contributing to the species' decline include

predation by feral cats and foxes (Paltridge 2002; Bradley *et al.* 2015) inappropriate fire regimes (Southgate & Carthew 2006; Southgate *et al.* 2007; Southgate & Carthew 2007; Bradley *et al.* 2015) and the degradation of habitat through pastoralism, introduced feral herbivores and clearing (Southgate 1990a; Pavey 2006; Bradley *et al.* 2015; Department of Environment 2016).

The Pilbara Region (Fig. 1) represents an important area for the continued survival of the most north-western wild populations (Cramer *et al.* 2017) given the contraction of the species from the remainder of the continent (Southgate 1990a; Bradley *et al.* 2015). Recent land clearing for agriculture and mining infrastructure (Brueckner *et al.* 2013) in the Pilbara may impact on bilbies, but there are only poorly constrained estimates of their range, which is otherwise undocumented in this region (e.g. Bradley *et al.* 2015). With the recent increase in development applications, and implementation of land management actions (Department of Water and Environmental Regulation 2020), an accurate range is needed to assist environmental impact assessment and management decisions at all levels of government in Australia. Of particular interest is the poorly documented western boundary.

The aim of this study was to generate an accurate range of the bilby within the Pilbara Region from confirmed recent and historical records and to identify areas of uncertain status within the region. Construction of a species distribution model (SDM) or mapping habitat suitability of the bilby in the Pilbara Region, which usually shows where a species may be found or where

