National Recovery Plan for the

Greater Bilby *Macrotis lagotis*

Australian Government

Northern Territory Government
Department of Natural Resources, Environment and the Arts

Department of Environment and Conservation

Queensland Government
Environmental Protection Agency
Queensland Parks and Wildlife Service

Government of South Australia
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Title: National Recovery Plan for the Greater Bilby *Macrotis lagotis*

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The Australian Government, in partnership with the Environmental Protection Agency/Queensland Parks and Wildlife Service, facilitates the publication of recovery plans to detail the actions needed for the conservation of threatened native wildlife.

The attainment of objectives and the provision of funds may be subject to budgetary and other constraints affecting the parties involved, and may also be constrained by the need to address other conservation priorities. Approved recovery actions may be subject to modification due to changes in knowledge and changes in conservation status.

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Recovery Plans are developed within the framework laid down in Department of Environment and Conservation (WADEC) Policy Statements Nos. 44 and 50. Recovery Plans outline the recovery actions that are required to urgently address those threatening processes most affecting the ongoing survival of threatened taxa or ecological communities, and begin the recovery process. WADEC is committed to ensuring that threatened taxa are conserved through the preparation and implementation of Recovery Plans or Interim Recovery Plans as resources permit, and by ensuring that such conservation action for Critically Endangered taxa commences as soon as possible and always within one year of endorsement of that rank by the Minister. This Recovery Plan will operate for five years from the date it is signed off by the Australian Government Minister for the Environment and Water Resources. It will remain in force until withdrawn or replaced. It is intended that this Recovery Plan will be reviewed after five years.

This Recovery Plan was approved by the Director of Nature Conservation on 20 December 2006. The allocation of staff time and provision of funds identified in this Recovery Plan is dependent on budgetary and other constraints affecting WADEC, as well as the need to address other priorities.

Foreward

The Northern Territory Department of Natural Resources, Environment and the Arts (formerly Department of Infrastructure, Planning and Environment), together with Queensland Environmental Protection Agency/Queensland Parks and Wildlife Service, Western Australia Department of Environment and Conservation obtained funding from the Australian Government Department of the Environment and Water Resources to produce this Recovery Plan. Recovery Plans delineate, justify and schedule management actions necessary to support the recovery of threatened species. The attainment of objectives and the provision of funds necessary to implement actions is subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery Plans do not necessarily represent the views nor the official position of individuals or organisations represented on the Recovery Team. Approved Recovery Plans are subject to modification as dictated by new findings, changes in species' status and completion of recovery actions.

Information in this Plan is accurate as at 18 July 2005.

Acknowledgments

Extensive input into the content of the plan was received from members of the greater bilby recovery team and staff of WADEC in Western Australia, South Australian Government Department for the Environment and Heritage, Queensland Environmental Protection Agency/Queensland Parks and Wildlife Service, Central Land Council, Arid Recovery, and Australian Wildlife Conservancy. Input was also received from Ari Schipf, Kylie Green, Jack Pettigrew, Bretan Clifford, Ben Sparrow, Al Glen, Michael Soulé, Brendan Mackey and Stephen Eldridge.

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Abbreviations

ARAZPA	The Australasian Regional Association of Zoological Parks and Aquaria, the peak zoo and aquarium organization in the Australasian region that is working towards developing zoos and aquaria as centres of excellence in conservation, education and research
AR	Arid Recovery, Roxby Downs, South Australia, an ecosystem restoration initiative operated and managed by a four-way partnership involving BHP Billiton Ltd, Department for Environment and Heritage (South Australia), University of Adelaide and The Friends of Arid Recovery
ASDP	Alice Springs Desert Park, a Northern Territory government run park that displays plants and animals in typical central Australian settings
AWC	Australian Wildlife Conservancy, an independent non-profit charitable organisation funded by donations from the public that owns or leases over 450,000 hectares of land for conservation purposes
WADEC	Department of Environment and Conservation, Western Australia
CLC	Central Land Council, a statutory authority representing Aboriginal people in the southern Northern Territory under the *Aboriginal Land Rights (Northern Territory) Act 1976*. It also has functions under the *Native Title Act 1993* and the *Pastoral Land Act 1992*
NSWDEC	Department of Environment and Conservation, New South Wales
SADEH	Department for Environment and Heritage, South Australia
EPA/QPWS	Environmental Protection Agency, Queensland, includes the Queensland Parks and Wildlife Service
GBRT	Greater Bilby Recovery Team
Kanyana	Kanyana Wildlife Rehabilitation Centre Inc., a private, volunteer-driven captive animal facility in Western Australia serving the dual purpose of caring for sick, injured and orphaned native animals and providing stock for reintroduction programs
KLC	Kimberley Land Council
MZP	Monarto Zoological Park, a 1000 ha fauna and flora sanctuary and open-range zoo near Murray Bridge, operated by the Royal Zoological Society of South Australia
NC	Ngaanyatjarra Council (Aboriginal Corporation), the administrative body for 11 Ngaanyatjarra communities in the western deserts of Western Australia
NGO	Non-government Organisation
NMC	Newmont Mining Corporation, a multi-national gold production company
NP	National Park
NRETA	Department of Natural Resources, Environment and the Arts (formerly Department of Infrastructure, Planning and Environment) of the Northern Territory; includes the Parks and Wildlife Service and the ASDP
NRM	Natural Resource Management
NSW	New South Wales
NT	Northern Territory
QLD	Queensland
SA	South Australia
TSN	Threatened Species Network, a joint program between the Federal government's Natural Heritage Trust and the World Wide Fund for Nature, that is a national network developed to involve the community in conservation programs for threatened species
WA	Western Australia
WDLAC	Western Desert Lands Aboriginal Corporation, the prescribed body corporate for the Martu Lands in Western Australia
WPZ	Western Plains Zoo, an open range zoo of over 350 ha at Dubbo operated by the Zoological Parks Board of New South Wales

Summary

Current Species Status

The greater bilby *Macrotis lagotis* is listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*.

Habitat Requirements and Threats

Bilbies are now mostly restricted to the drier and least fertile parts of their former range with the exception of populations in the north of the NT and WA. Remaining populations occupy three major vegetation types, namely: open tussock grassland on uplands and hills, mulga woodland/shrubland growing on ridges and rises, and hummock grassland in plains and alluvial areas.

Known and potential threatening processes include predation by introduced carnivores (European red fox, feral cat); competition with introduced/exotic herbivores; habitat degradation and destruction resulting from feral and domestic herbivores, unsuitable fire regimes, mining and other development; drought; and road mortality.

Recovery Plan Objectives

The current recovery plan builds on conservation actions that have already commenced including protection and management of bilby habitat, applied research on wild populations and their predators, reintroduction within the former range, and coordinated management of captive individuals.

Overall Objectives

- To improve and at least maintain the national conservation status of the greater bilby (currently listed nationally as Vulnerable) over the duration of the plan.
- To achieve an accurate assessment of distribution (both extent of occurrence and area of occupancy), trends in occurrence, and successfully reduce the impacts of key threatening processes.

Specific Recovery Objectives

1. Reduce impact of predation by introduced carnivores.
2. Maintain genetic diversity by a) management aimed at maintaining number and size of remnant populations, and b) controlled management of a captive breeding program based on direction from the national studbook.
3. Establish self-sustaining populations within the former range.
4. Monitor trends in occurrence and abundance.
5. Assess the impact of predators, fire and other threatening processes on bilby populations.
6. Inform and involve the community and all stakeholders in the recovery process.

Actions Needed

- Control predators at priority sites including reintroduction sites and naturally occurring wild populations.
- Continue husbandry and coordinated management of captive populations.
- Continue to reintroduce the species to predator-free or predator-controlled sites across its former range.
- Refine monitoring/survey/data capture methodology to make it more effective and efficient.
- Monitor trends in occurrence and abundance of the bilby across its range including at reintroduction sites.
- Measure and monitor impact of threatening processes on bilby populations at reintroduction sites.
- Continue to manage the recovery process through a recovery team.

Estimated costs of recovery (in $1,000s)

Actions	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
1	90.0	90.0	90.0	90.0	90.0	450.0
2	367.35	313.1	313.1	313.1	313.1	1619.75
3*	433.4	330.4	330.4	330.4	330.4	1755.0
4	25.0	25.0				50.0
5a	65.0					65.0
5b		77.0	77.0			154.0
5c						
6						
7						0.0
Total	980.75	835.5	810.5	733.5	733.5	4093.75

* includes costs for actions 5c and 6.

Note: The institutions involved in recovery actions 2 and 3 have committed funds to these actions i.e. external funding is not needed for these actions to go ahead

Species information and general requirements

Species Description

The greater bilby *Macrotis lagotis* is the only surviving member of the sub-family Thylacomyinae (Family Peramelidae). The species has soft silky fur that is ash grey over most of the body, but pure white to cream on the belly. The tail is distinctive, with the first 20 percent being the same colour as the upper-body, the central 40% being black and the distal 40% pure white. The forelimbs are equipped with three stoutly clawed toes (and two unclawed toes) that enable the bilby to burrow effectively. The hind limbs are slender. The long snout is well equipped with sensory vibrissae. The ears are large. Sexual dimorphism is present with mature males attaining double the body mass of mature females (males 800 - 2500g, females 600 - 1100g), having longer canines and a noticeably enlarged forehead.

Conservation Status

The greater bilby *Macrotis lagotis* is listed as **Vulnerable** under Schedule 1 of the *Environment Protection and Biodiversity Conservation Act 1999*. The

species occurs in three states QLD, WA and the NT and is being reintroduced to SA and NSW. The conservation status of the greater bilby in each of these states/territories is:

QLD - **Endangered** (*Nature Conservation Act 1992*);

NT - **Threatened** (Section 29, *Territory Parks and Wildlife Conservation Act 2000*);

WA - **Vulnerable,** specially protected as species threatened with extinction, pursuant to the *Wildlife Conservation Act 1950***.**;

SA – **Endangered** (Schedule 7, *National Parks and Wildlife Act 1972*, amended September 2000).

