Recovery Plan for the

Southern Brown Bandicoot in the Mount Lofty Ranges, South Australia,

2004 to 2009

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Government of South Australia

Department for Environment and Heritage

Natural Heritage Trust

TABLE OF CONTENTS

Summary

Introduction

The recovery of the Southern Brown Bandicoot in the Mount Lofty Ranges relies on the reduction of threatening processes, the enhancement and protection of suitable habitat and the establishment of connections between patches of remnant vegetation.

The Mount Lofty Ranges is defined in this recovery plan by the region's Integrated Natural Resource Management Plan (INRM) boundary. A description of this area can be found in the Draft Biodiversity Plan for the Greater Mount Lofty Ranges, South Australia (DEH 2003).

Status

Of the eight species of bilby and bandicoot that originally occurred in South Australia, only the Southern Brown Bandicoot, *Isoodon obesulus*, can still be found here (Kemper 1990). One subspecies of this taxa, *I. o. obesulus*, occurs in the Mount Lofty Ranges. Suitable habitat within this area has become fragmented and the species range has contracted from its northern extent. *Isoodon. obesulus obesulus* is currently listed as Endangered under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999.* In South Australia the species is listed as Vulnerable under the *National Parks and Wildlife Act 1972*. Threats to bandicoots within the Mount Lofty Ranges are exacerbated by their peri-urban distribution and by conflicts between biodiversity conservation and human land-use requirements.

Threats and threatening processes

- Habitat loss and fragmentation
- Habitat degradation
- Rabbit control methods
- Bushfire and modification of habitat as a result of fire management regimes
- Predation by foxes, dogs and cats
- Road Mortality
- Disease

Recovery plan objective

The overall objective of this recovery plan is to:

Identify, develop and implement monitoring protocols and threat abatement actions that are necessary to:

- Maintain or increase the current distribution of Southern Brown Bandicoots in the Mount Lofty Ranges; and
- Maintain or increase the current abundance of Southern Brown Bandicoots within the Mount Lofty Ranges.

Primary Recovery actions

1 Implement the recovery plan through a recovery team;
2 Increase knowledge of the distribution, abundance and ecology of Southern Brown Bandicoots in the Mount Lofty Ranges
3 Identify key threatening processes and the degree to which these are impacting on key populations of Southern Brown Bandicoots in the Mount Lofty Ranges
4 Implement threat abatement strategies
5 Enhance the public profile of Southern Brown Bandicoots and their threats and encourage community participation in the recovery program

Estimated costs over 5 year period (in thousands of dollars)

Year	Action 1	Action 2	Action 3	Action 4	Action 5	Action 6	Action 7	Action 8	Action 9	Total
1	0.5	21.8	0.0	0.0	0.0	13.0	0.0	6.0	2.0	43.3
2	0.5	15.0	31.8	22.0	14.3	7.0	4.0	20.0	2.0	116.6
3	0.5	40.0	0.0	20.0	11.3	3.0	25.0	10.0	2.0	111.8
4	0.5	10.0	0.0	19.0	10.5	3.0	10.0	10.0	2.0	65
5	0.5	10.0	0.0	4.0	10.5	3.0	0.0	0.0	2.0	30
Total	2.5	96.8	31.8	65.0	46.6	29.0	39.0	46.0	10.0	**366.7**

A detailed description of the implementation and costs for Southern Brown Bandicoot Recovery in the Mount Lofty Ranges is provided in Table 4.

Conservation status

The Southern Brown Bandicoot *I. obesulus obesulus* is listed as Vulnerable under the South Australian *National Parks and Wildlife Act 1972* (Section 8) and as Endangered under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). *I. o. obesulus* is also listed as Endangered in NSW (*Threatened Species Conservation Act 1995*) and as Near Threatened in Victoria (DSE 2003). A national recovery plan is currently in preparation (Brown 2004) and a draft recovery plan exists for the species in NSW (NSW National Parks and Wildlife Service 2001).

Stakeholders

Southern Brown Bandicoots in the Mount Lofty Ranges currently inhabit a diversity of habitats across a variety of land tenures and therefore a number of organisations and individuals have responsibilities for the conservation of the species. Bandicoots predominantly occupy areas managed by the Department for Environment and Heritage (DEH), ForestrySA and SA Water. Bandicoots also occur on private property, including some covered by Heritage Agreements (which protect nominated areas of native vegetation on private land). Records from private property have been increasing as a result of recent publicity generated by the program and its partners.

At a State level, the Department for Environment and Heritage has a legislative responsibility under the *National Parks and Wildlife Act* 1972 to protect the Southern Brown Bandicoot. Broader community responsibilities apply under the EPBC Act which states that any person proposing to undertake an action that has, will have, or is likely to have a significant impact on the species must seek approval for this action from the Commonwealth Minister for the Environment. Guidelines are available from the federal Department of the Environment and Heritage to assist in determining whether a proposed action is likely to require referral to the Minister (http://www.deh.gov.au/epbc/assessmentsapprovals/guidelines/administrative/index.html)

Other legislation relevant to the conservation of the Southern Brown Bandicoot and its habitat within South Australia includes:

- *Native Vegetation Act 1991;*
- *Development Act 1993;*
- *Forestry Act 1950*;
- *Country Fires Act 1989 ;*
- *Animal and Plant Control (Agriculture and Other Purposes) Act 1986.*

Organisations whose involvement is likely to be required to implement actions outlined in this recovery plan include: Department for Environment and Heritage, local councils, Catchment Water Management Boards, the Animal and Plant Control Commission and the Animal and Plant Control Boards, ForestrySA, SA Water and TransportSA.

Conservation organisations including the World Wildlife Fund (WWF) Threatened Species Network and Nature Foundation SA Inc. provide valuable support to threatened species recovery programs and their continued involvement is anticipated.

The peri-urban distribution of some bandicoot populations in the region necessitates the direct involvement of the general public in this recovery plan. Threats to the species in semi-urban areas are often the result of differing human land-use and biodiversity conservation priorities. Many people have little knowledge of bandicoots, often misidentifying them as rats or possums. Improving the public's awareness of Southern Brown Bandicoots and seeking their involvement in this recovery plan will assist in the protection of habitat on private land, the adoption of responsible pet ownership initiatives, and will increase the public's willingness to assist in the restoration of habitat on private and public land.

Numerous community conservation groups are already actively involved in the management and restoration of bandicoot habitat and their continued involvement in the implementation of this recovery plan is anticipated. These groups include, but are not limited to, the Aldgate Valley Landcare Group (incorporating the Valley of the Bandicoots project), the Sturt Upper Reaches Landcare Group, Friends of Belair National Park, Mylor Parklands Bushcare Group, the Fourth and Sixth Creek Catchment Groups, Friends of Kenneth Stirling Conservation Park, Friends of

Mark Oliphant, Friends of Scott Creek Conservation Park and Friends of Deep Creek.

Background Information

Taxonomy

The Southern Brown Bandicoot (*Isoodon obesulus*), is also known as the short-nosed bandicoot, brown bandicoot, southern short-nosed bandicoot, and by the indigenous names Quenda, Bung (Braithwaite 1995) and Marti (by the local Kaurna indigenous people). Of the eight species from the family Peramelidae that occurred in South Australia (Pig-footed Bandicoot *Chaeropus ecaudatus*, Western Barred Bandicoot *Perameles bougainville*, Eastern Barred Bandicoot *P. gunnii*, Desert Bandicoot *P. eremiana*, Golden Bandicoot *I. auratus*, Southern Brown Bandicoot, Bilby *Macrotis lagotis*, Lesser Bilby *Macrotis leucura*) only the Southern Brown Bandicoot is still extant in the state (outside of captivity).

Five subspecies of Southern Brown Bandicoot are recognised according to the classification of Seebeck *et al.*(1990). Two of these, *I. o. nauticus* and *I. o. obesulus*, occur within South Australia (Fig. 1). This recovery plan is concerned with the latter of these subspecies which is found on Kangaroo Island, in the Mount Lofty Ranges, in the far south-east of the state and possibly on the Eyre Peninsula, as well as in Victoria and New South Wales. The information that follows concerning the habits and ecology of the Southern Brown Bandicoot emphasises, where possible, information specifically relating to *I. o. obesulus*, with particular emphasis on South Australian populations. However, it has also been necessary to draw on general information from the other four subspecies.

Morphology

The Southern Brown Bandicoot is a medium-sized marsupial that is robust and compact in appearance. The species has small, round ears and a short, pointed snout relative to other bandicoots (Jones 1924). Short, spiny brown and straw coloured hairs over the animal's head and back result in the coat having a grizzled brown appearance while its underside is a creamy white colour (Jones 1924).