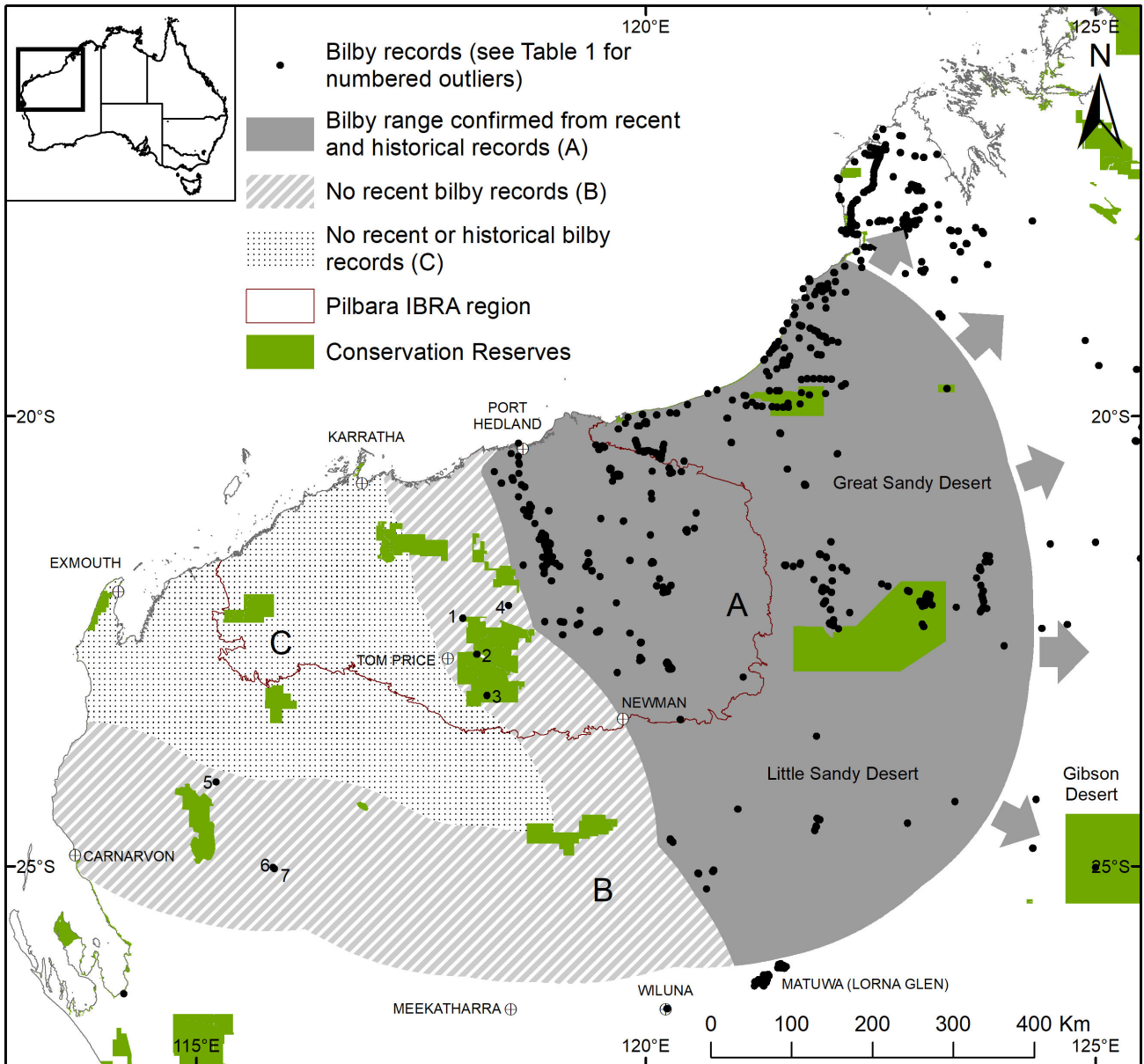


Figure 1. Bilby range in the Pilbara Region. Arrows indicate the bilby range continues into the southern Kimberley and central deserts.

there are suitable habitats for that species (Merow *et al.* 2013; Yackulic *et al.* 2013), will be the subject of future work.

METHODS

Bilby records were sourced from the Department of Biodiversity, Conservation and Attractions NatureMap database (NatureMap 2020), and the Pilbara Threatened Fauna Database. Records within the Pilbara Threatened Fauna Database were sourced from published and unpublished literature: the latter includes consultant and internal departmental survey reports covering areas within and surrounding the Pilbara, as well as liaison with departmental staff, consultants, mining companies, pastoral leaseholders and managers, and other land

holders and users.

Records were screened for certainty and location accuracy. Uncertain records were discarded and only those with a location accuracy 10 km or less were included; however, we flagged any outliers from the main distribution of records for further examination even if they were uncertain or had low location accuracy. We generated a range employing a 300 km buffer surrounding the Pilbara bioregion (Thackway & Cresswell 1995; www.environment.gov.au/land/nrs/science/ibra accessed May 12, 2020)—this area is here referred to as the generalised ‘Pilbara Region’. To delineate the range, we included all screened records in the analyses. Most records do not distinguish between observations of multiple bilbies or individuals as records of sign alone (e.g. scats, diggings, tracks, burrows, camera

Table 1. Key to numbered outlier bilby records from Figure 1.

No.	Year	Source	Observer	Description	Certainty	Accuracy
1	2001	Pilbara Threatened Fauna Database	Nearby pastoral lease holders	Saw possible bilby on road at the turn off to Hamersley Gorge 10 years ago (record taken 2/12/2011). Coordinates are of the location of the turn off road to Hamersley Gorge obtained from Google Earth as exact observation coordinates are unknown.	Uncertain	~200 m
2	1991	Pilbara Threatened Fauna Database	Ninox Wildlife Consulting (1992)	Evidence for their presence was based only on two burrows that may have been dug by bilbies. However, there has been no evidence of tracks, scats, or sightings (Environmental Protection Authority 1992).	Uncertain	~20 km
3	1984	Southgate (1990b)	Personnel involved in feral horse culling	O'brien's Well 1	Uncertain	~100 m
4	2001	Pilbara Threatened Fauna Database	Pastoral lease holders	Colony of bilbies were present at Mulga Downs 10 years ago (record taken 2/12/2011). Coordinates are indicative of Mulga Downs only (close to airport) and not representative of where the bilbies were. Note: several reliable records exist to the east on Mulga Downs Station, within the confirmed bilby range – it is most likely this record refers to that area.	Certain	~50 km
5	1969	NatureMap (2020)	Mr D. Evans	Day sighting. One only recently seen on station, apparently many in 1956, 1957 and 1958 (according to Mr J. A. Leeuwen, Morley); Mr R. Ugle (station employee) stated that he had seen animals like that, also in Kennedy Ranges. ID confirmed with picture shown by investigating Warden.	Moderately certain	10 km
6	1969	NatureMap (2020)	-	Weedarra Station. Observed and ran off.	Moderately certain	10 km
7	1969	NatureMap (2020)	K. Teage	Weedarra Station. Five individuals observed that ran off.	Moderately certain	1 km