NSW - **Presumed extinct** (Schedule 1, *Threatened Species Conservation Act 1995*).

The species is not listed as having occurred in Victoria (Conservation and Natural Resources 1995).

Internationally, the greater bilby is listed as Vulnerable, (C2a), under the IUCN Red List.

International Obligations

The greater bilby is listed in Appendix 1 of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES). This recovery plan is consistent with CITES and with Australia's other obligations under international treaties.

Affected Interests

Despite a dramatic decline in its range over the past 150 years, the greater bilby still occurs over a large area of Australia. The species occupies a variety of land tenures as specified below.

- Aboriginal land including freehold, leasehold and reserve. In the NT most of the range of the greater bilby is within the 385,607 square kilometres of inalienable Aboriginal freehold land in the southern NT. This land includes former Aboriginal reserves, previously unalienated

Crown land claimed and granted under the Land Rights Act, and 12 former pastoral leases purchased by Aboriginal interests.

- Aboriginal land currently managed by mining companies.
- Land under native title claim (WA).
- Pastoral lease.
- State and Territory government controlled land, including formal State and Territory Government conservation reserves (national park, nature reserve, etc.) and also uncommitted Crown land.
- Privately owned and leased conservation areas managed by AWC (Scotia Sanctuary, Yookamurra Sanctuary) and AR. These sites are based on reintroduction projects.
- Privately owned land such as Thistle Island, SA.

All affected interests will be involved in the implementation of this plan to some degree. An important aspect of the plan is bilby monitoring and predator management actions undertaken on Aboriginal land involving Aboriginal organisations and communities. Employment of traditional owners in fieldwork is an important component of these actions. State and Territory government agencies will be involved in many recovery actions and will play a key role in providing infrastructure and expertise throughout the plan's implementation. Pastoralists, especially in south-western QLD, will be encouraged to play an increased role in bilby recovery. The input of private and community-based conservation organisations (AWC, AR, and Kanyana) in the recovery of the greater bilby is substantial.

In addition, because of the greater bilby's position as an iconic animal that has become a flagship for arid zone conservation in Australia, educational organizations and groups play an important role in bilby conservation and are recognised here as "affected interests". These include organisations as diverse as the "Save the Bilby Fund", which raises money for bilby conservation in Queensland, and the Bunyaville Environmental Education Centre which runs the highly successful Easter Bilby educational program.

Role and Interests of Indigenous People

Much of the current range of the greater bilby occurs on Aboriginal Land and the species is of considerable cultural significance to Aboriginal people throughout its former and current range. The species was formerly a major food species for many traditional Aboriginal people. A large number of Aboriginal names for the greater bilby are listed in Burbidge *et al.* (1988) and Tunbridge (1991).

The successful recovery of the greater bilby relies on actions to be undertaken by Aboriginal people on their traditional lands. In particular, the plan aims to involve Aborigines in undertaking survey and monitoring activities, and carrying out management actions such as predator control.

Biodiversity Benefits

The biodiversity benefits to accrue from successful implementation of the greater bilby recovery plan are likely to result from three outcomes; (a) a reduction in the impact of threatening processes; (b) maintenance (or restoration) of the role played by the greater bilby in ecosystem functioning; and (c) improved coordination in management of the recovery of a suite of threatened vertebrates that occupy arid and semi-arid Australia. These outcomes are discussed below.

(a) Management of threatening processes

Recovery of the greater bilby will require the elimination or control of a range of threatening processes such as predation by introduced carnivores. These threatening processes impact on a wide range of animals including other threatened species (e.g. kowari, mulgara, mala, great desert skink, plains rat) and more common but declining species (e.g. Australian bustard, emu). Actions undertaken as part of the greater bilby recovery plan, such as predator control, will benefit a wide range of species that are sympatric with the greater bilby. These biodiversity benefits occur both in the vicinity of wild populations and at reintroduction sites.

(b) Ecological role of the greater bilby in ecosystems

Although the topic is not widely researched, it is possible that the greater bilby plays (played) an important ecological role as an ecosystem engineer. Dietary research shows that at certain times of the year the underground fruiting bodies of fungi are a major component of its diet (Watts 1969, Gibson 2001). This observation raises the possibility that the greater bilby acts as an important dispersal agent of fungal spores as do several species of bettong in eucalypt forest in southern and northern Australia (Johnson 1996). Given that all arid zone bettongs and bandicoots are extinct within the current range of the greater bilby, this species may be the sole disperser of spores of many fungi with underground fruiting bodies.

Burrows of the greater bilby appear to be an important refuge site for a range of fauna. In addition, burrows and foraging digs of bilbies may act as focal points for the establishment of particular plant species and for other ecosystem processes such as nutrient and water movement.

(c) Improved coordination of threatened vertebrate recovery in arid and semi-arid Australia

The greater bilby is one of a suite of threatened, high profile species that still occur in the wild in arid and semi arid regions of the NT, Queensland and WA. By combining some of the survey, monitoring and management actions presented in this plan with those for other threatened species (especially mulgara, great desert skink, marsupial mole), it should be possible to achieve more efficient conservation outcomes. In particular, there are opportunities for standardized monitoring, surveys for multiple threatened species and introduced mammals, landscape-scale recovery actions (e.g. fire management), and centralized database management.

Social and Economic Impacts

No immediate adverse social or economic impacts are likely to arise from implementation of this recovery plan. However, the impacts of mining activity in areas that support high densities of bilbies (e.g. Tanami Desert) need to be assessed and alterations of management regimes may be required. Within

the Tanami bioregion there is a high potential for negative effects on bilby populations because mining operations are often located adjacent to paleodrainage systems, which appear to be important habitat areas for bilbies. Therefore, mining operations may have an adverse impact on regionally significant bilby populations in the long-term.

Numerous positive social and economic impacts are likely to arise from implementation of this recovery plan. The greater bilby is an iconic animal that has become a flagship for arid zone conservation in Australia. This position was formalised when National Bilby Day was launched by the Federal Minister for Environment and Water Resources on 15 June 2005. It will fall each year on the second Sunday in September. The greater bilby thus became the only animal to have a special day set aside for it in the national calendar. The species is promoted as an alternative commercial symbol of Easter (Faithfull 2000) and Easter Bilby chocolates are produced by several Australian companies. The continued success of recovery efforts for the species will have positive social and educational impacts through much of Australia. This Recovery Plan also provides employment opportunities for Aboriginal people and can serve to assist the development and training of Aboriginal ranger groups.

Evaluation of the Performance of the Recovery Plan

The Northern Territory Department of Natural Resources, Environment and the Arts, in conjunction with the recovery team, will evaluate the performance of this recovery plan. The plan is to be reviewed within five years of its implementation. Any changes to management/ recovery actions will be documented accordingly.

Distribution and Location

Distribution

Historical distribution

Historically, the greater bilby occupied a vast area of Australia (Figure 1). The latitudinal range spread from 16^{o} South in northern WA (Dampierland bioregion) to south of Adelaide (Flinders Lofty Block bioregion). In NSW, the

species occurred on the slopes west of the Great Dividing Range and south-east of a line joining Moree in the north to the Murray-Darling junction in the south-west (NSW South Western Slopes, Darling Riverine Plains, Brigalow Belt South, South Eastern Highlands, Riverina bioregions) (Marlow 1958). The range spread west across central Australia to the WA coast (Swan Coastal Plain bioregion) (Abbott 2001). In QLD, the species was historically recorded from relatively few localities, a pattern that results from an impoverished record rather than necessarily implying a restricted range. The range of the greater bilby extended over much of south-western QLD with the most easterly record from Surat (G. Lundie-Jenkins personal communication). No confirmed Victorian records exist, although it may have occupied parts of the Murray-Darling Depression bioregion in Victoria (Menkhorst 1995) as there are records south of the River Murray in SA and near the SA-Victoria border (Southgate 1990a).

Current distribution

The species occurs in two separate geographic areas; one extending from the western deserts region (Tanami, Great Sandy, Gibson) of NT and WA north to the Pilbara and Kimberley regions, the second in south-western QLD (Figures 2 and 3). Detailed molecular analysis (mitochondrial DNA and microsatellite loci) indicates that the species should be considered as a single Evolutionary Significant Unit (i.e. no evidence of strong genetic structure across populations) (Moritz *et al.* 1997). However, Moritz *et al.* (1997) recommended that populations in each State/Territory should be considered as separate management units. The recovery plan follows this recommendation. This approach may not be entirely accurate because it is very likely that bilbies in the western deserts of NT and WA are a distinct meta-population with movement of individuals across State/Territory boundaries. However, a State/Territory-based approach seems a useful interim measure until core populations are better defined. The current distribution in each State/Territory is described below.

Queensland. The greater bilby occurs within approximately 70,000 km^2 of the Channel Country and Mitchell Grass Downs bioregions (Diamantina Shire) in an area bordered by the settlements of Birdsville, Bedourie, Boulia and

Betoota. The distribution is disjunct across this area and some populations are small and extremely limited in extent. The main population is centred on Astrebla Downs NP and adjacent pastoral properties. Another population is centred on Roseberth Station and adjacent parts of Durrie and Adria Downs Stations (Gordon & McRae 1993). Recent unconfirmed records in the vicinity of Winton require investigation (G. Lundie-Jenkins personal communication).

Northern Territory. The species occurs in the central and western parts of the Tanami bioregion, the southern Sturt Plateau bioregion and the northern Great Sandy Desert bioregion. A road killed male was collected in 2001 in the Burt Plain bioregion. The most southerly recent records are in the vicinity of Kintore, the most northerly around Newcastle Waters and Wave Hill (Southgate & Paltridge 1998).