Sexual size dimorphism is apparent. On average, males weigh 850 g (range 500 to 2000 g) and have a head-body length of 330 mm (range 200 to 360

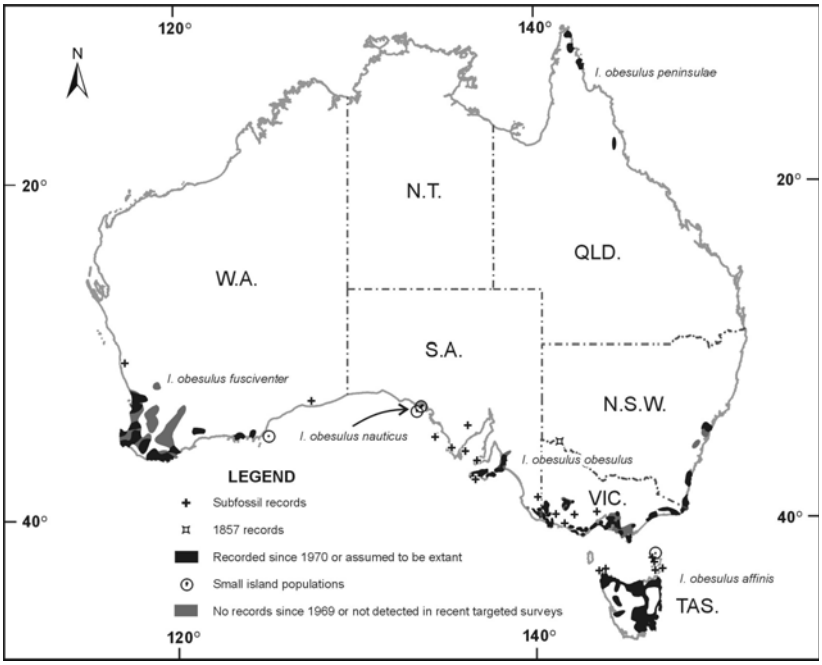

Figure 1: Distribution of *Isoodon obesulus* (Adapted from Rees and Paull 2000; originally compiled from Ashby *et al.* 1990, Friend 1990, Gordon *et al.* 1990, Hocking 1990, Kemper 1990, Menkhorst and Seebeck 1990, Paull 1995, Seebeck *et al.* 1990, Rees and Paull (unpublished data).

mm) (Paull 1992, Braithwaite 1995). Females weigh 700 g on average (range 400 to 1100 g) and have a head-body length of 300 mm (range 280 mm to 330 mm) (Paull 1992, Braithwaite 1995). Weights of bandicoots studied in the Mount Lofty Ranges can be found in Appendix 1.

Reproduction, longevity, and juvenile recruitment

The annual duration of reproduction for Southern Brown Bandicoots varies across Australia, but peak breeding tends to occur from winter through to summer (Stoddart and Braithwaite 1979, Lobert and Lee 1990, Paul 1992). Pouch young have been recorded throughout the year in Belair National Park in the Mount Lofty Ranges (Reese 2000, Kovac 2002) although the primary breeding season in this region occurs from June to December (Paull 1992).

The synchronicity and duration of the breeding season have been correlated with environmental factors such as day length, rainfall and temperature (Stoddart and Braithwaite 1979, Barnes and Gemmell 1984) presumably because these factors ultimately influence food availability (Heinsohn 1966, Lobert and Lee 1990).

In South Australia, Southern Brown Bandicoots have an average of three young per litter and are capable of producing between two and five litters annually (Paull 1992). This high fecundity is offset by relatively low juvenile survival at some South Australian sites with mortality rates of 50% (Paull 1992) and 70% (*I. o. nauticus*; Copley *et al.* 1990) recorded between the ages of birth and independence. Even so, the high reproductive potential and dispersal rates of Southern Brown Bandicoots should allow their successful re-establishment in suitable habitat across the Mount Lofty Ranges given favourable conditions.

Southern Brown Bandicoots have been recorded as living for 3.5 to five years (Lobert and Lee 1990, Gooch and Haby 2003). Longer survival rates can be expected in captivity (Paull 1992).

Diet

Southern Brown Bandicoots are omnivorous, consuming a wide variety of invertebrates and plant matter. Dietary items identified from studies in South Australia and Tasmania (*I. o. affinis*) have included invertebrates of the orders Arachnida (spiders and harvestmen), Acarina (mites), Isopoda (slaters), Chilopoda (centipedes), Hemiptera (bugs), Coleoptera (beetles), Oligochaeta (earthworms), Hymenoptera (bees, wasps and ants), Orthoptera (crickets), Dermaptera (earwigs), Diplopoda (millipedes), Siphonaptera (fleas), Diptera (flies) and Lepidoptera (moths and butterflies) as well as small vertebrates such as skinks (family Scincidae) and tree frogs (family Hylidae). Plant matter including grasses, hypogeous fungi, moss, clover root nodules, and various fruits and seeds from plants such as Pink Ground-berry (*Acrotriche fasciculiflora*), Blackberry (*Rubus fructicosus*), Boneseed (*Chrysanthemoides monilifera*), Flame Heath (*Astroloma conostephioides*), and African Boxthorn (*Lycium ferocissimum*) is also consumed (Heinsohn 1966, Quin 1985, Paull 1992, T. Herbert unpubl. data).

Behaviour

Southern Brown Bandicoots are predominantly solitary (Braithwaite 1995). They are known to be aggressive towards other individuals (Heinsohn 1966) with animals often having a shortened or scarred tail and rump as a result of confrontations (Claridge 1988 cited in Claridge *et al.* 2001, Thomas 1990, Reese 2000). Aggressive behaviour in captivity may lead to the death of an individual (Heinsohn 1966).

Southern Brown Bandicoots are usually recorded as being predominantly nocturnal or crepuscular with some diurnal activity (Jones 1924, Braithwaite 1995). However, a study in Victoria found individuals to be predominantly diurnal (Lobert 1992) and at Scott Creek Conservation Park, Petersen (2002) captured older animals (i.e. greater than 1.5 years of age) predominantly overnight and younger animals (<1.5 years of age) during the day.

At any one time the population of Southern Brown Bandicoots within an area may consist predominantly of transient rather than sedentary individuals (Paull 1992). The high juvenile dispersal rates that have been recorded are presumed to allow the species to exploit habitats that are patchily available in space and time (Stoddard and Braithwaite 1979, Lobert 1985, Cockburn 1990).

During the day bandicoots shelter in nests which consist of leaf litter and soil mounded into a shallow depression in the ground, sometimes with a hollow nesting chamber (Lobert 1990, Paull 1992, Braithwaite 1995, Claridge *et al.* 2001). Bandicoots have also been recorded sheltering in rabbit burrows (Paull 1992; Haby 2000).

Home range

Home range estimates for *I. obesulus* are limited. Those described vary from 0.5 to 5.3 ha, with the exception being a single study that reports ranges as high as 20 ha (Table 3). On the mainland of South Australia no accurate home range estimates have been reported. Paull (1992) collected some home range data by radiotracking four males (home range size 0.5 to 5.7 ha), but only over a two week period.

Home range size is thought to be influenced by the availability of food resources (Moloney 1982 cited in Paull 1992, Lobert and Lee 1990, Broughton and Dickman 1991) and there is some indication that individuals may readily alter the area they utilise in response to temporal changes in these resources (Broughton and Dickman 1991). The degree of home range overlap observed between individuals varies between studies from minimal overlap (between males) in Paull's short-term study (1992) to extensive overlap within and between the sexes (Lobert 1985). This has lead to varying conclusions on the territoriality of individuals (Jones 1924, Heinsohn 1966, MacKenzie 1967 cited in Lobert 1985, Lobert 1985).

Habitat requirements

Southern Brown Bandicoots occupy a range of sclerophyllous forest, woodland, scrubland and heathland communities and some grassland sites (Claridge *et al.* 1991 cited in Claridge 1993, Friend 1990, Gordon *et al.* 1990, Hocking 1990, Laidlaw and Wilson 1989, Menkhorst and Seebeck 1990, Opie *et al.* 1990). In South Australia, Paull (1992) recorded bandicoots predominantly within open forests, woodlands and tall shrublands containing the following key species: Messmate *Eucalyptus obliqua,* Pink Gum *E. fasciculosa,* Prickly Tea-tree *Leptospermum juniperinum,* Heath Tea-tree *L. myrsinoides,* Silver Banksia *Banksia marginata,* Large-leaf Bush-pea *Pultenaea daphnoides,* Bracken *Pteridium esculentum,* Pink Ground-berry, Common Flat-pea *Platylobium obtusangulum,* Yacca *Xanthorrhoea semiplana,* Wire Rapier-sedge *Lepidosperma semiteres* and Golden Wattle *Acacia pycnantha*. Thompson *et al.* (1989) recorded bandicoots predominantly in vegetation associations containing Messmate, Pink Gum, Cup Gum *E. cosmophylla,* Blackwood *A. melanoxylon,* Golden Wattle, Yacca, Beaked Hakea *Hakea rostrata, Allocasuarina* spp. and Myrtle Wattle *A. myrtifolia*.