images) cannot determine the number of individuals. Each record is indicative of the confirmed presence of a bilby, or bilbies, at a specific time and location. We plotted all screened bilby records within 500 km of the Pilbara bioregion to ensure generated range boundaries at its edges were congruent with the extended bilby range. Conservation tenure was plotted to examine overlap with bilby range and distribution.

Three shapefiles were created, the first showing known bilby range and two other combined areas of potential and uncertain range. Outliers to the west of the main distribution of records were excluded to construct an alpha-concave hull using the 'alphahull' v2.2 package (Pateiro-Lopez & Rodriguez-Casal 2019) in R v3.6.2 (R Core Team 2020). A buffer of 15 km was added to account for populations that could shift up to 10 km over three years (Southgate & Possingham 1995) as well as the selected accuracy of 10 km to included records. It was then clipped with the Pilbara Region shapefile to represent a range from confirmed and accurate historical and recent records. Using the outliers near the western boundary of the known range (Fig. 1, points 1–4), the distance to the farthest of these outliers (plus a 15 km

buffer) from the western boundary of the known range was used to create a polygon west of the main range. Similarly, the distance to the farthest of the south-western outliers (Fig. 1, points 5–7) from the southern boundary of the Pilbara Region (plus 15 km buffer) was used to create a polygon south-west of the main range. These two polygons were then merged to represent an area of uncertain range. All spatial analyses were completed using ArcGIS (Esri®) and QGIS software.

RESULTS

A total of 4386 bilby records, dating from 1899 to 2019, were included in the analysis (Fig. 2). These records have increased over the last 10 years due to surveys associated with expanded mining activities.

Within the Pilbara Region, the western boundary of the bilby range, established from recent and historical records, lies approximately 50 km west of Port Hedland and extends south-east beyond Newman (Fig. 1, area A). To the east and south-east there are no distinct boundaries to this range, which continues into the Great

Sandy, Little Sandy and Gibson Deserts, as well as into the south-western Kimberley. This confirmed bilby range represents 52% (34.4 million ha) of the Pilbara Region and 48% (8.5 million ha) of the Pilbara bioregion. In the Pilbara bioregion, there are no conservation reserves within the confirmed bilby range (Fig. 1).

To the west and south-west of the confirmed bilby range is an area of uncertain status (Fig. 1, area B). Within this area, there have been no extensive bilby surveys, and the only records present are either uncertain, have low location accuracy or were reported approximately 50 years ago (Table 1). In the area to the extreme north-west (Fig. 1, area C), there are no recent or historical bilby records, and no extensive bilby surveys.

DISCUSSION

Mapping the bilby range across the Pilbara Region based on positive, confirmed recent and historical records shows that their western extent is much farther west than previously estimated (Friend 1990; Southgate 1990a) and confirms previous attempts to map based on estimations without direct evidence of presence (Bradley *et al.* 2015). This increase in the known range across the Pilbara is due to the increased number of general fauna and targeted bilby surveys (Fig. 2). Furthermore, this increase may be attributed to more frequent recording of bilby signs (scats, tracks, burrows, diggings) rather than just captures or sightings, which make up the majority of historical records.