Western Australia. The species occurs in the Gibson Desert and Great Sandy Desert bioregions as far south as Tjirrkali Community and west to about Newman. Populations exist in the Pilbara bioregion (including the Hamersley Range area, along the Fortescue River and north-east to Shay Gap), in the Dampierland bioregion (along 80 Mile Beach north to Beagle Bay) and in the Central Kimberley and Ord-Victoria Plains bioregions south of the Fitzroy and Margaret Rivers (Southgate 1990a). The distribution is highly fragmented within this area (Friend 1990).

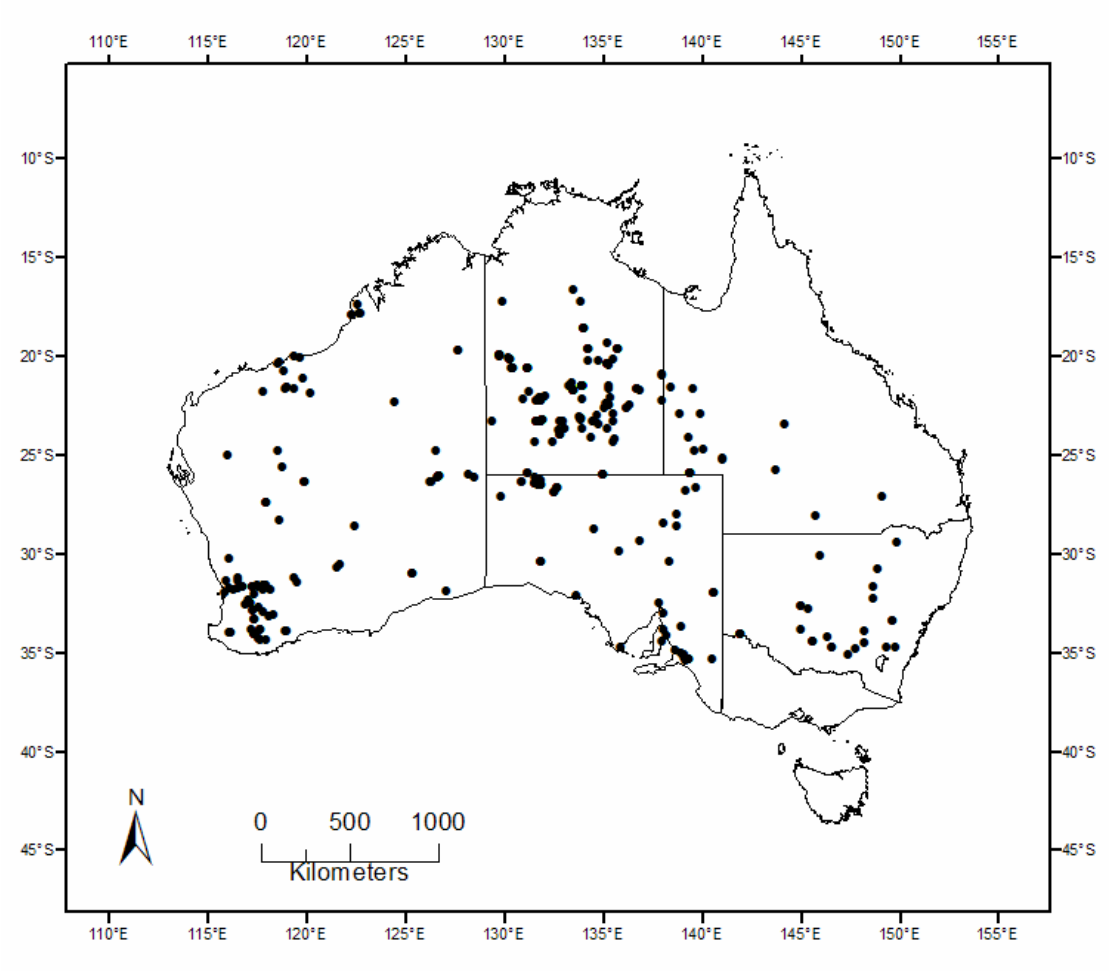

Figure 1. Greater Bilby records up to and including 1970. Records obtained from the national greater bilby database.

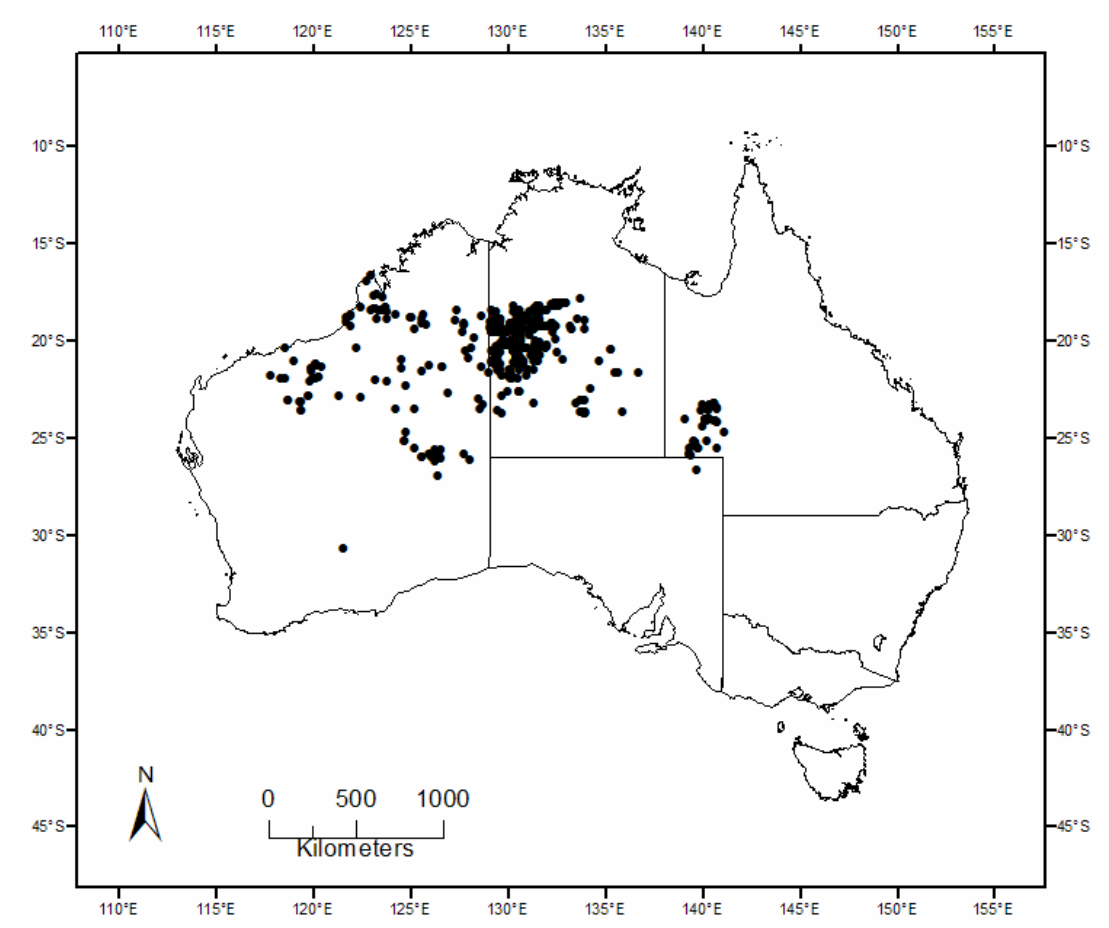

Figure 2. Greater Bilby records over the 20 year period from 1971 to 1990. Records obtained from the national greater bilby database.

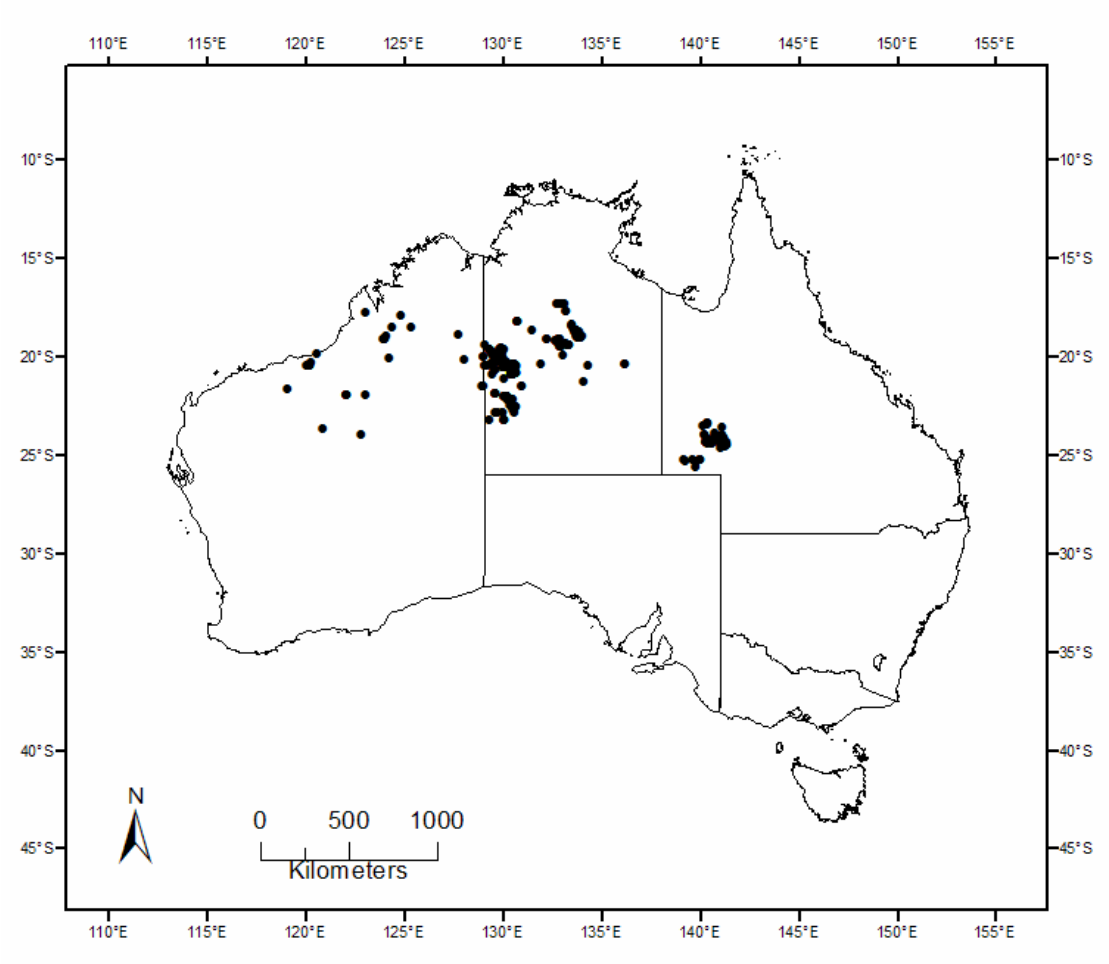

Figure 3. Greater Bilby records from 1991 to 2004. Records obtained from the national greater bilby database.