Pivotal to their habitat choice is the presence of areas with dense ground cover (e.g. Heinsohn 1966, Paull 1992, Copley *et al.* 1990). In the Mount Lofty Ranges bandicoots were found to be less common in vegetation with less than 50 % ground cover and more abundant in vegetation with between 60 and 70 % ground cover (Paull 1992). A microhabitat investigation in Cox Scrub Conservation Park identified that different fine scale vegetation associations were preferred for different activities (Haby 2000).

Southern Brown Bandicoots preferentially forage in areas with comparatively infertile soils (Claridge and Barry 2000). Dominant soils types at sites occupied by bandicoots include well-drained sandy to sandy loam soils (Opie *et al.* 1990, Petersen 2002, Paull 2003). In Scott Creek Conservation Park, Petersen (2002) found greater evidence of bandicoot foraging on easterly, southerly and westerly aspects. Also, fewer captures were obtained at trap sites positioned on northerly aspects. However, no correlation between digging abundance and aspect was identified by Paull (1992).

Temporary nest sites have been identified in Jointed Twig-sedge *Baumea articulata,* Yellow Buttercup *Hibbertia hypericoides* (Broughton and Dickman 1991) and in rabbit burrows (Paull 1992; Haby 2000). Permanent nest sites have been located under Yaccas, Banksias, Blackberry, Bracken, Wire Rapier-sedge and in hedgerows of Gorse *Ulex europaeus* and African Boxthorn (Heinsohn 1966, Broughton and Dickman 1991, Paull 1992, N. Haby pers. obs.). In the Mount Lofty Ranges and SE South Australia, Paull (1992) found most nests under mature Yaccas *Xanthorrhoea spp*.

In cleared areas, Southern Brown Bandicoots may utilise vegetation along roadsides, watercourses and Blackberry infested drainage lines (Paull 1992). They have been recorded moving up to 350 m along vegetated roadsides as narrow as 5 m in

width but their capacity to use such narrow corridors to disperse greater distances between habitat patches is unknown (Paull 1995). In accordance with their known habitat preferences, the presence of dense vegetation, native or exotic, has been found to be a common attribute of corridors utilised by bandicoots (Paull 1995).

Distribution and abundance

In the Mount Lofty Ranges, Southern Brown Bandicoots have been known to occur from immediately north of the River Torrens, through the Adelaide Hills, and in the northern and southern Fleurieu Peninsula regions (Paull 1995) (Fig. 2). There are also subfossil records from the Yorke and Eyre Peninsulas along with several modern museum records from the Eyre Peninsula (Kemper 1990) but the species is no longer considered to occur in these areas (Paull 1995). Bandicoots have not been sighted north of the River Torrens since the 1960s, despite the Field Naturalists Society (Mammal Club) and the DEH biological survey group having undertaken surveys in this area.

In the Adelaide Hills, the Southern Brown Bandicoot distribution appears to have changed little in 15 years, with populations persisting in and around Cleland Conservation Park, Belair National Park, Mark Oliphant Conservation Park, Kenneth Stirling Conservation Park, Scott Creek Conservation Park and east of Montacute Conservation Park (Figure 2). In the northern Fleurieu, Southern Brown Bandicoots appear to be restricted to the area around Cox Scrub Conservation Park. The 1983 Ash Wednesday fires in this area seem to have caused the extinction of populations at Kyeema Conservation Park and Kuitpo Forest (Thompson *et al.* 1989). In the southern Fleurieu, the species is present in the vicinity of Myponga, Mount Billy and Deep Creek Conservation Parks. The number of bandicoot records from the Fleurieu Peninsula appears to have declined during the last 15 years, suggesting that their abundance and/or distribution may have declined in this area.

Throughout the Mount Lofty Ranges there is a bias of records towards DEH reserves, principally due to recent studies carried out therein (see Appendix 1). However, with the exception of a survey by Paull (1995), few targeted distribution surveys have been conducted for bandicoots and the existing distribution records have been collected with varying levels of accuracy. Consequently, the precise extent of the species distribution and the current status of populations is unknown. Paull's survey (1995) occurred between 1986 and 1990 and found evidence of bandicoots at 13 of 28 sites across the region. A broad-scale survey of the fauna of the southern Mount Lofty Ranges was conducted by the Biodiversity Survey and Monitoring Section of DEH in 2000 - 2001 (Armstrong *et al.* 2003). This confirmed the presence of bandicoots at 11 of 111 sites, including four sites unsurveyed by Paull (1995). However, the survey was not specifically designed to locate bandicoots and hence the survey effort is likely to have been insufficient to detect this species at all sites.

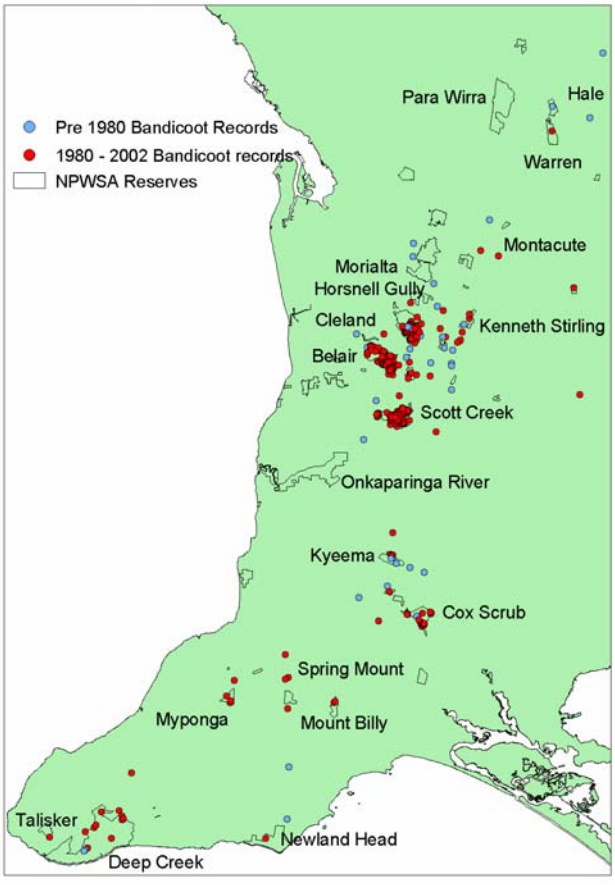

Figure 2. Historical and current distribution of Southern Brown Bandicoots in the Mount Lofty Ranges. Note that the accuracy of these records has not yet been verified.

Threats

Predation by foxes, dogs and cats

A number of species are known to prey on Southern Brown Bandicoots, including owls (Copley *et al.* 1990, Lobert 1990, Heinsohn 1966), tiger snakes (Copley *et al.* 1990, Lobert 1990), diurnal birds of prey (Lobert 1990), dogs (Heinsohn 1966, Lobert 1990, Rees and Paull 2000), foxes (Lobert 1990, Rees and Paull 2000, Coates and Wright 2003) and probably cats (Lobert 1990, Dickman 1996, Rees and Paull 2000). The nomination for listing the Southern Brown Bandicoot as a nationally threatened species (Threatened Species Scientific Committee 2001) recognised predation by foxes and cats as a significant threat to the species.

Regular (annual, biannual or seasonal) fox control currently occurs in eight parks in the Mount Lofty Ranges that contain bandicoots (Table 1). Intermittent control occurs on selected SA Water properties and in the Cudlee Creek Forestry Reserve by ForestrySA. Approximately 2860 private property owners also conducted in fox baiting in the Mount Lofty Ranges in 1999 (V. Linton, Rural Solutions SA).

Table 1: Frequency of fox baiting at DEH parks in the Mount Lofty Ranges that are known to contain Southern Brown Bandicoots (distribution records since 2000).

District / Park	*Annual baiting frequency*
Cleland	
Cleland CP	4
Kenneth Stirling CP	1/2
Sturt	
Scott Creek CP	4
Belair NP	4
Mark Oliphant CP	4
Fleurieu	
Deep Creek CP	2-3
Cox Scrub CP	1
Myponga CP	0
Mount Billy CP	Occasional (0-1)

To be effective, fox baiting programs in areas less than 10 000 ha are recommended to occur greater than four times per year (Williams 2001b). Monitoring the effectiveness of fox baiting programs is inherently difficult and costly. Consequently, there is insufficient data to determine whether or not fox control programs in the Mount Lofty Ranges are reducing fox numbers to the extent that they are benefiting native fauna. Anecdotal information however, has attributed fox baiting programs in Belair National Park, Mount Bold Reservoir Reserve and Cleland, Scott Creek and Mark Oliphant Conservation Parks to an apparent increase in bandicoot numbers in the vicinity of these parks (Armstrong 2003) and extended bandicoot longevity (Gooch and Haby 2003). In the Portland region of Victoria, fox control using bait stations spaced at 200 m apart appeared to reduce fox numbers and a corresponding increase in Southern Brown Bandicoot numbers was observed (Rees and Paull 2000).