Bilbies are broadly distributed in the eastern half of the Pilbara Region and are linked to populations in the central deserts to the south-east and in the southern Kimberley to the north-east (Fig. 1). To the west and south-west of the confirmed bilby range is an area of uncertain status (Fig. 1, area B). The few records for this zone are either unreliable or old; however, bilby populations may be present. Terrestrial fauna surveys for environmental impact assessment are typically focused

on species with a higher likelihood of being present in the area, and desktop assessments using existing and historical records. As the western portion of the Pilbara Region lacks records of bilbies, targeted surveys with definitive presence/absence records are not always incorporated in all surveys. Traditional surveys relied heavily on trapping of fauna, and because bilbies are not readily trapped (Southgate *et al.* 2019), it is possible that they have not been adequately surveyed across the Pilbara, particularly the areas designated as uncertain to the west and north-west in Figure 1.

In the extreme north-west of the Pilbara there have been no recent or historical bilby records (Fig. 1, area C). Consequently, the likelihood of populations being found in this region is low. Whereas there are several reasons for zero or few bilby records in the west of the Pilbara Region, existing minimal records do not necessarily indicate their absence. The two areas of uncertainty (Fig. 1, areas B and C) would benefit from widespread targeted bilby surveys (Cramer *et al.* 2017; Southgate *et al.* 2019), especially where there are suitable bilby habitats. Areas of habitat suitability can be derived from models (Hirzel *et al.* 2006), and focused on for future surveys to maximise efficiency.

Although some bilby populations exist on conservation reserves to the east (e.g. Walyarta Conservation Park, Karlamilyi National Park), bilbies are poorly protected by conservation reserves within the Pilbara bioregion. Within this bioregion their confirmed range encompasses 8.5 million ha (i.e. 48% of this region), but there are no conservation reserves in which bilby populations may be protected (Fig. 1). This may present complexities for future conservation management because most bilby populations are found on pastoral leases or mining tenements (Cramer *et al.* 2017).

This work also highlighted the importance of screening data as unscreened data can provide false, inflated or inaccurate distributions and ranges. For example, there are two excluded records from the