Habitat

Habitat at time of European settlement

At the time of European settlement, bilbies occupied a wide range of vegetation types including eucalypt open forest and woodland in south-west WA (Abbott 2001) and the southern Tablelands of NSW, tall shrublands and open woodlands in semi-arid regions, and hummock grasslands and sparse forblands in arid Australia (Southgate 1990b).

Current Habitat

Most of the area currently occupied by the species probably represents the least favourable portions of its former range. From a survey of sites in WA, QLD and NT in the mid-1980s, Southgate (1990b) found that a broad range of environments are still occupied by the greater bilby. Three major vegetation types were recognised:

1. open tussock grassland (both grasses and forbs) growing on uplands and hills,
2. mulga woodland/shrubland (both pure mulga and mixed stands of mulga/witchetty bush) growing on ridges and rises, and
3. hummock grassland growing on sand plains and dunes, drainage systems, salt lake systems and other alluvial areas.

Potential habitat for reintroduction within former range

Reintroduction of the greater bilby into predator-controlled or predator-free habitat is underway at a number of locations throughout its former range. Sites are located in SA (AR at Roxby Downs, Venus Bay Conservation Park, Thistle Island, Yookamurra Sanctuary), WA (Dryandra Woodland, Peron Peninsula), QLD (Currawinya NP), and NSW (Scotia Sanctuary). Other potential reintroduction sites should be investigated. Given the extent of the former range

of this species, a number of other reintroduction locations should be available once threatening processes are managed. The NT government has identified Watarrka NP as a suitable site and the EPA/QPWS is investigating potential sites in QLD including the Culgoa Floodplain NP and on private lands in the Brigalow Belt South and Mulga Lands bioregions (Sattler and Williams 1999) (G. Lundie-Jenkins personal communication).

Delineation of potential habitat critical within current range

Notwithstanding the difficulty with identifying core populations and the likelihood that known populations do not occupy optimal habitat, areas of potential habitat critical to the survival of the greater bilby are described below.

Queensland. Mitchell grass downs on deep clay soils and gibber plains on desert loam soils throughout its QLD range. These habitats support predominantly short grasses and forbs (open tussock grassland). Aerial surveys completed in western Queensland in 1993-94 and repeated in 1999 identified major accumulations of active bilby burrows as occurring adjacent to the Diamantina River on the properties Davenport Downs, Coorabulka and Monkira (G. Lundie-Jenkins personal communication).

Northern Territory. Surveys in the Tanami Desert indicate that sign of bilbies is most likely to be found in the Granites-Rabbit Flat region and west of Tennant Creek. Until dispersal patterns of the species in the NT are better understood, it seems reasonable to consider the Tanami bioregion (west of the Stuart Highway) and the northern Great Sandy Desert bioregion as potential critical habitat of the species. This landscape is characterised by sandy soils dominated by hummock (*Triodia* spp.) grasslands with an overstorey of low shrub cover dominated by *Acacia* and *Melaleuca* species. Broadscale surveys of bilbies in the NT in the 1990s indicated that laterite and drainage line land systems were occupied more frequently than sand plain and dune systems (Southgate *et al.* 2005).

Western Australia. The status of the greater bilby in large parts of WA is unclear. Bilby sign is consistently recorded at a range of sites including the Gibson Desert (in vicinity of Kiwirrkura community, Nyinmi Outstation, Young Range – Mt Everard – Mt Beadell region), the Pilbara (Edgar Range near Shay Gap and north of Nullagine), and the Great Sandy Desert adjacent to the Canning Stock Route and Talawana Track.

In the Gibson Desert, bilbies occur in mulga shrublands on stony plains and along the lower slopes of ranges, in sandplains and in sand dune systems. Around Shay Gap, bilbies occupy sandplain environments. In the Great Sandy Desert, bilbies are present on recently burnt sandplains, interdune corridors or stony plains dominated by *Triodia* grasses and Acacias. The species also occupies the edges of salt-lakes where samphire (*Halosarcia* spp.) or Melaleucas dominate (C. O'Malley personal communication).

Given the large area in WA over which the greater bilby occurs and the fragmented nature of its occurrence, identification of habitat critical to the species will remain difficult until further survey work is carried out.

Known and potential threats

Biology and Ecology Relevant to Threatening Processes

Life History

The greater bilby is an omnivorous burrowing marsupial. It is generally solitary, strictly nocturnal and can breed throughout the year. The greater bilby can reach a density of 12 – 16 individuals/km^2 in optimal habitat; however; a density of 1-2/km^2 is more typical (Southgate 1987).

Foraging ecology

The bilby has an opportunistic feeding strategy that enables it to persist in arid regions despite the unpredictable temporal and spatial availability of food

resources (Gibson 2001). A wide range of plant and animal taxa is consumed with major dietary components varying across both seasons and geographic range (Southgate 1990c, Gibson 2001). Important plant foods include seed from various grasses (particularly *Yakirra australiense* and *Dactyloctenium radulans)* and sedges, and bulbs from Bush Onion/Yalka (*Cyperus bulbosus*) and *Wurmbea deserticola*. Major invertebrate prey includes termites, ants, beetles, insect larvae and spiders. In the Tanami Desert, it appears that seed and bulb plant foods are exploited opportunistically and invertebrates, especially termites, are relied upon when plant food is scarce (Southgate & Carthew in prep.). Most of the food of the greater bilby is excavated from the soil and holes may attain 250 mm in depth. The diggings are used to expose the roots of shrubs such as *Acacia* spp. (which contain insect larvae), penetrate termite galleries or ant nest stores, expose bulbs and gain access to fruiting bodies of underground fungi.

Shelter

Bilbies dig burrows up to 3 metres deep that generally descend in a gentle spiral. Some burrows have multiple entrances. Most burrows are isolated but complex systems consisting of interconnecting burrows are sometimes dug (Watts 1969). Several warrens with more than 20 entrances have been observed on Thistle Island (J. van Weenen personal communication). No nest chamber is constructed and nest material is not placed in the burrow. Burrows are used for shelter during daylight hours and intermittently throughout the night for rest and refuge. An individual may have over a dozen regularly used burrows within its home-range (Watts 1969; Southgate 1987). Up to 30% of burrows may be reused by both males and females, with females exhibiting long-term site fidelity (Moseby & O'Donnell 2003).

Activity patterns and movements

Bilbies emerge from their burrows after twilight and begin to forage. Mature males range more widely than females and have been recorded occupying burrows over 2 km apart on consecutive days (Southgate & Possingham 1995). Estimates of short-term home range sizes in the NT vary from 1.1 to 3 km^2 (Southgate & Paltridge 1998), whereas in a semi-wild population in SA average home range size was 0.18 km^2 for females and 3.16 km^2 for males (Moseby & O'Donnell 2003). Male home ranges and male-female home ranges overlap considerably, however; little overlap in home ranges among females has been observed (Moseby & O'Donnell 2003). Average dispersal distance of females in a reintroduced population at Watarrka NP was 2.3 km/year (Southgate & Possingham 1995). In this population one group established itself 10.5 km from the release site during a 3 year period.

Reproduction

The greater bilby appears to have a polygynous mating system: each reproductive male mates with multiple females (Moritz *et al.* 1997). Litters of one to three young can be produced at any time of year (Southgate *et al.* 2000). The length of the oestrus cycle is approximately 21 days and gestation takes about 14 days (McCracken 1990). Young remain in the pouch for approximately 75 days, before being cached and suckled in maternal burrows for a further 2 weeks prior to independence. Under ideal conditions, there is the potential to produce 4 litters every year. Captive females can begin breeding at 5 months of age or 560 grams body mass and continue breeding for up to 5 years. Captive males can commence breeding at about 800 grams body mass or 8 months of age. Captive animals live up to 10 years (Southgate *et al.* 2000).

Reasons for Listing

Reduction in extent of occurrence and area of occupancy

The distribution of the greater bilby has declined dramatically since European settlement (Figures 1-3). Historically, the greater bilby occurred across 70% of continental Australia, whereas the current distribution includes about 20% of its former range (Southgate 1990c). The greater bilby appears to have become extinct in NSW and southern SA around the 1910s (Watts 1969). It disappeared from the Flinders Ranges in the 1920s (Tunbridge 1991) and from northern SA in the 1930s. The species declined dramatically in south-west WA in the 1920s and 1930s, although it may have persisted until the 1970s or even the 1980s (Abbott 2001). The overall decline in the species' distribution to its approximate current range was documented by Watts (1969) based on survey work carried out in 1968. Southgate (1990a) noted a similar distribution based on survey work throughout its range in the 1980s. Since this survey, a number of populations to the north-west and north-east of Alice Springs (e.g. around Yuendumu (Watts 1969) and Papunya) appear to have gone extinct. Aerial and ground surveys in western QLD during the 1990s indicated a significant and ongoing contraction in the species' range in that state (P. McRae unpublished data).