The risk 1080 fox baits pose to Southern Brown Bandicoots is considered to be negligible. Southern Brown Bandicoots are able to excavate baits buried up to 10 cm deep and have been observed to consume up to 60% of a non-toxic Foxoff ® bait (Fairbridge *et al.* 2000). However, Southern Brown Bandicoots have a greater tolerance to 1080 than most other native mammals in eastern Australia (McIlroy 1983). LD_{50}s of approximately 7.0 mg/kg (McIlroy 1983) and 8.0 mg/kg (Twigg *et al.* 1990) have been recorded for the species meaning individuals would have to consume more than two baits containing the standard 3 mg dose of 1080 to receive a lethal dose. Fox baiting programs in the Mount Lofty Ranges require that baits are deployed at a density of 4 to 6 baits per 100 ha (DEH 2001b). Bandicoot home ranges equate to a fraction of this area and hence bandicoots are unlikely to frequently encounter baits. Even if baits cached by foxes are found at higher densities it is unlikely that an individual bandicoot would consume more than a single bait.

Domestic, stray, and feral cats are known to kill native fauna (Environment Australia 1999, Dickman 1996) and are considered to be a threat to Southern Brown Bandicoots (Lobert 1990, Rees and Paull 2000, Threatened Species Scientific Committee 2001). Although instances of cat predation on Southern Brown Bandicoots have not been reported in the literature, there are many anecdotal reports of cat predation. Predation of Eastern Barred Bandicoots and Long-nosed Bandicoot, *P. nasuta* by cats has been well documented (Brown 1989, Dufty 1994, Dickman 1996). Cats were found to be responsible for up to

45% of the juvenile mortality rate for Eastern Barred Bandicoots at Hamilton, Victoria, with lower levels of predation experienced by adult animals (Brown 1989, Dufty 1994).

Although a number of methods are available to control feral cats, the success of these methods can be variable (Environment Australia 1999) and methods such as shooting and baiting have a very limited application in semi-urban environments.

Dogs are also known to prey on Southern Brown Bandicoots (Heinsohn 1966, Lobert 1990, Rees and Paull 2000). Feral or wild dogs do not frequently occur in the Mount Lofty Ranges (R. Incoll pers. comm.) but domestic dogs are likely to pose a threat to native wildlife in the region. Bandicoot populations in the Mount Lofty Ranges exist in a relatively fragmented and urbanised environment and consequently, numbers of domestic and stray cats and dogs in the area that are potential predators of bandicoots will be high.

Summary of threats:

- Predation by foxes, cats and dogs
- Lack of broadscale predator control
- Efficacy of control programs unknown
- Inadequate control of domestic pets

Rabbits: Habitat Degradation and Control Methods

Although European Rabbits directly compete for resources with some native mammals, including Yellow-footed Rock Wallabies, Burrowing Bettongs and Bilbies (Williams *et al.* 1995), there is currently no evidence that competition with rabbits is a threat to Southern Brown Bandicoot populations. Rabbits may however contribute to the degradation of bandicoot habitat by preventing the regeneration of native vegetation. Additionally, because rabbits are the primary prey of foxes and feral cats (Williams *et al.* 1995), large rabbit populations will support large populations of predators that opportunistically prey on native fauna (Seebeck 1978, Catling 1988). In arid South Australia, Read and Bowen (2001) demonstrated that foxes and cats switched to preying more on native mammals, birds and reptiles following a decline of their primary food source, rabbits. The local fox population declined following this reduction in rabbit numbers, however, the cat population remained relatively stable as a result of more effective prey switching (Read and Bowen 2001). However, a review by Newsome *et al.* (1997) noted that there is generally little rigorous evidence of increased predation on native Australian wildlife populations following the collapse of the predator's primary prey (rabbits).

The importance of cat control in conjunction with fox control was highlighted by Copley *et al.* (1999) who reported an increase in cat numbers at Venus Bay, SA, following a decrease in fox numbers. The loss of 14 reintroduced Brush-tailed Bettongs *Bettongia penicillata* at this site was subsequently attributed to cat predation.

Several rabbit control methods may pose a risk to Southern Brown Bandicoots. Firstly, given that Southern Brown Bandicoots have been observed to utilise rabbit burrows (Paull 1992, N. Haby 2000) the destruction of these burrows to control rabbit numbers may threaten bandicoots. This technique should therefore be used with caution in bandicoot habitat.

Although 1080 fox baits pose negligible risk to bandicoots, McIlroy (1983) noted that bandicoots are theoretically capable of consuming enough 1080 poisoned rabbit bait (carrots or pellets) to receive a lethal dose. However, he concluded that their true risk would be determined by the palatability of the bait, the quantity of bait available to them in the field, and the toxicity of the bait, which will decrease over time in the environment (McIlory 1983). The Animal and Plant Control Commission calculated that Southern Brown Bandicoots would be required to consume approximately 500 oat grains in order to obtain a lethal dose and they considered this level of consumption unlikely (P. Bird, Animal and Plant Control Commission pers. comm.).

Pindone poisoned bait is frequently used in semi-urban areas to control rabbits because poisoned non-target animals (namely domestic pets) are able to be treated with an antidote. Southern Brown Bandicoots have been killed by Pindone bait in Western Australia (Twigg *et al.* 1999) and it is therefore recommended that Pindone baiting not be conducted in close proximity to bandicoot populations.

Summary of threats:

- Degradation of habitat through grazing
- Rabbit populations support fox and cat populations
- Some risk that rabbit control techniques may impact bandicoots

Habitat loss, fragmentation and isolation

The majority of the area within the Mount Lofty Ranges INRM boundary has been cleared for development and agriculture (Blason and Carruthers 2002). Of the 13.3 % of native vegetation that remains only 22.1 % is protected in DEH Reserves, Conservation Reserves, Native Forest Reserves and under Heritage Agreements (Blason and Carruthers 2002). Additionally, much of the remnant vegetation is highly fragmented with most patches (69.9 %) between 1 and 10 hectares in size and only 3.6% of patches greater than 100 hectares (Blason and Carruthers 2002). Threats within such fragmented habitats are exacerbated; habitat degradation is hastened by 'edge effects' such as increased weed invasion, feral animals are able to easily access disturbed sites and roads that bisect habitats are a source of mortality. Isolated habitat patches are also less likely to be recolonised following stochastic events and decreased gene flow between isolated populations may reduce the genetic diversity and therefore the genetic fitness of populations (Bennett 1990, Catling and Burt 1995, Burgman and Lindemayer 1998, Bennett *et al.* 2000, Jones 2000).

The minimum patch size required to sustain a viable population of Southern Brown Bandicoots is unknown, and patch size is hard to define given that even within continuous tracts of apparently suitable habitat bandicoots may not occupy the entire site (Rees and Paull 2000). Bennett (1990) found that forest fragmentation in south-western Victoria has had a severe impact on populations of Southern Brown and Long-nosed Bandicoot, with these species now sparsely distributed and predominantly confined to larger forest fragments.

Small patches of vegetation in the Mount Lofty Ranges continue to be further fragmented and isolated by land management and development practices. For example, clearance of native vegetation occurs for the construction of houses and tracks and the clearance of understorey vegetation to create and maintain fire management boundaries.

Summary of threats:

- Large proportion of extant native vegetation is fragmented and unprotected
- Habitat fragmentation exacerbates other threats
- Continued loss of native vegetation through activities such as development

Habitat degradation

Management of environmental weeds
Many environmental weeds are present in the Mount Lofty Ranges and these are degrading the floristic integrity of native vegetation communities. Weeds are targeted for control on both public and private land, but ironically, bandicoots appear to benefit from the shelter and food resources provided by some of these weed species. For example Blackberry, Gorse, Broom *Cytisus scoparius* and African Boxthorn have been used by Southern Brown Bandicoots for nest sites and shelter (Paull 1992, 1995, Heinsohn 1966) and fruits of Boneseed and Blackberry as food items (Reese 2000). Some control techniques, particularly broadscale clearance, reduce bandicoot habitat structure and therefore quality. The removal of Blackberry has been found to alter the home ranges of Southern Brown Bandicoots and the removal of *Erica* spp. is suggested to have caused a localised decline in the utilisation of an area by bandicoots (Reese 2000).

Phytophthora cinnamomi
Phytophthora cinnamomi is a soil and water borne watermould (a fungus-like organism) that causes disease and death in a variety of native plants. Consequently it has the capacity to alter the structural and floristic composition of vegetation communities (Environment Australia 2001, Weste *et al.* 2002). In 2000, dieback caused by *P. cinnamoni* was listed as a threatening process under the EPBC Act 1999. The resulting national threat abatement plan (Environment Australia 2001) recognises the capacity this watermould has to degrade the habitat of several threatened species, including *I. obesulus*, through the

Table 2: DEH reserves known to have Southern Brown Bandicoots (distribution records since 2000) and known or suspected to have *Phytophthora cinnamomi*
(P.C. site information from R. Velzeboer pers. comm.)