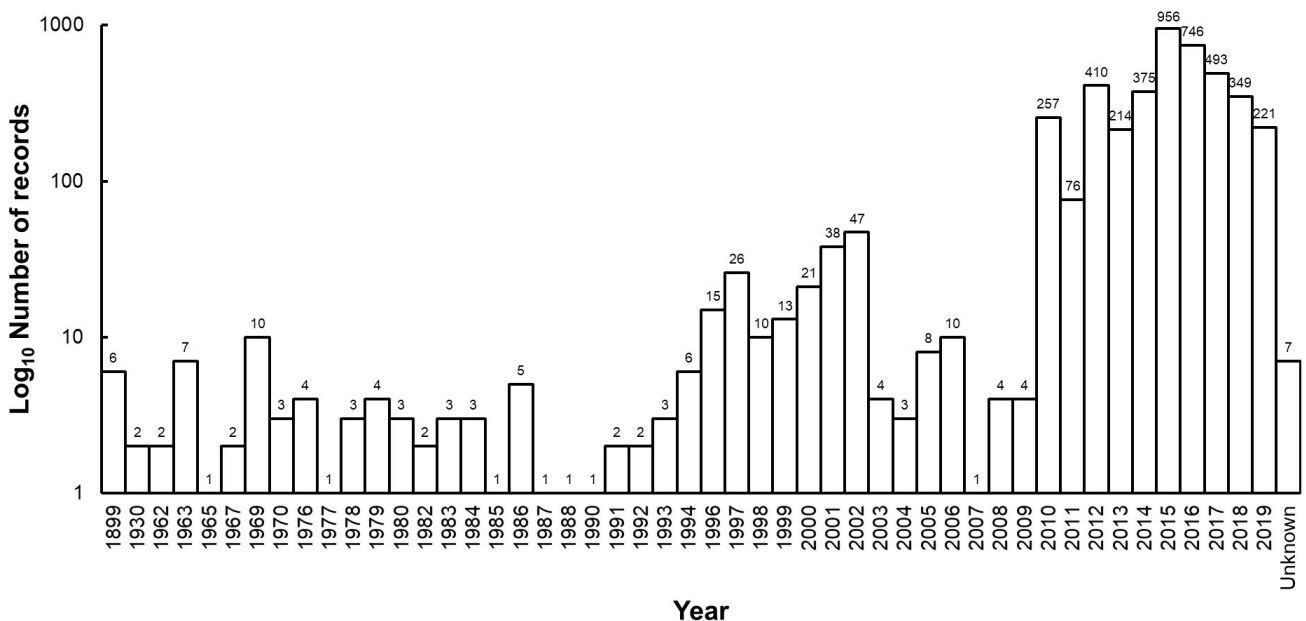


Figure 2. Frequency histogram of screened bilby records used in analyses (n = 4386).

1940s in which the distinguishing feature identifying the presence of bilby was the ‘obnoxious smell of male’ (NatureMap 2020). This is not a characteristic of bilbies and probably was confused with another species. Furthermore, sign data must also be carefully screened to avoid inclusion of misidentified observations (e.g. varanid lizard or rabbit diggings and burrows), and to ensure only verified evidence of bilbies is included (Southgate *et al.* 2019).

CONCLUSIONS

Our definition and mapping of bilby range across the Pilbara Region is based on reliable recent and historical records. This extent of occurrence represents 48% of the Pilbara bioregion and 52% of the wider Pilbara Region (bioregion plus a buffer of 300 km). To the west and south-west of this area targeted bilby surveys are required to confirm the absence of the species. The Pilbara Region includes the north-western edge of remaining wild bilby populations and confirms the area as important for the continued persistence of wild bilby populations, particularly as their range and occupancy reduces. This study provides both government and industry with an accurate range for informed, evidence-based, environmental impact assessment and management decisions. The bilby range shapefiles are available at the following link: https://www.rswa.org.au/publications/shape_files/2019_Pilbara_Bilby_Shapefiles.zip

ACKNOWLEDGEMENTS

We thank all individuals, Traditional Owners and organisations that have contributed bilby records to the State’s NatureMap database and we encourage all to keep doing so to ensure a better understanding of bilby range and distribution across the State. We are grateful to Keith Morris and Stephen van Leeuwen for their support during this project. This research was supported through offset funding received from Fortescue Metals Group, Millennium Minerals and Roy Hill, and we thank Todd Edwards (FMG), Ian Gale (Millennium Minerals) and Harriet Davie (Roy Hill) for their cooperation and support.

REFERENCES

ABBOTT I 2008. Historical perspectives of the ecology of some conspicuous vertebrate species in south-west Western Australia. *Conservation Science Western Australia Journal* **6**, 1–214.

ABBOTT I 2001. The bilby, *Macrotis lagotis* (Marsupialia: Peramelidae) in south-western Australia: original range limits, subsequent decline and presumed regional extinction. *Records of the Western Australian Museum* **20**, 271–305.

BRADLEY K, LEES C, LUNDIE-JENKINS G, COPLEY P, PALTRIDGE R, DZIMINSKI M, SOUTHGATE R, NALLY S & KEMP L 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.

BRUECKNER M, DUREY A, MAYES R & PFORR C 2013. The mining boom and Western Australia’s changing landscape: Towards sustainability or business as usual? *Rural Society* **22**, 111–124. 10.5172/rsj.2013.22.2.111

CHAPMAN T F 2013. Relic bilby (*Macrotis lagotis*) refuge burrows:

assessment of potential contribution to a rangeland restoration program. *The Rangeland Journal* **35**, 167–180. 10.1071/RJ13012

CRAMER V A, DZIMINSKI M A, SOUTHGATE R, CARPENTER F, ELLIS R J & VAN LEEUWEN S 2017. A conceptual framework for habitat use and research priorities for the greater bilby (*Macrotis lagotis*) in the north of Western Australia. *Australian Mammalogy* **39**, 137–151.