Reduction in population size

The rapid decline in distribution up to 1970 has resulted in a significant decrease in overall population size. In addition, some anecdotal evidence suggests a decline in abundance within its current area of occupancy; however, no reliable estimates of population size are available.

Population fragmentation

Available information indicates that bilby populations in some areas are surviving in fragments of suitable habitat within a matrix of inhospitable environments. This fragmentation appears to be occurring in south-western QLD (P. McRae

unpublished data), NT (Southgate 1990 a, Watts 1969) and at the range margins in WA.

Increase in threatening processes

Although experimental evidence of the impact of particular threatening processes on greater bilby populations is not available, the distribution of the bilby correlates negatively with the ranges of a number of introduced predators and herbivores. Most of these introduced species are extending their ranges into bilby habitat and, therefore, may potentially exert further pressure on remnant bilby populations. Specifically, it is generally accepted that control and eradication of European red foxes and feral cats is essential if further declines of arid zone mammals are to be averted (e.g. Burrows *et al.* 2003). Either or both introduced carnivores have already prevented the success of several arid zone mammal reintroductions and are likely to do so again in the future (Burrows *et al.* 2003 and references therein).

Identification of Threats

The greater bilby faces a number of threats throughout its range; however, the relative importance of each threat and the interaction between threats is not clearly known. Each of the potential threats is detailed below.

Predation

Predation by the introduced European red fox, feral cat and dingo/wild dog is considered to be a major threat to the greater bilby. Dingo and feral cat predation on bilbies is recorded in the Tanami Desert (Paltridge 2002) and foxes may also be a significant threat there (R. Paltridge personal communication). During attempted reintroductions at Watarrka NP and Simpson's Gap (West MacDonnell NP), bilby populations were expanding with fox and cat densities of 0.15 animals/km^2 and dingo densities of 0.11 animals/km^2. Bilby populations were

declining at fox and cat densities of 0.25 animals/km^2 and dingo densities of 0.16 animals/km^2 (Southgate *et al.* 1994). Both foxes and dingos were responsible for bilby mortalities in this study (Appendix 1).

Feral cats are known to have taken bilbies released outside the predator-proof fence at AR (Hill *et al.* 2004).). In contrast, there have been no records of feral cat predation on reintroduced bilbies at Peron Peninsula. Bilbies appear to have increased both population size and area occupied in an environment without foxes or dingoes, but with cat densities of between 0.07 and 0.50 animals/km of road transect over a 4.5 year period (averaging about 0.25/km during this time). This observation suggests that in some circumstances cats may not have a significant effect on bilbies (C. Simms personal communication).

Although predation is generally considered as the major threatening process faced by the greater bilby there is still an urgent need to address the nature of this threat. Not only do all three predators appear capable of having a large impact on bilby populations, but also there is considerable interaction between the predators. Specifically, the red fox and feral cat may compete with each other for limited prey resources and foxes are known to prey on cats (Southgate & Paltridge 1998). More significantly, dingoes may protect a range of native species by controlling cats and foxes either through direct predation or excluding them from carrion during droughts (Environment Australia 1999, Southgate & Paltridge 1998, J. Pettigrew personal communication). In the Gibson Desert, cat numbers increased following baiting of foxes and dingoes (Christensen & Burrows 1994). Research aimed at better understanding predator interactions and the impact of the three predator species on native vertebrates is currently being developed (refer to Appendix 2).

The impacts of predation may be increased by pastoral activity, mining and other development. These activities may facilitate the movement of predators (e.g. along railway corridors), provide access to water and scavenging opportunities (e.g. at rubbish dumps), and dingo/wild dog control carried out on pastoral properties and mine sites may increase the abundance of foxes and cats. Therefore, management practices undertaken on mining and pastoral leases and development sites may have a negative impact on prey populations extending beyond the boundaries of the properties involved.

Competition with introduced herbivores

Competition with rabbits may be a major threatening process faced by the greater bilby. Southgate (1987) concluded that the 1980s distribution of the greater bilby was correlated with an absence or low abundance of rabbits. Additional anecdotal evidence of a decline in bilby numbers following invasion by rabbits is available from the Flinders Ranges (Tunbridge 1991). Despite the potential impact of rabbits on bilby numbers, no data are available to assess the precise nature of the interaction between the species. The reductions in rabbit populations in arid and semi-arid Australia following the introduction of RCD (Rabbit Haemorrhagic Disease) may have reduced the significance of this threat; however, the population response of bilbies, if any, is unclear. At Peron Peninsula, the reintroduced bilby population has become well established and individuals continue to disperse, despite the presence of a moderately high rabbit population that has been unaffected by RCD. A similar situation of coexistence also occurs at Venus Bay Conservation Park in SA, however, at this site RCD occasionally impacts on the rabbit population (J. van Weenen personal communication). Peron Peninsula is notable for the complete absence of foxes for 10 years and the >90% reduction in introduced stock for a 12-15 year period (C. Simms personal communication).

Habitat degradation by introduced herbivores

Grazing by cattle has been implicated as a potential threat to the greater bilby both in QLD (Morton & Newsome 1994) and in the eastern Pilbara and Dampierland (Southgate 1990a). Cattle activity results in physical damage to friable soils, an impact that is exacerbated by the provision of water-points that increase the grazing range of livestock. Although the impact of cattle grazing on bilbies in QLD has been disputed by some researchers (Lavery & Kirkpatrick 1997), evidence of ongoing declines in bilby populations in western QLD suggest that elements of the existing management of this landscape require some modification to ensure long-term persistence of bilbies. The potential threat posed by stock grazing has been mitigated to a significant extent with the gazettal of key areas of bilby habitat as national park in QLD and the associated removal of cattle.

The increase in feral camel numbers in western NT (Edwards *et al.* 2004) and WA is also a potential threat to populations of the greater bilby because of the potential of camels to affect habitat dynamics across arid environments. In the NT, the camel population is doubling in size approximately every 8 years (Edwards et al. 2004). The environmental impacts of camels in arid Australia are not well understood, but their large size (up to 1000 kg), consumption of a range of plant species, and preference for dune systems, indicates that the species may impact significantly on bilby habitat. Feral camels feed on more than 80 % of available plant species and they have serious impacts on vegetation at densities of greater than 2 animals km^{-2} (Dörges & Heucke 1996). Populations already occur at this density and above over much of the species' range in the NT. Management approaches for control of feral camel numbers in arid Australia are currently being developed (refer to Appendix 3).

Habitat degradation resulting from unsuitable fire regimes

Unsuitable fire regimes may restrict breeding and impede dispersal and colonisation of unoccupied areas by the greater bilby. Of particular concern are high intensity wildfires that burn uncontrolled across large areas of the western deserts of WA and NT. However, no data linking specific fire histories with bilby abundance are currently available. Fire appears to be a less significant factor in the Mitchell grass dominated environments of QLD (G. Lundie-Jenkins personal communication).

Dietary data from the Tanami Desert demonstrate that seed promoted by fire is an important component of the diet of the greater bilby at some locations (Southgate & Carthew in prep.). This result indicates that a mosaic of fire ages will increase the chance that a crop of fire promoted plants will occur each year (R. Southgate personal communication). Bilbies in the Tanami Desert are known to occupy the full spectrum of seral states from recently burnt to long unburnt vegetation (Southgate 2001). Both the role of fire as a threatening process and the use of fire management to promote suitable bilby habitat are issues requiring further investigation.

Drought

Recent physiological research suggests that the greater bilby is only partly adapted to arid environments placing it at risk of local extinction during severe droughts. Specifically, members of the QLD population exhibited a negative energy balance during one summer of a two year study (Gibson & Hume 2000). The unpredictability of food availability in arid environments indicates that the greater bilby may experience severe physiological stress during periods of food shortage throughout its current range. Such conditions would severely limit population growth rates and may explain the disappearance of colonies following prolonged drought.

Habitat destruction and degradation resulting from mining and other development

A number of mines are operating within the NT and WA range of the greater bilby including in the Tanami, Pilbara, and Great Sandy Desert bioregions. The greatest direct impact of mining operations is the destruction and degradation of greater bilby habitat. Although mining operations impact on a relatively small area of the potential habitat available to bilbies in the NT and WA, the location of mines adjacent to paleodrainage systems, which appear to be important habitat areas for bilbies (e.g. Paltridge & Southgate 2001), may have an impact on regional populations in the long-term. The positioning of tailing dams on laterite substrates can also have negative impacts on bilbies and other threatened marsupials (R. Southgate personal communication).

Other developments, including the recently completed Alice Springs to Darwin railway, major roads (e.g. Stuart Highway), and inland gas pipelines (Jackson to Mt Isa) occur within bilby habitat. Construction of these structures has destroyed bilby habitat and introduced a number of negative indirect consequences (see Predation above).

Road mortality

Haul roads constructed and operated during mining operations may be a significant cause of bilby mortality at a local scale because of a combination of vehicles operating on these roads throughout the night and the location of mining operations adjacent to favoured bilby habitat. Collisions with vehicles on haul roads at night have been a cause of bilby mortality in the Tanami Desert. Bilby mortalities from collisions with private vehicles have also been recorded on public roads including the Stuart Highway (NT) and Peron Peninsula, where at least 6 mortalities have been recorded (C. Simms personal communication).

Existing conservation measures

Conservation of the greater bilby has been guided by a previous recovery plan (Bellchambers & Johnson 1991) that covered the period 1992-2001, and a draft recovery plan that covered the period 1995-1999 (Southgate unpublished). Significant conservation actions have been completed to date involving protection and management of bilby populations and habitat, applied research on wild populations and their predators, reintroduction within the former range, and coordinated management of captive individuals. Specific actions undertaken over the past 15 years include:

- aerial and ground surveys of bilby populations in western QLD;
- surveys of bilby populations at different latitudes within the Tanami Desert;
- monitoring of bilby and predator activity in drainage line and sand plain habitat at different latitudes in the Tanami Desert;
- assessment of food, nutrition, and physiology of the species in Mitchell grass habitat in QLD;
- assessment of the impact of fire, rainfall and temperature on bilby food production in the Tanami Desert;
- reintroduction/introduction of populations to Thistle Island (SA), Venus Bay (SA), and Dryandra Woodland (WA);
- determination of population genetics;
- management of captive animals within a national captive management program (the ARAZPA greater bilby studbook);
- examination of diseases and parasites of wild and captive populations;
- establishment of a national bilby distribution database.