Park name	*PC confirmed*	*PC suspected*
Belair NP	X	
Cleland WP and CP	X	
Deep Creek CP	X	
Scott Creek CP	X	
Kenneth Stirling CP		X
Myponga CP		X
Cox Scrub CP		X
Mount Billy CP	adjacent to park only	
Mark Oliphant CP		no evidence of PC

destruction of shelter and food resources. Species of plants known to be affected by *Phytophthora* in the Mount Lofty Ranges include Yaccas, Silver Banksia, Desert Banksia *B. ornata*, Beaked Hakea, Cone-bush *Isopogon ceratophyllus*, Mt Lofty Bush-pea *Pultenaea involucrata*, Messmate and Myrtle Wattle (R. Velzeboer pers. comm.). Some plant species, particularly *Xanthorrhoea* spp., are recognised as preferred nesting sites for Southern Brown Bandicoots (Paull 1992, Broughton and Dickman 1991) and the loss of these may have a significant impact on bandicoot populations. Known bandicoot sites that are infected, or are suspected of being infected by *Phytophthora* are listed in Table 2.

Mundulla Yellows (Dieback) Syndrome
Mundulla Yellows is a term used to describe a series of symptoms expressed in a range of Australian native plant species (Williams 2001a). The expression of these symptoms is often followed by the death of the plant (Williams 2001a). Symptoms of Mundulla Yellows have been observed in the Myrtaceae family (e.g. River Red Gum *Eucalyptus camaldulensis*, Blue Gum *E. leucoxylon*, Pink Gum, *E. leptophylla*, Tasmanian Blue Gum *E. globulus*, Sugar Gum *E. cladocalyx*, Red-flowering Gum *Corymbia ficifolia, Angophora* spp. and *Melaleuca* spp.), *Acacia* spp., *Adenanthos* spp., *Hakea* spp., *Kunzea* spp., *Dampiera* spp., *Xanthorrhoea* spp. and *Allocasuarina* spp. (H. Stewart pers. comm.).

The indirect effect of Mundulla Yellows on small mammals in the Mount Lofty Ranges is unknown. However, the resulting degradation of habitat quality through the reduction in species diversity and vegetation structure may alter the patterns of habitat utilisation by bandicoots.

The cause of Mundulla Yellows has not yet been identified as abiotic or biotic in nature (Williams 2001a). Its distribution appears to be restricted to road reserves and the edges of patches of remnant vegetation (H. Stewart pers. comm.). This may impede the restoration and enhancement of habitat patches.

Grazing and soil compaction
Brown (1989) highlighted the impact of grazing pressure on soil compaction and soil invertebrates. This was considered to affect foraging patterns of Eastern Barred Bandicoots. Grazed habitat is also likely to have reduced understorey structure and diversity.

Summary of threats:

- Weed control strategies may reduce bandicoot habitat suitability
- Potential degradation of suitable habitat due to *Phytophthora cinnamomi*
- Potential degradation of suitable habitat due to Mundulla Yellows
- Loss of habitat structure, composition and potentially of invertebrate prey, due to grazing and soil compaction

Road Mortality

Roads are a cause of wildlife mortality and may act as a barrier to dispersal for some small mammal populations (Barnett *et al.* 1978). Wildlife road mortality rates have been positively

correlated with traffic volume (eg. Eastern Barred Bandicoots; Driessen *et al.* 1996) and speed (eg. Eastern Quolls and Tasmanian Devils; Jones 2000). The extensive network of relatively major roads through much of the Mount Lofty Ranges puts bandicoots in this area at a relatively high risk of road mortality.

Bandicoot distribution records indicate that road-killed bandicoots have been collected from in and around Cleland Conservation Park, Mark Oliphant Conservation Park, Belair National Park and Kenneth Stirling Conservation Park. Each of these areas is associated with a close network of major roads. At least eight road-killed bandicoots were observed from along the Summit Road between the South-east Freeway and Greenhill Rd during the first six months of 2001 (B. Gooch pers. comm.). The level of threat this poses at a population level is unknown. Adult males, that typically move over greater distances than females, and dispersing juveniles are likely to be the demographics most affected by road mortality.

Summary of threats:

- Road kill in fragmented habitat bisected by busy roads

Wildfires and Prescription Burns

Knowledge of the immediate, short and long-term impacts of fire on Southern Brown Bandicoots is incomplete. In fragmented habitats, like the Mount Lofty Ranges, there is an increased risk of localised fauna extinctions if fire burns an entire habitat patch. Additionally, habitat patches that are relatively isolated may not be able to be recolonised via dispersal from neighbouring patches. A study in the Mount Lofty Ranges found bandicoots survived the immediate impact of a relatively hot fuel reduction burn that removed most of the understorey vegetation but left a few unburnt patches (Thompson *et al.* 1989). The remaining animals continued to reside and forage in the burnt area. However, local extinctions of bandicoot populations were recorded from this same area (Kyeema Conservation Park and Kuipto Forest Reserve) following the extensive 1983 Ash Wednesday fires (Thompson *et al.* 1989). Surveys conducted between 1986 and 1990 found bandicoots in a number of other habitat patches that were burnt in the Ash Wednesday fires (Cleland, Mount Lofty, Mark Oliphant, Cox Scrub, Myponga Tiers and Deep Creek) but it is unknown if these animals survived the impact of the fires or dispersed from nearby unburnt habitat (Paull 1995).

The lack of habitat structure post-fire may indirectly impact bandicoots by increasing their exposure to exotic and native predators. During an investigation by Fox (1982) in New South Wales, fox numbers increased on a study site following fire, while Catling and Newsome (1981) found that predator numbers were relatively low immediately post-fire but increased as native vertebrate numbers began to recover.

Kruger (1983) suggested that fire frequency is determined by vegetation structure and productivity and surmises that widespread fires may occur between four and 17 years following prior burns. DEH reserves in the Mount Lofty Ranges have not been extensively burned since Ash Wednesday suggesting that they are at an increased risk of wide-spread burning. This may threaten some bandicoot populations. Fire protection actions such as the maintenance of fire breaks and the enforcement of restrictions on the use of campfires are conducted in most parks. However few parks have specific fire management plans. While reducing the risk of extensive wildfires burning entire habitat patches is important for bandicoot conservation, strategies to regularly reduce fuel loads in reserves for this purpose and for asset protection may reduce vegetation structure and therefore the short-term habitat suitability for bandicoots.

Despite the risk that fires and post-fire predation pose to bandicoots there is also some evidence that bandicoot abundance and habitat utilisation is correlated with certain successional vegetation stages. However there is little consensus within the literature on this topic. In some Victorian heathlands, Southern Brown Bandicoots have been recorded as preferring young vegetation associations (Stoddart and Braithwaite 1979, Catling and Newsome 1981, Friend 1993) whilst other studies in Victoria and New South Wales, including one (Lobert 1985) at the same site as the above listed study by Stoddart and Braithwaite (1979), have found that bandicoots prefer later successional vegetation (eg. 12-20 years old) (Lobert 1985, Claridge and Barry 2000).

Fox (1982), during an investigation of the effect of burning on small mammals, including the Northern Brown Bandicoot, *Isoodon macrourus*, highlighted the importance of mosaic burning to provide a variety of seral stages, while Short and Turner (1994) found that for Golden Bandicoots other seasonal factors have a greater influence than the spatial pattern of mosaic burns (or other disturbance).

The presence of dense vegetation appears to underlie some of this variation in habitat preference, with Southern Brown Bandicoots found to prefer those successional stages associated with dense understorey vegetation at a given site (Catling and Newsome 1981, Lobert 1985, Claridge and Barry 2000). High habitat productivity associated with some successional stages has also been a suggested explanation of bandicoot habitat preference (Stoddart and Braithwaite 1979) and this may vary between sites.

Recent research in SE South Australia on Southern Brown Bandicoots found that "fire regeneration age of sites may relate to the quality of the habitat in some of the land systems occupied by the species but not all" (Paull 2003). In this study Paull concluded that other factors including vegetation and soil type are more important than fire history when predicting the distribution of bandicoots.

Summary of threats:

- Wildfire in fragmented habitat increases the risk of local bandicoot extinctions
- Potential conflict between fire regimes required for asset protection and for bandicoot conservation
- Lack of adequate protection from increased predation following fire.
- Bandicoot habitat preferences in relation to vegetation succession is unclear.

Diseases of Southern Brown Bandicoots

While disease (Toxoplasmosis) is believed to have contributed to declines of Eastern Barred Bandicoots (Lenghaus *et al*. 1989) there is no evidence that disease is currently threatening Southern Brown Bandicoot populations. However, the effect of any new diseases or disease outbreaks on populations that are small and fragmented may lead to local extinctions.