DAWSON S J, BROUSSARD L, ADAMS P J, MOSEBY K E, WADDINGTON K I, KOBRYN H T, BATEMAN P W & FLEMING P A 2019. An outback oasis: the ecological importance of bilby burrows. *Journal of Zoology* **308**, 149–163. 10.1111/jzo.12663

DEPARTMENT OF ENVIRONMENT 2016. *Macrotis lagotis* — Greater Bilby in Species Profile and Threats Database. <http://www.environment.gov.au/sprat> [Accessed February 9, 2016]

DEPARTMENT OF WATER AND ENVIRONMENTAL REGULATION 2020. The Pilbara Environmental Offsets Fund. *The Government of Western Australia*. www.dwer.wa.gov.au/peof

ENVIRONMENTAL PROTECTION AUTHORITY 1992. *Marandoo Iron Ore Mine and Central Pilbara Railway*. Environmental Protection Authority, Bulletin **643**, Perth, Western Australia. www.epa.wa.gov.au/sites/default/files/EPA_Report/599-B643-290892.pdf

FLEMING P A, ANDERSON H, PRENDERGAST A S, BRETZ M R, VALENTINE L E & HARDY G E StJ 2014. Is the loss of Australian digging mammals contributing to a deterioration in ecosystem function? *Mammal Review* **44**, 94–108. 10.1111/mam.12014

FRIEND J A 1990. Status of bandicoots in Western Australia. Pages 73–84 in Seeback J H, Brown P R, Wallis R L & Kemper C M, editors *Bandicoots and bilbies*. Surrey Beatty & Sons, Sydney

GORDON G, HALL L S & ATHERTON R G 1990. Status of bandicoots in Queensland. Pages 37–42 in Seeback J H, Brown P R, Wallis R L & Kemper C M, editors *Bandicoots and bilbies*. Surrey Beatty & Sons, Sydney

HIRZEL A H, LE LAY G, HELFER V, RANDIN C & GUISAN A 2006. Evaluating the ability of habitat suitability models to predict species presences. *Ecological Modelling* **199**, 142–152. 10.1016/j.ecolmodel.2006.05.017

HOFSTEDTE L & DZIMINSKI M A 2017. Greater bilby burrows: important structures for a range of species in an arid environment. *Australian Mammalogy* **39**, 227–237. 10.1071/AM16032

INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE 2020. The IUCN Red List of Threatened Species Version 2020-2. www.iucnredlist.org [accessed July 9, 2020]

JAMES A I & ELDRIDGE D J 2007. Reintroduction of fossorial native mammals and potential impacts on ecosystem processes in an Australian desert landscape. *Biological Conservation* **138**, 351–359. 10.1016/j.biocon.2007.04.029

JAMES A I, ELDRIDGE D J, KOEN T B & MOSEBY K E 2011. Can the invasive European rabbit (*Oryctolagus cuniculus*) assume the soil engineering role of locally-extinct natives? *Biological Invasions* **13**, 3027–3038. 10.1007/s10530-011-9987-9

JOHNSON K A & SOUTHGATE R I 1990. Present and former status of bandicoots in the Northern Territory. Pages 85–92 in Seeback J H, Brown P R, Wallis R L & Kemper C M, editors *Bandicoots and bilbies*. Surrey Beatty & Sons, Sydney.

MARLOW B J 1958. A survey of the marsupials of New South Wales. *CSIRO Wildlife Research* **3**, 71–114. 10.1071/CWR9580071

MEROW C, SMITH M J & SILANDER J A 2013. A practical guide to MaxEnt for modeling species’ distributions: what it does, and why inputs and settings matter. *Ecography* **36**, 1058–1069. 10.1111/j.1600-0587.2013.07872.x

NATUREMAP 2020. NatureMap: Mapping Western Australia’s Biodiversity. *Department of Biodiversity, Conservation and Attractions Western Australia*. <http://naturemap.dbca.wa.gov.au/>