These actions have been largely successful particularly those involving reintroduction and captive management, population genetics and research on ecology and distribution of wild populations. However, in a number of cases more detailed data analysis or further research effort is required to further inform future recovery efforts. An example of the former case is interpretation of trends in abundance resulting form successive bilby surveys in western QLD. Further work

is required to assess the interaction between fire, rainfall and bilby food availability.

Additional actions not identified in Bellchambers & Johnson (1991) or Southgate (unpublished), but carried out over the past 15 years are listed below.

- Reintroduction to sites in SA (Yookamurra Sanctuary, AR), WA (Peron Peninsula) and NSW (Scotia Sanctuary).
- Surveys for bilbies at a wide range of sites in WA, usually with the involvement of local Aboriginal communities, including in the Gibson Desert, Edgar Range/Geegully Creek/Shay Gap area (Pilbara), and along the Canning Stock route and Talawana track in the Great Sandy Desert (around Parnngurr, Punmu and Kunawarritji communities).
- Predator baiting trials and monitoring of bilby response in the Tanami Desert.
- Establishment of a predator control fence at Currawinya NP and introduction of bilbies into the fenced area.

A number of actions identified as priorities in Bellchambers & Johnson (1991) or Southgate (unpublished) have not been completed. These actions include research on population dynamics (including survival, fecundity and dispersal) in QLD and NT, monitoring of the impact of weed invasion in NT, research on the impact of predators on bilby populations in QLD, and reintroduction into unmanaged landscapes in NT. Other actions have commenced but are not yet completed or have been discontinued. These actions include systematic monitoring of the NT population, assessment of the dispersal and spatial organisation of predators on the Diamantina plains (QLD), feral cat control and management in QLD, and reintroduction to sites in NSW and QLD.

Assessment of the success of previous actions is difficult because many are incomplete and/or results are not yet available. However, a number of actions have been successfully carried out including field surveys in QLD, NT and WA, ecological research in QLD and NT, reintroduction projects, captive management

under the bilby studbook program, and assessment of genetics. Investigations into the impacts of various threatening processes have proceeded slowly and this is a major shortcoming in knowledge for bilby conservation.

Strategy for recovery

The recovery plan will be implemented with the support of the GBRT, which is comprised of representatives from organizations and the broader community including NGOs (team is currently chaired by the arid rangelands coordinator of the TSN), Aboriginal organisations (CLC, NC), state and territory government departments (EPA/QPWS, SADEH, WADEC, NRETA, DEC), private conservation organisations (AWC, AR), private consultants, and zoos (ASDP, MZP, WPZ). Although composition of the recovery team is reasonably inclusive, it should be strengthened as opportunities arise, particularly with the inclusion of representatives from relevant regional NRM organisations and other traditional owner groups seeking engagement in the recovery of the species.

Past recovery actions for the greater bilby have been fragmented at times with a lack of national-level coordination. An obvious exception to this is management of the captive population which is effectively coordinated by ARAZPA. The development of several state-based recovery teams (e.g. SA, QLD) places greater emphasis on the need for effective communication and information dissemination among stakeholders. Therefore, there remains a vital requirement for an effectively-functioning national greater bilby recovery team.

Recovery Objectives and Criteria

Rationale for the Recovery Process

Overall philosophy of the recovery plan

The current plan lists only those actions that are considered to be of the highest priority. Recovery actions are listed in a rough order of priority. These actions have been arrived at through a detailed consultation process with a wide range of stakeholders.

The recovery plan follows the recommendation of Moritz *et al.* (1997) in recognising bilbies in each of QLD, WA and NT as separate management units. The only exception is with regard to captive management where bilbies from NT and WA have been managed as a single unit under the ARAZPA studbook scheme.

Although a number of potential threatening processes are identified above, there is unanimous support for the impacts only of predation by introduced carnivores. Because resources are limited and the value of some management actions is debatable, recovery effort dealing with active threat management is restricted to predator control (Action 1). The exception is reintroduction sites in Queensland, where restoration and maintenance of suitable habitat, through the management of herbivores and fire, is also listed as a recovery action. Recovery effort that seeks to assess the impact of predation and other threatening processes is covered in Action 6. The intention of Action 1 is that predator control at wild populations should focus on selected sites in the core of the species' range and on the range margins where the species' distribution is contracting. Action 1 also includes predator control at reintroduction sites.

Ongoing and future projects

A number of ongoing projects will proceed during the life of this plan and will provide information of value in the recovery of the greater bilby. These projects are not listed as recovery actions, but are detailed below.

- Research on trophic regulation among introduced carnivores mediated by the dingo. This ARC Linkage project will examine the hypothesis that the dingo plays a significant role in the conservation of medium-sized mammals, including the greater bilby, by its impacts on the numbers and behaviour of foxes and feral cats (refer to Appendix 2).
- Research on ecosystem services provided by the greater bilby. Projects in two locations are examining whether the reintroduction of bilbies and other burrowing marsupials can help restore ecosystem function (soil nutrient cycling, plant growth) in degraded arid environments. Study sites are at the AR (involving students from University of Adelaide and University of Sydney) and Currawinya NP (EPA/QPWS, University of QLD).
- Development of an action plan for the management of feral camels in Australia. This action plan will be developed following a stakeholder workshop that was run in April 2005 by NRETA and funded by the National Feral Animal Control program of the Natural Heritage Trust (NHT) (refer to Appendix 3).
- Regional projects such as the Tanami predator baiting study, which uses a before-after control-impact design with two control sites and one baiting site within a 20 000 ha area to examine the impact of predator reduction on occurrence of bilby sign. This project is a collaboration between CLC, Warlpiri Rangers (a local Aboriginal Community Ranger program), and NRETA.
- Development of regional fire management plans as part of the NRM process.
- Collation of greater bilby records in a centralised national bilby distribution database.

During the life of this recovery plan preparations should be carried out for potential future recovery actions. Among these is the need to collect genetic material when wild animals are handled. Given the well established captive management program presently in place and the development of sign based monitoring methodology, opportunities to handle wild animals will be reduced in future. However, genetic analysis offers an excellent opportunity to assess the conservation significance of bilby populations. Therefore, whenever the opportunity arises tissue samples should be taken and appropriately stored.

Overall Recovery Objectives

The recovery program aims to achieve two major objectives as detailed below.

- To improve and at least maintain the national conservation status of the greater bilby (currently listed nationally as Vulnerable) over the duration of the plan.
- To achieve an accurate assessment of (a) distribution, (b) trends in occurrence, and (c) successfully reduce the impacts of key threatening processes.

Specific Recovery Objectives

1. Reduce impact of predation by introduced carnivores.
2. Maintain genetic diversity through captive breeding program.
3. Establish self-sustaining populations within former range.
4. Monitor trends in occurrence and abundance.
5. Assess the impact of predators, fire and other threatening processes on bilby populations.
6. To inform and involve the community and all stakeholders in the recovery process.
7. Continue to manage the recovery process through a national recovery team.

Table 1. Relationships between specific objectives, recovery criteria and actions.

Objectives		Recovery Criteria		Actions
• Reduce impact of predation by introduced carnivores.	⇔	• Impact of predation at priority sites is reduced.	⇔	1a Control predators at priority sites. 1b Monitor predators and bilbies at priority sites.
• Maintain genetic diversity through captive breeding program.	⇔	• Captive populations successfully maintained. • Level of genetic diversity at release sites increased to 90%.		2a. Continue husbandry and coordinated management of captive populations. 2b. Evaluate the levels of genetic diversity in captive versus wild bilby populations.
• Establish self-sustaining populations within former range.	⇔	• Self-sustaining populations established in at least three locations. • Level of genetic diversity at release sites increased to 90%.	⇔	3a. Continue to reintroduce the species to predator-free or predator-controlled sites across its former range. 3b. Evaluate the level of genetic diversity in reintroduced vs wild populations.
• Monitor trends in occurrence and abundance.	⇔	• Current area of occupancy and extent of occurrence of wild populations assessed across the species' range.	⇔	4. Refine monitoring methodology. 5a. Monitor trends in occurrence and abundance of wild bilby populations in QLD.

		• Trends in abundance determined for the QLD population. • Trends in abundance and occurrence determined for each reintroduced population.		5b. Monitor trends in occurrence of wild bilby populations in WA and NT. 5c. Monitor trends in abundance and occurrence of reintroduced populations. 5d. Ensure effective data collection and collation processes are in place to maximise the documentation of survey/opportune records.
• Assess the impact of predators, fire and other threatening processes on bilby populations.	⇔	• Effects of threatening processes are quantified at sites. • Monitoring sites in place to assess impact of threatening processes across the species' range.	⇔	6. Measure impact of threatening processes on bilby populations
• Inform/involve community and all stakeholders in the recovery process.	⇔	• National recovery team holds regular meetings. • Direct involvement of all major stakeholders, including regional recovery teams/working groups within the national recovery process.	⇔	7. Continue to manage the recovery process through a national recovery team.

Recovery Actions

Action 1. Control predators at key bilby populations.

Aim

To reduce fox and cat numbers at both reintroduction sites and key wild populations where bilbies are in decline.

Justification

Excessive predation by foxes and cats is a serious threat to wild populations of bilbies in some areas and may lead to declines in abundance. Predation can also have a serious impact on the success of reintroduction efforts. Predator control needs to be carried out urgently at these sites.