Toxoplasmosis is a disease caused by *Toxoplasma gondii* of which cats are the primary host (Obendorf and Munday 1990). Infection of bandicoots may occur through the consumption of invertebrates containing *Toxoplasma* oocysts (Obendorf and Munday 1990). The abundance of domestic and feral cats in the Mount Lofty Ranges may increase the susceptibility of Southern Brown Bandicoots in the area to Toxoplasmosis.

Clinical signs of the disease develop in animals with lowered immune systems (perhaps as a result of environmental stressors) and may lead to the death of the individual (Obendorf and Munday 1990). In the rural area of Hamilton, Victoria, *Toxoplasma gondii* was detected in 10% of road killed Eastern Barred Bandicoots and was classified as the primary cause of death in three, and associated with the death of seven other adult bandicoots (Lenghaus *et al*. 1989). Lenghaus *et al*. (1989) also identified ectoparasites as a possible significant cause of death in four Eastern Barred Bandicoots.

Summary of threats:

- Small, fragmented populations are at an increased risk of extinction from disease outbreaks.
- Bandicoots may be at an increased risk of contracting Toxoplasmosis due to high numbers of domestic and feral cats.

Management practices

Management practices that have the greatest role to play in bandicoot conservation are fire management, fox control and appropriate weed control. The development of best-practice protocols for these activities is imperative. An integral part of this process is the establishment of periodic monitoring and review procedures. These will allow management agencies to determine whether or not the management actions are achieving their primary goals, enabling deficiencies to be addressed so that management actions and protocols can be refined and optimised. Training courses may be required to explain and demonstrate new management protocols to staff.

Existing conservation measures

A chronology of general events relating to Southern Brown Bandicoot recovery in South Australia can be found in Table 3.

No standard monitoring programs for Southern Brown Bandicoots have been established in the Mount Lofty Ranges and therefore few comparisons can be made between existing datasets. A lack of guidance in the design and technical training associated with distributional surveys has resulted in: a) the accurate recording of trap site locations, using a GPS, in only the most recent surveys (1999 and 2000), and b) the loss of data obtained from 1998 during its transfer into a Microsoft ACCESS database. This highlights the importance of providing technical support and training to all field officers and the need for an improved and simplified data storage mechanism.

A number of research projects targeting small mammals and / or Southern Brown Bandicoots have been conducted (See Appendix 1). Some general concerns have been raised about these projects including: the scale at which some projects have been conducted, their contribution to issues relating to the management of Southern Brown Bandicoots, the adequacy of project design and methodology, and the accuracy and type of data recorded.

In collating distribution records for the species, variations in the recorded accuracy of site locations has proved problematic (e.g. South Australia Museum data). Although the use of GPSs in recent years has assisted field staff in recording the precise locations of bandicoot records, the datum (AGD or GDA) used when collecting this information is frequently not recorded. Such data has an accuracy of just ± 200 m (the greatest distance of shift between grid systems).

Table 3: Chronology of Southern Brown Bandicoot events in the Mount Lofty Ranges.

Year	*Event*
1988/1989	Southern Brown Bandicoots released into Warrawong Sanctuary, Mylor
1990	Southern Brown Bandicoot listed as Vulnerable in SA under the N*ational Parks and Wildlife Act 1972* (Section 8)
1990	Southern Brown Bandicoots released into Wirra Birra Sanctuary, Ironbank
1994	Southern Brown Bandicoots released into Quenda Sanctuary
1994	Southern Brown Bandicoots released into a wildlife refuge at Cherry Gardens
1997	Meeting to discuss management strategies of Southern Brown Bandicoots throughout the Mount Lofty Ranges
April 2001	*I. o. obesulus* listed as Endangered on the EPBC Act 1999
2001	Meeting to discuss management strategies of Southern Brown Bandicoots throughout the Mount Lofty Ranges
2001	Collation of Southern Brown Bandicoot records, fire history data and fox baiting history data
2001	NPSWA Bandicoot management team formed.
2001	Nature Foundation SA bandicoot media campaign and fund raising event
2002	Establishment of a Southern Brown Bandicoot management team, preparation of a draft interim recovery plan
2002/3	Development of interpretive web site, fact sheets and brochure
2003	Nature Foundation SA bandicoot media campaign and fund raising event
2003/4	Southern Brown Bandicoot recovery project funded by INRM group.

Implementation

Parties responsible for the implementation of the actions outlined in this recovery plan are specified in Table 4. The total cost of implementing these actions is $368,700. It is anticipated that these funds will predominantly originate from State and

Federal Government grants and in kind contributions from participating organisations.

Social and economic consequences

The primary social and economic costs likely to be borne from the implementation of this recovery plan will be associated with possible increases in limitations placed on the clearance of native vegetation for housing and other developments, and on processes such as grazing of habitat. Other land management practices that will need to be conducted in a manner sympathetic to bandicoot conservation are weed control, rabbit control and fuel reduction burning in bandicoot habitat. The recovery team is mindful that restrictions placed on these practices must be practical and targeted to areas where bandicoots may be placed at threat.

A number of social and economic benefits will be gained from the successful implementation of this recovery plan. Economic gains will be made as a result of the refinement of habitat management and predator control practices which will increase the efficiency and effectiveness of these practices. From a social perspective, threatened species conservation has become of greater concern to society. The planned public education campaign will reach a broad section of the community, creating a more informed public with a greater appreciation and understanding of Australia's native fauna and of the conservation issues affecting these fauna. The recovery plan will also provide members of the community with an avenue to assist in a threatened species conservation program, giving them a sense of achievement and a vested interest in the region's environmental values. There is already a high level of community involvement in the recovery program and community members can perceive the benefits they are having to their environment and community.

Contemporary indigenous cultural values

The greater Mount Lofty Ranges forms part of the cultural landscape heritage of the Kaurna, Permangk and Ngarrindjeri Aboriginal peoples who are the traditional owners of this region. Although little is known of the interactions and mythological significance of the Southern Brown Bandicoot within traditional Aboriginal 'dreaming' and oral history, it is likely that this species was an important food source for the Kaurna and Permangk people and that it was incorporated into the social and ceremonial fabric of local Aboriginal culture and tradition. The Kaurna name for bandicoot is **Marti**.

Today, Kaurna and Permangk Aboriginal peoples are located predominantly in Adelaide and in various regional communities within the Riverland, the Yorke Peninsula and in the South-east of the State. Bandicoots, along with all other native species are important components of the cultural base for Aboriginal communities. Therefore it is expected that members of these communities, and their heritage interests, will be interested in threatened species recovery programs. This Recovery Plan will be referred to the Aboriginal Partnerships Section of DEH who will present it to local indigenous stakeholders for their information.

Biodiversity benefits

The conservation of the Southern Brown Bandicoot and its habitat is expected to have flow-on benefits for other native flora and fauna species, achieving broader conservation goals.

A number of actions within this plan will directly benefit other flora and fauna. The protection and restoration of habitat, including the retention of a complex habitat structure and an increase in habitat connectivity, will benefit a diversity of species. As will the development and implementation of road-kill mitigation measures and effective predator control programs.

Bandicoots may also play a role in maintaining the health of vegetation communities in the Mount Lofty Ranges. The hypogeal fungi bandicoots eat form symbiotic relationships with plants, increasing the nutrient uptake of these plants (eg. Malajczuk *et al.* 1987). It is thought that fungivorous animals such as bandicoots and potoroos may play an important role in the dispersal of the spores of these fungi (Malajczuk *et al.* 1987, Claridge 1993, P. Catcheside pers. comm.).

For several reasons the Southern Brown Bandicoot constitutes an excellent 'flagship species' whose profile can be used to highlight the conservation issues facing native fauna and habitats generally. The species affords a relatively high public profile simply because it is relatively rare and is one of the last remaining medium-sized native mammals in the region. From a biological perspective, the

conservation plight of the species highlights a range of broad conservation and biodiversity issues, including land clearing, habitat degradation, and the threats posed by exotic plant and animal species. The priority given to public education and involvement in this recovery plan provides opportunities to further promote the species, its conservation status, and the biodiversity issues and habitats it represents.