NEWELL J 2008. *The role of the reintroduction of greater bilbies*

- and burrowing bettongs in the ecological restoration of an arid ecosystem: foraging diggings, diet and soil seed banks. PhD Thesis, University of Adelaide.
- NINOX WILDLIFE CONSULTING 1992. *Marandoo Project Area - Vertebrate Fauna Assessment (1975–1991)*. Report prepared for Enviroscan, Perth, Western Australia.
- PALTRIDGE R 2002. The diets of cats, foxes and dingoes in relation to prey availability in the Tanami Desert, Northern Territory. *Wildlife Research* **29**, 389–403. 10.1071/WR00010
- PALTRIDGE R 2016. *What did we learn from the 2016 Ninu Festival?* Desert Wildlife Services, Alice Springs.
- PATEIRO-LOPEZ B & RODRIGUEZ-CASAL A 2019. *alphahull: Generalization of the Convex Hull of a Sample of Points in the Plane*. <https://CRAN.R-project.org/package=alphahull>
- PAVEY C 2006. National Recovery Plan for the Greater Bilby *Macrotis lagotis*. Northern Territory Department of Natural Resources, Environment and the Arts.
- R CORE TEAM 2020. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. <http://www.R-project.org/>
- READ J L, CARTER J, MOSEBY K M & GREENVILLE A 2008. Ecological roles of rabbit, bettong and bilby warrens in arid Australia. *Journal of Arid Environments* **72**, 2124–2130. 10.1016/j.jaridenv.2008.06.018
- SOUTHGATE R 1990a. Distribution and abundance of the greater bilby *Macrotis lagotis* Reid (Marsupialia: Peramelidae). Pages 303–309 in Seeback J H, Brown P R, Wallis R L & Kemper C M, editors *Bandicoots and bilbies*. Surrey Beatty & Sons, Sydney.
- SOUTHGATE R 1990b. *The distribution and abundance of the bilby*. Masters Thesis, Macquarie University, Sydney.
- SOUTHGATE R 1994. Why reintroduce the bilby? Pages 165–170 in Serena M, editor *Reintroduction biology of Australian and New Zealand fauna*. Surrey Beatty & Sons, Sydney.
- SOUTHGATE R & CARTHEW S 2006. Diet of the bilby (*Macrotis lagotis*) in relation to substrate, fire and rainfall characteristics in the Tanami Desert. *Wildlife Research* **33**, 507–519. 10.1071/WR05079
- SOUTHGATE R & CARTHEW S 2007. Post-fire ephemerals and spinifex-fuelled fires: a decision model for bilby habitat management in the Tanami Desert, Australia. *International Journal of Wildland Fire* **16**, 741–754. 10.1071/WF06046
- SOUTHGATE R, DZIMINSKI M A, PALTRIDGE R, SCHUBERT A & GAIKHORST G 2019. Verifying bilby presence and the systematic sampling of wild populations using sign-based protocols – with notes on aerial and ground survey techniques and asserting absence. *Australian Mammalogy* **41**, 27. 10.1071/AM17028
- SOUTHGATE R, PALTRIDGE R, MASTERS P & CARTHEW S 2007. Bilby distribution and fire: a test of alternative models of habitat suitability in the Tanami Desert, Australia. *Ecography* **30**, 759–776. 10.1111/j.2007.0906-7590.04956.x
- SOUTHGATE R & 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. 10.1016/0006-3207(95)00052-6
- THACKWAY R & CRESSWELL I D 1995. *An Interim Biogeographic Regionalisation for Australia: a framework for setting priorities in the national reserves system cooperative program*. Australian Nature Conservation Agency, Canberra.
- WALSH F & CUSTODIANS OF THE BILBY 2016. *Bilby is part of this country and for everybody, cultural report about bilbies and the Ninu Festival, Kiwirrkura, 2016*. Report to Central Desert Native Title Services, Alice Springs.
- YACKULIC C B, CHANDLER R, ZIPKIN E F, ROYLE J A, NICHOLS J D, CAMPBELL GRANT E H & VERAN S 2013. Presence-only modelling using MAXENT: when can we trust the inferences? O'Hara R B, editor. *Methods in Ecology and Evolution* **4**, 236–243. 10.1111/2041-210x.12004