Methods

Predator control methods vary across the range of the bilby. At each site a balance should be struck between the most cost-effective methods and the needs of the people carrying out the control. Available methods include aerial baiting, ground baiting, and hunting. Important bilby populations occur in the vicinity of Aboriginal communities; however, the use of baits is not currently acceptable to some Aboriginal people. Therefore, more effective education about the impacts of foxes and/or cats should be incorporated into this activity. Potential sites for predator control at wild populations in WA/NT include Tjirrkali, Kanpa, Kiwirrkurra, Parnngurr, Punmu, Edgar Range/Geegully Creek area and Sangster's Bore, and at sites in south west Queensland including Astrebla Downs NP. Predator control is already ongoing at some of these sites.

Predator control should seek to reduce numbers to a level that enables bilbies to continue to persist in these areas. Attempted reintroductions in the southern NT provide information on predator densities at which bilbies can persist. Specifically, bilby populations were expanding with fox and cat densities of 0.15 animals /km^2 and dingo densities of 0.11 animals /km^2, whereas bilby populations were declining at fox and cat densities of 0.25 animals/km^2 and dingo densities of 0.16 animals /km^2 (Southgate *et al*. 1994).

Potential contributors

AR, AWC, WADEC, SADEH, EPA/QPWS, NRETA, CLC, KLC, NC, WDLAC

Costs ($1000s)

Costs of predator control at reintroduction sites are built into Action 3 (below). Costs below are for predator control and monitoring at wild populations based on work at five sites per year at an estimated cost of $18,000/site/year (including employment and labour, travel costs, materials and administration).

Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
90.0	90.0	90.0	90.0	90.0	450.0

Note: Ideally conducted in conjunction with monitoring to evaluate effects on bilbies and their ecosystem.

Action 2. Continue husbandry and coordinated management of captive populations.

Aim

To ensure that captive populations of the greater bilby continue to be managed effectively for reintroduction purposes.

Justification

Captive breeding should occur in support of, not as a substitute for, wild populations. Although captive greater bilby serve an important function in public education, this objective alone does not necessarily justify taking a threatened species from the wild. Therefore the primary objective of managing captive populations of greater bilby should be as a source of animals for reintroduction, with the secondary purpose of public education.

Methods

It is essential that captive colonies are well managed and displayed in appropriate circumstances. Genetic integrity of populations should also be maintained and QLD and WA-NT stock should continue to be treated as separated management units. Captive breeding will be managed with the aim

of providing stock for release that will increase the genetic diversity at release sites to at least 90%.

As at March 2005, 17 institutions have captive animals registered with ARAZPA. Significant holdings by state are WA (Kanyana, Peron Captive Breeding Centre), SA (MZP), NSW (WPZ, Scotia Sanctuary), QLD (Charleville Breeding Facility, David Fleay Wildlife Park), and NT (ASDP). The genetic integrity of captive stock will continue to be managed by ARAZPA through the studbook program. As the need for animals for reintroduction projects is presumably reduced, the future of captive management will need to be re-assessed during year 1 of the recovery plan.

Stakeholders

ARAZPA, Kanyana, EPA/QPWS, WADEC, AWC, NRETA, Royal Zoological Society of SA (MZP), Zoological Parks Board of NSW (WPZ), other institutions.

Costs ($1000s)

The ARAZPA studbook (as at March 2005) listed 151 animals in captivity; 39 are animals from the QLD management unit. The expectation is that the Peron colony will be greatly reduced in size after year 1. The institutions involved in this recovery action have already committed funds to the project i.e. external funding is not needed for this action to continue. Cost estimates are mostly based on estimates provided by the institutions themselves. However, if no estimates were available costs were calculated based on an annual cost of managing a captive bilby estimated at $3100 per year inclusive of food, labour and veterinary care (G. Fry personal communication).

Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
367.35	313.1	313.1	313.1	313.1	1619.75

Action 3. Continue to reintroduce the species to predator-free or predator-controlled sites across its former range.

Aim

To facilitate further reintroduction programs and to continue management of bilby populations that have been re-introduced into the wild or that occur within predator-proof fences within the former range.

Justification

An important aim of bilby conservation is to reintroduce populations to areas of their extensive former range where the species no longer occurs. Reintroduction projects have commenced within the species' former range in southern SA (Roxby Downs, Yookamurra Sanctuary, Venus Bay Conservation Park, Thistle Island), WA (Dryandra Woodland, Peron Peninsula), south-western QLD (Currawinya NP) and western NSW (Scotia Sanctuary). Continued management of reintroduced populations in the wild and within predator-proof enclosures is needed to ensure that these become self-sustaining over time. An important component of ensuring long term persistence of these populations is to increase the level of genetic diversity at release sites to 90%.

Methods

Management and monitoring of bilbies at reintroduction sites will continue. Specific components of this task, specifically predator management and monitoring of population trends are included under actions 1 and 5c, respectively. However, costs of all these activities are included in this action. Reintroduced bilbies at each site will be subject to a monitoring program that will enable assessment of survivorship, population structure, fecundity, population trends and condition. The aim of genetic management will be to release animals so that the genetic diversity of the reintroduced population is 90% or above. To this end, this action will work to increase/maintain the level of genetic diversity at the release sites at Roxby Downs, Venus Bay, Peron and Dryandra to at least 90%. This will be achieved through the breeding and release of un- and under-represented founders at each site. A genetic diversity of 90% should ensure there is no long-term loss of adaptive potential.

Future potential reintroduction sites for Queensland are the Culgoa Floodplain NP and private land in the Brigalow Belt South and Mulga Lands bioregions. The degree of habitat degradation / vegetation change since the greater bilby was last recorded will be assessed for each reintroduction site, and potential causes of degradation / change identified. Suitable greater bilby habitat at these sites will be restored and maintained through the management of herbivores and fire using an adaptive management approach, thus also contributing to Action 6.

Additional potential sites for reintroduction in Queensland will also be investigated.

Stakeholders

WADEC (Dryandra Woodland, Peron Peninsula), SADEH (Venus Bay Conservation Park, Thistle Island), AWC (Yookamurra Sanctuary, Scotia Sanctuary), AR (Roxby Downs), EPA/QPWS (Currawinya NP, Culgoa Floodplain NP and other sites).

Costs ($1000s)

Estimated costs for existing reintroduction projects including salaries, equipment, fencing, feral animal control and consumables. Costing does not include Queensland.

Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
433.4	330.4	330.4	330.4	330.4	1755.0

Action 4. Refine monitoring methodology.

Aim

To ensure that an effective and reasonably uniform monitoring methodology is developed and refined. This methodology should be used to interpret changes in bilby occurrence within and across sites.

Justification

Most interpretation of changes in bilby distribution and abundance result from an assessment of sign. However, trends in bilby abundance based on sign are difficult to interpret. If changes in abundance are to be accurately interpreted, it will be necessary to develop effective and accurate monitoring methods that can examine both changes in abundance within a population and differences in abundance across sites. However, it remains a strong possibility that bilby sign alone cannot be used to accurately estimate abundance. Therefore, it will be necessary to develop effective protocols to assess presence/absence.

Method

Members of the GBRT should develop the monitoring methodology. A number of potential methods are available, each with advantages and disadvantages depending on the environment, context, budget, and availability of skilled trackers. A rapid site-based sign survey method compiled by Colleen O'Malley and Rachel Paltridge (National Bilby Recovery Team Update June 2003) proposes the use of 200 m by 300 m plots surveyed over a period of 15-20 mins. At AR a combination of methods (track counts, spotlighting, burrow activity and scanning plates) is used to survey bilbies at relatively high densities. Southgate *et al.* (2005) examined three methods (fixed transect, random plot, aerial survey) for broadscale surveys. A combination of these approaches can be developed to define a more standardised approach.

Stakeholders

GBRT.

Costs ($1000s)

Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
25.0	25.0				50.0

Action 5. Monitor trends in occurrence and abundance of the greater bilby across its range including at reintroduction sites.

5a. To continue to monitor occurrence and relative abundance trends of the Queensland population

Aim

To carry out an aerial and ground survey of the greater bilby population in QLD in order to estimate population size based on density of burrows.

Justification

South-western QLD is the only area where the distribution of wild bilby populations is relatively well understood (e.g. Gordon & McRae 1993). Aerial monitoring data are available for 1988, 1994 and 1999. It is critical that this monitoring continue and that data are analysed and the methodology validated in order to detect changes in status of this management unit.

Method

The methodology should be based on that used in surveys carried out in 1994 and 1999, but refined by incorporating recent input from The University of QLD. In addition, existing survey data should be appropriately analysed to detect population trends.

Stakeholders

EPA/QPWS, various research institutions, NRM bodies.

Costs ($1000s)

Estimated cost of $65,000 for the survey to be carried out in 2006.

Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
65.0					65.0

5b. Monitor trends in occurrence in WA and NT

Aim

To establish a monitoring system that will provide reliable, readily interpretable information on trends in occurrence of bilby sign across bioregions in WA and NT.

Justification

Knowledge of the location of and trends in the occurrence of bilby populations is fundamental to their conservation across Australia. Repeated surveys are important to gain an understanding of temporal change in distribution and to relate this to environmental conditions and threat parameters. However, before this can be done it is essential to gain an understanding of the current extent of occurrence and area of occupancy of the species in WA and NT. A survey carried out in 1983-85 can be used as a baseline against which to compare current patterns in occurrence and occupancy. The results of this study will be used to select monitoring sites for future work.

Method

An intensive survey of bilby sign throughout the WA and NT range of the species will be carried out based on the methodology, survey effort, and locations of Southgate (1990a). This survey will involve two people for 12 months with an estimated 150 days of field work. The survey will particularly target locations at the edge of the species' range where there have been few recent (within 10 years) records. In WA, surveys are required in the Woodstock area, the Edgar Range, Telfer and Shay Gap areas, Dampierland, along the Canning Stock Route, and in the southern Gibson Desert. If possible, ongoing fauna surveys will be modified to include a component that involves targeted surveys for the greater bilby.

At the completion of this action an assessment can be made of the area of occupancy and extent of occurrence of the bilby in WA and NT. This information will serve as baseline data for future assessments of the greater bilby's distribution and status. Data collation, storage and analysis are important components of this action. These aspects will need to be negotiated with relevant stakeholders.