Fauna species of significance in South Australia known to coexist with the Southern Brown Bandicoot include:

Mount Lofty Ranges Southern Emu Wren	(Endangered)
Yellow-tailed Black-Cockatoo	(Vulnerable)
Painted Button-quail	(Vulnerable)
Shining Bronze-cuckoo	(Rare)
Peregrine Falcon	(Rare)
Bassian Thrush	(Rare)

(note that the conservation status of species within South Australia are currently under review)

An additional conservation program occurring within the Mount Lofty Ranges is the Birds for Biodiversity Program. Significant species of birds that occur in areas occupied by Southern Brown Bandicoots include the following:

Near threatened species:
Bassian Thrush

Declining species:
Painted Button-quail
Tawny Frogmouth
Scarlet Robin
Varied Sittella
White-naped Honeyeater
Brown-headed Honeyeater
Brush Bronzewing

Probably declining species:
Rufous Whistler
Yellow-faced Honeyeater
Eastern Spinebill
Tree Martin
Red-browed Finch
Common Bronzewing
White-throated Treecreeper
Yellow-tailed Black-Cockatoo
Brown Thornbill
Striated Thornbill

As the Southern Brown Bandicoot is not listed under any international agreement, the implementation of Australia's international environmental responsibilities is not affected by this plan. However, the implementation of the recovery plan will further support the principles of the following international conventions and agreements:

- 1992 United Nations Convention on Biological Diversity
- 1992 Rio Declaration on Environment and Development (Agenda 21

Table 4: Implementation and costs estimated for Southern Brown Bandicoot recovery in the Mount Lofty Ranges, South Australia

			Estimated cost ('000s)					
		Priority*	Year 1	Year 2	Year 3	Year 4	Year 5	
Implement the recovery plan through a recovery team								
1.1	Operate a recovery team for the Southern Brown Bandicoot in the Mount Lofty Ranges	1	0.5	0.5	0.5	0.5	0.5	DEH, SAW, CMA, T, FSA, COM
Increase knowledge of the distribution, abundance and ecology of Southern Brown Bandicoots in the Mount Lofty Ranges								
2.1	Conduct surveys to determine the distribution of Southern Brown Bandicoots in the Mount Lofty Ranges	1	20	5				DEH
2.2	Identify minimum data collection requirements for all survey, monitoring and research programs	1	1.8					DEH
2.3	Identify, conserve and monitor core populations of Southern Brown Bandicoots within the MLR	1		10	10	10	10	DEH, SAW, FSA,
2.4	Conduct research to determine the genetic diversity within and between Southern Brown Bandicoot populations in the Mount Lofty Ranges	2			30			DEH, T
Identify key threatening processes for the recovery of Southern Brown Bandicoots in the Mount Lofty Ranges								
3.1	Undertake research to clarify the impact of known and suspected threatening processes on Southern Brown Bandicoot populations	1		30				DEH, T
3.2	Map threats	2		1.8				DEH
Implement threat abatement strategies: Pest animal species								
4.1	Undertake research to assess the efficacy of current fox control programs	1		15	15	15		DEH, T, SAW, FSA, APCB
4.2	Advise land managers of precautions that need to be undertaken when conducting fox and rabbit control programs near bandicoot habitat	2		No funding required				DEH, APCB

4.3	Investigate the feasibility of conducting broad-scale predator control programs around core bandicoot populations	1		1	1			DEH, APCB
4.4	Undertake public education to raise awareness about responsible domestic cat and dog ownership	1		3	1	1	1	DEH, COM, CN, CAP
4.5	Implement targeted feral and stray cat and dog control programs in key areas	3		3	3	3	3	DEH, FSA, SAW, APCB, CN
Implement Threat Abatement Strategies: Habitat loss and fragmentation								
5.1	Increase protection of remnant vegetation	1		3				Recovery Team
5.2	Target areas of suitable remnant vegetation to add to the Heritage Agreement Scheme	1		0.8	0.8			DEH
5.3	Enhance habitat connectivity between populations of Southern Brown Bandicoots	2		5.5	5.5	5.5	5.5	DEH, COM, CN, FSA, SAW
5.4	Monitor the use of rehabilitated or revegetated habitat links by Southern Brown Bandicoots	2		5	5	5	5	DEH, T, COM, , FSA, SAW
Implement Threat abatement strategies: Habitat degradation								
6.1	Enhance existing habitat through targeted habitat restoration programs	2	3	3	3	3	3	DEH, COM, FSA, SAW, CN
6.2	Monitor the effect of staged weed removal and habitat restoration programs on resident Southern Brown Bandicoots	1	10.0	4.0				DEH, APCB, COM
6.3	Adopt *Phytophthora cinnamomi* hygiene guidelines at sites near Southern Brown Bandicoot populations	1	No funding required					DEH, FSA, SAW, APCB, COM, T
6.4	Support research into the identification, control and management of *Phytophthora cinnamomi*	3	No funding required					Recovery Team
6.5	Support research into the identification, control and management of Mundulla Yellows	3	No funding required					Recovery Team
Implement Threat Abatement Strategies: Road Mortality								
7.1	Investigate the need for road-kill mitigation measures and determine the efficacy and feasibility of potential mitigation measures	2		4				DEH, T
7.2	Implement and monitor road-kill mitigation measures	2			25	10		DEH, CN, TSA, T

Threat abatement strategies: Fire regimes								
8.1	Investigate the distribution and abundance of bandicoots in the Mount Lofty Ranges in relation to fire history	2	3					DEH
8.2	Develop interim fire management protocols for bandicoot habitat	1	3					DEH
8.3	Implement monitoring programs to determine the effect of fire management regimes on bandicoot populations	2		20	10	10		DEH, T
Enhance the public profile of Southern Brown Bandicoots and encourage community participation in the recovery program								
9.1	Disseminate educational information to the community on Southern Brown Bandicoot conservation	1	2	2	2	2	2	DEH, COM, CAP
9.2	Encourage community participation in local conservation programs	2	No funding required					DEH, COM, CAP
	TOTAL		**43**	**117**	**112**	**65**	**30**	**Grand Total $367,000**

*Reflects priority of the actions within the recovery program, with 1 being the highest priority.

Shaded cells indicate the suggested timeline for actions implementation.

Abbreviations: APCB: Animal and Plant Control Boards; CAP: Captive breeding or display institutes, including the Adelaide Zoo, Cleland Wildlife Park and Warrawong Sanctuary, COMM: Community Groups; FSA: ForestrySA; CN: Local Councils; DEH: Department for Environment and Heritage; SAW: SA Water, T: Tertiary institutions; TSA: Transport SA

Recovery objectives and criteria

Recovery objectives

The overall objective of this recovery plan is to:

Identify, develop and implement monitoring protocols and threat abatement actions that are necessary to:

1. Maintain or increase the current distribution of Southern Brown Bandicoots in the Mount Lofty Ranges, and;
2. Maintain or increase the current abundance of Southern Brown Bandicoots within Mount Lofty Ranges.

Recovery criteria

1. Survey, monitoring and threat abatement protocols developed and adopted by key stakeholeders.
2. Surveys indicate no reduction in the distribution of Southern Brown Bandicoots in the Mount Lofty Ranges.
3. Bandicoot abundance, or indices of abundance, at monitored sites constant or increasing.

For a comprehensive summary of the specific objectives and actions relating to these overall objectives, refer to Table 8.

Recovery Plan Actions

1 Implement the recovery plan through a recovery team

1.1 Operate a recovery team for the Southern Brown Bandicoot in the Mount Lofty Ranges

The Southern Brown Bandicoot regional recovery team will meet at least bi-annually to coordinate the implementation of actions identified in the recovery plan. The team is responsible for identifying whether performance criteria have been met and for reviewing the recovery plan during its operation and at the completion of the first five years.

Currently the recovery team comprises of representatives from the Department for Environment and Heritage, Nature Foundation SA Inc, SA Water, ForestrySA, the Field Naturalists' Society of South Australia (Mammal Club), Threatened Species Network, Adelaide University, Torrens Patawalonga Catchment Water Management Board, Mount Lofty Ranges Catchment Program, Aldgate Valley Landcare Group and Sturt Upper Reaches Landcare Group. The Department for Environment and Heritage will convene and provide executive support to the recovery team.

***Performance criteria**:* Successful operation of the recovery team over the 5 years of the recovery plan, with actions implemented and progress documented annually.

2 Increase knowledge of the distribution, abundance and ecology of Southern Brown Bandicoots in the Mount Lofty Ranges and conserve core populations

2.1 Conduct surveys to determine the distribution of Southern Brown Bandicoots in the Mount Lofty Ranges

No broad-scale distributional survey of Southern Brown Bandicoots has been conducted in the Mount Lofty Ranges since the late 1980s. As a result, the number, location and status of populations within the region is poorly known. A targeted survey is required to clarify the distribution of bandicoots in the region and allow the identification of core populations (see Action 2.2). Effective and efficient survey methods will be used to undertake the survey and bandicoot records will be entered into a database and mapped.

***Performance criteria*:** Survey of Southern Brown Bandicoots in the Mount Lofty Ranges conducted with the survey methods and results documented and bandicoot distribution mapped.

2.2 Identify minimum data collection requirements for all survey, monitoring and research programs

To increase knowledge of Southern Brown Bandicoot ecology a standard data collection protocol will be developed for live-trapping studies. This will maximise the collection of relevant, comparable, biological information across sites with minimal additional effort. The adoption of this protocol could be made a scientific permit requirement. Where necessary, DEH staff and community volunteers will be

trained on the implementation of survey and monitoring protocols.