Following this survey, it is intended that monitoring will be carried out every 2-3 years at sites located across bioregions where the species occurs. This methodology will enable trends in presence/absence of the greater bilby to be assessed in both WA and NT. Although the full range of monitoring sites should be determined after the completion of the intensive survey, existing monitoring projects should continue in the interim. Current monitoring sites in NT are located in the Tanami bioregion. In WA monitoring sites are in the Edgar Range/Geegully Creek area, along the Canning Stock route (around Parnngurr, Punmu and Kunawarritji community), and in the Gibson Desert.

Stakeholders

WADEC, NRETA, CLC, KLC, NC, NMC, WDLAC.

Costs ($1000s)

The survey will be undertaken over a 150 day field season with the remaining period set aside for data collation, analysis, reporting and data use negotiation. Employment of a scientist and a technical officer for 12 months is estimated at $118,000 (including 25% on costs). An additional $36,000 is set aside for the involvement of Aboriginal people participating in surveys.

Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
	77.0	77.0			154.0

5c. Monitor trends in abundance and occurrence at each reintroduction site.

Aim

To monitor trends in bilby population size and occurrence at locations where the species is being reintroduced into its former range.

Justification

Monitoring data are an essential component of attempts to reintroduce the greater bilby into its former range. Information on survivorship, reproduction and range are needed to assess the success or otherwise of reintroductions.

Method

Methodology will vary with location and substrate but is likely to include a combination of radio tracking, track counts, burrow activity and spotlighting.

Stakeholders

AR, AWC, WADEC,SADEH, EPA/QPWS.

Costs ($1000s)

Costs are included under action 3 (above).

Action 6. Measure impact of threatening processes on bilby populations at reintroduction sites.

Aim

To attempt to quantify the impact of the major potential threatening processes on bilby populations.

Justification

The impact of potential threatening processes on the occurrence/abundance of bilbies is not well understood. An urgent requirement for effective conservation planning is to gain knowledge of the factors involved in the range contraction of this species. However, the impact of threatening processes may not be readily extrapolated across regions (e.g. from the Tanami Desert (NT) to the Channel Country of QLD). Further, although the need for collecting this information in wild populations has long been established (e.g. Bellchambers & Johnson 1991); it is logistically very difficult to obtain meaningful data. Studying the impact of threatening processes on bilby populations at reintroduction sites offers an effective method to rapidly gain knowledge of the processes involved. This work combined with ongoing projects such as the Tanami predator baiting study and trophic regulation among introduced carnivores study will provide an effective framework on which to base future management and research addressing threatening processes.

Methods

Monitoring of the response of bilbies to various management regimes should be undertaken as opportunities arise. The current reintroduction of bilbies into the 10 km buffer zone surrounding the AR reserve provides an opportunity to assess the response of bilbies to reduced numbers of predators (introduced carnivores) and potential competitors (rabbits). Proposed pen trials at AR involving combinations of threats are also an ideal source of information on the response of bilbies to threatening processes.

Stakeholders

AR, AWC, WADEC, SADEH, EPA/QPWS.

Costs ($1000s)

Costs for reintroduction sites are included under Action 3 (above).

Action 7. Continue to manage the recovery process through a national recovery team.

Aim

To guide the implementation of the recovery plan and to ensure that all relevant stakeholders are involved and/or informed of progress.

Justification

A national recovery team is important for the successful implementation of a recovery plan for species with a large geographic range such as the greater bilby. The existing greater bilby national recovery team is the appropriate group to implement this plan. The existence of several state-based recovery teams (e.g. SA, QLD) places even greater emphasis on the need for effective communication and dissemination of information about greater bilby recovery as does the recent launch of National Bilby Day. Because the greater bilby has become the only Australian animal to have a special day set aside for it in the national calendar it is imperative that positive outcomes from bilby conservation are communicated in a coherent fashion to the Australian public.

Methods

The national recovery team will oversee the development and implementation of this recovery plan. The team will meet formally once every 12 to 18 months and will keep in regular contact via email.

Costs ($1000s)

The GBRT is maintained through in-kind support from the member organisations.

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Appendix 1. Summary of reintroduction attempts into unfenced habitat in southern NT 1982-1991.

Two reintroductions of the greater bilby into arid southern NT were attempted but failed during a previous recovery plan. Both reintroductions took place outside of predator-proof fences. Information on these reintroductions is provided in Southgate *et al.* (1994) but is summarised in the Table to inform future reintroduction attempts especially into areas without fencing. Monitoring at Simpson's Gap was not sufficient to determine a cause for the failure of the reintroduction; however, it is likely that predation was involved (Southgate 1994). Predation by foxes and dingoes did contribute to mortality of radio tagged animals at Watarrka NP (Southgate 1994, Southgate & Possingham 1995). Based on the results of these reintroductions, Southgate *et al.* (1994) proposed that bilby populations were expanding with fox and cat densities of 0.15 animals/km^2 and dingo densities of 0.11 animals/km^2 whereas densities of foxes and cats of 0.25 animals/km^2 and dingoes of 0.16 animals/km^2 were associated with declining populations. These densities may be of use in determining suitable conditions for future reintroductions.

Apart from the two releases in the NT, subsequent releases of greater bilbies into unfenced habitat have been undertaken at Dryandra in WA and AR in SA. Predation has been observed at Dryandra, including by cats. At AR, six of 12 animals released outside the fence were taken by feral cats (Hill *et al.* 2004).

Table. A summary of releases of the greater bilby into the wild at Watarrka NP and Simpson's Gap (West MacDonnell NP) between 1982 and 1991. Information is taken from Southgate *et al.* (1994) and Southgate & Possingham (1995). Each location had two release sites. The distance between sites was about 5 km at Simpson's Gap and about 10 km at Watarrka NP.

Location	Date	No. of animals released	Maximum survival (months)*
Simpson's Gap – site 1	August 1982	18	>7
	July 1983	14	>6
	June 1985	5	>6
Simpson's Gap – site 2	April 1987	4	3
Watarrka NP – site 1	April 1988	4	27
	October 1988	4	24
	January 1990	2	7
	December 1990	3	<1
	January 1991	2	<1
Watarrka NP – site 2	November 1990	5	8

* maximum period of time that released individuals survived at the site.

Appendix 2. Details of a workshop covering the topic of trophic regulation among introduced carnivores mediated by the dingo. The workshop is planned for October 2005 and involves a research consortium including ANU (Dr Brendan Mackey), Prof. Michael Soulé, University of Sydney (Alistair Glen) and SA DEH. The information given here was provided by these researchers in February 2005.

In Australia, the dingo, as a top order predator, is perceived both as an agricultural pest and as a possible trophic regulator of foxes and cats. A growing body of evidence suggests that suppression of cats and foxes by dingoes may have beneficial effects for some native prey species. There is also evidence that dingoes regulate the density of herbivores, including rabbits and red kangaroos.

The legislative control and conservation of dingoes varies between States. Conservation legislation recognises the dingo as an established native species, but not as a strongly interacting species that may confer conservation benefits to species at lower trophic levels. A consequence is that the dingo tends to be conserved within some, but not all, protected areas and controlled elsewhere to minimise livestock losses.

Often, where dingoes (and other wild dogs) are declared as vermin, the trigger for control is livestock loss (which can be a preventive measure based on a perceived number of dogs).

Given agricultural constraints, policy makers must adopt an ecological view that ensures the persistence of the dingo at ecologically effective population densities (and structure) and maximal spatial occurrence (Soulé *et al*. 2003).

Conservation policy must be based on rigorous science (Soulé *et al*. 2005). The interactivity of the dingo has not been specifically researched, though there is circumstantial and anecdotal evidence for its beneficial effects. More information is needed before there will be a consensus on policy guidelines.

To address this knowledge gap, the WildCountry Science Council, in partnership with the South Australian Department for Environment and Heritage and funded by the Australian Research Council, will convene a workshop of invited researchers to design research protocols and experiments on the species interactivity of the dingo.

The two-day workshop will be held in Adelaide on 13-14 October 2005.

A literature review by the University of Sydney will form the framework for the workshop. During the workshop, specific hypotheses will be generated with a view to investigating three broad questions:

a) Do dingoes limit the abundance of other predators?

b) Do dingoes affect the function of other predators (e.g. by altering their spatial or temporal activity patterns)?

c) If either or both of the above can be demonstrated, do these effects translate into greater abundance or diversity of native species at lower trophic levels?

Having identified a set of more specific hypotheses, experiments and surveys at appropriate spatial and temporal scales will be designed to test these. Proposals will be developed for submission to the ARC.

Appendix 3. Details of a workshop on feral camel management held at Alice Springs in April 2005. The workshop was organised by NRETA, Alice Springs.

Government agencies and stakeholder groups will be invited to a two-day professionally-facilitated workshop to be held in Alice Springs. The workshop will include discussions on current agricultural and environmental impacts, management objectives, management options, cultural sensitivities, stakeholder obligations and imperatives, opportunities for commercial utilization etc.

Minutes of the workshop proceedings will be accurately recorded and used to produce an action plan for the management of feral camels in Australia identifying:

- Research and management priorities
- Monitoring and reporting requirements
- Appropriate population control techniques
- Roles and responsibilities of individual stakeholders
- Management time-frame incorporating goals and milestones
- Estimated costs
- Potential funding sources.

Outcomes

1. The project will facilitate the coordinated management of the impacts of feral camels in Australia - a significant improvement on current ad hoc programs operating independently within each jurisdiction.
2. The project will allow the cooperation of stakeholders (including government agencies, the camel industry, pastoralists and traditional owners) across all jurisdictions in working towards common management goals.
3. The project will ensure that jurisdictional policies and procedures are consistent across the entire range of feral camels in Australia.
4. The project will provide individual land managers with a vehicle for effectively and strategically managing the impacts of feral camels on their land.