The data collection protocol may also be used to facilitate the collection of genetic samples and information on the disease status of populations. While disease is not currently believed to be a significant threat to bandicoot populations in the Mount Lofty Ranges, standardised data collection protocols should assist in detecting any new disease outbreaks.

Wildlife databases managed by the Biological Survey and Monitoring branch of DEH will be used to store the collected data. A database manager within this branch, along with the Bandicoot Project Officer, will audit the incoming data and ensure it is consistent with the data collection protocols. The Regional Ecologist and/or the Bandicoot Project Officer will oversee the design and implementation of bandicoot surveys in the region and the subsequent collation of this data. They will also act as a community liaison for the collection of opportune records and the retrieval of distributional data. Analysis of records from this database will assist in the assessment of the second overall recovery criteria.

As an addendum to these protocols, guidelines will be written outlining the process for dealing with sick or dead bandicoots that are encountered by chance, or as a result of trapping. If the cause of sickness or death is unknown, the animal should be examined and treated by a vet, or a post-mortem should be conducted. Veterinary diagnoses should be compiled within the database and periodically reviewed by the Recovery Team to identify any new or increasing threats to populations.

***Performance criteria*:** Data collection protocol developed, documented, and adopted and data entered into a functional spatial database.

2.3 Identify, conserve and monitor core populations of Southern Brown Bandicoots within the Mount Lofty Ranges

The identification of core populations of Southern Brown Bandicoots will enable the prioritisation of recovery actions, with core populations being the primary (but not the sole) focus of recovery efforts. Long-term monitoring of these populations (or a sample of them) will be conducted to enable the status of populations to be tracked over the course of the recovery program and beyond. A standardised monitoring protocol will be developed and applied across all sites so that data between sites and time periods can be compared. The results of this action will assist in the assessment of the second overall performance criteria.

***Performance criteria*:** Core populations identified, standardised monitoring protocol developed, and long-term monitoring of these populations commenced.

2.4 Conduct research to determine the genetic diversity within and between Southern Brown Bandicoot populations in the Mount Lofty Ranges.

Populations of Southern Brown Bandicoots in the Mount Lofty Ranges are isolated from each other and from populations in other regions. This may have altered the genetic diversity within and between populations. Genetic research is required to:

1. determine the level of genetic diversity between the Mount Lofty Ranges populations and populations elsewhere in the species' range. This may have implications for the conservation and management of the subspecies at a national level.
2. determine the level of genetic diversity between populations within the Mount Lofty Ranges to identify if any populations are genetically distinct. This may have implications for the regional conservation and management of the species.
3. determine the levels of genetic exchange currently occurring between populations. This will improve knowledge of the dispersal abilities and the level of connectivity between habitat patches and will assist in prioritising the restoration or revegetation of habitat corridors.

This research will be conducted in such a way that the results are comparable with genetic research that is being, or has been, conducted on the species in other parts of its range. To assist in the collection of genetic material, samples will be collected as an adjunct to all live-trapping studies conducted in the region (as part of the data collection protocol) within the time-frame of the

genetic research (eg. see Action 2.2). Additional trapping may also need to be conducted. Arrangements will be made to store genetic material at the South Australia Museum or at a collaborating tertiary institute.

This action, or components of it, may be suitable as a postgraduate research project.

***Performance criteria*:** Estimates of the genetic variability within and between bandicoot populations in the Mount Lofty Ranges published and estimates compared with those from other regions.

3 Identify key threatening processes for the recovery of core Southern Brown Bandicoot populations in the Mount Lofty Ranges

3.1 Undertake research to clarify the impact of known and suspected threatening processes on core Southern Brown Bandicoot populations

The level of impact that each of the identified threatening processes is having on bandicoot populations in the Mount Lofty Ranges is currently unknown. To address this, research is required to determine the rates and causes of mortality in core bandicoot populations. This would be best undertaken using by fitting radio transmitters with mortality sensors to animals at a small sample of sites to track the fate of these animals over time. The findings of this research will be used to prioritise threat abatement strategies and to develop new strategies if they are required.

***Performance criteria*:** Causes and rates of bandicoot mortality at core populations identified and results published. Threat abatement strategies prioritised accordingly.

3.2 Map threats

Threats to bandicoots are likely to vary between locations. To help focus and prioritise management efforts, the threats affecting each bandicoot population will be documented for and ranked according to their perceived severity. For example road mortality is likely to be a greater threat to those bandicoot populations whose habitat is bisected by busy roads. Where it is available, data quantifying the severity of threats will be used to inform this process.

GIS mapping techniques will be utilised to identify the spatial distribution of the threats across the region. Map layers may be created for each threat so that the distribution and severity of a given threat across the landscape can be visualised.

***Performance criteria**:* Threatening processes identified and ranked for each population, with the extent and severity of these threats mapped across the region.

4 Implement threat abatement strategies: Pest animal species

4.1 Undertake research to assess the efficacy of current fox control programs

Existing fox control programs at sites containing bandicoots will be continued in an effort to protect populations. However, it is acknowledged that the benefit these fox control programs are providing to Southern Brown Bandicoots is unknown. To address this, mortality rates of bandicoots in areas with and without fox control will be compared by integrating this action with Action 3.1. If necessary, an adaptive experimental management program will be established to determine how best to optimise the efficacy of fox control programs.

As well as monitoring bandicoot mortality rates, data on population distribution, size, and demography may provide indicators of the effectiveness of fox control operations. This action may be a suitable post-graduate research project.

***Performance criteria*:** Research conducted to determine the effectiveness of existing fox control programs at reducing the threat of fox predation on Southern Brown Bandicoots.

4.2 Advise natural resource management professionals of the precautions that land managers need to be undertake when conducting fox and rabbit control programs near bandicoot habitat

Predator control programs should be conducted in conjunction with broad-scale rabbit control programs to minimise the risk of increasing predation on native prey. Equally, rabbit control should be conducted in conjunction with broad-scale predator control programs to prevent

eruptions in rabbit numbers. This is of particular concern where rabbits are likely to impact on native vegetation regeneration or revegetation programs.

Where rabbit control programs are to be conducted in or close to bandicoot habitat, precautions should be taken to minimise impacts on bandicoots. Specifically, trails of 1080 or Pindone bait should be located as far as practical from bandicoot habitat, and warrens in bushland should only be destroyed once it is established they are not occupied by bandicoots.

***Performance criteria*:** Natural resource management professionals (e.g. DEH Bush Management Advisors, Landcare officers, Animal and Plant Control Board officers, INRM project officers) advised of the precautions that land managers need to take when conducting rabbit and/or predator control programs in or around bandicoot habitat.

4.3 Investigate the feasibility of conducting broad-scale predator control programs around core bandicoot populations.

Broad-scale predator control programs are recognised as being more effective than small scale programs. Therefore, where practical, co-operative predator control initiatives involving private and public landholders should be considered in areas surrounding bandicoot populations. Fox control must be consistent with the Animal and Plant Control Board fox control procedures (APCC 2003), or any applicable DEH minor use permits or procedures.

***Performance criteria*:** The feasibility of conducting broad-scale community fox control programs investigated with programs implemented if they are deemed to be both effective and practicable.

4.4 Undertake public education to raise awareness about responsible domestic cat and dog ownership

Many pet owners are not aware of the impact their pets are having on native wildlife or of the simple measures they can adopt to reduce this impact, such as having their pets de-sexed and keeping them indoors or restrained at night. An intensive public education campaign is required to highlight this issue. Key stakeholder groups should be identified and contacted to assist in the development and implementation of this action. Suitable extension methods should be identified to implement this action, such as print and radio media, workshops, brochures and existing community publications.

Support from local councils should be sought to investigate the feasibility of introducing bylaws in areas surrounding known bandicoot populations to prevent domestic cats and dogs being allowed to roam, particularly between dusk and dawn. Incentives for desexing cats in key areas should also be investigated.

***Performance criteria*:** Threats posed to bandicoots and other native fauna by domestic and stray cats and dogs reduced through:

- increased public awareness of, and adherence to, responsible pet ownership guidelines as a result of an intensive education campaign.
- local councils having adopted measures to encourage and/or enforce responsible pet ownership.

4.5 Implement targeted feral and stray cat and dog control programs in key areas

If predation by feral cats and dogs is found to be a critical threat to Southern Brown Bandicoots, the feasibility of implementing control programs will be investigated. If effective control methods are identified these will be implemented and their success monitored and reviewed periodically.

***Performance criteria*:** Feral cat and dog control programs implemented (where practical) and monitored in areas these animals are threatening bandicoot populations.

5 Implement Threat Abatement Strategies: Habitat loss and fragmentation

5.1 Increase protection of remnant vegetation

Southern Brown Bandicoot populations are already known to occur in or near patches of remnant vegetation within the Mount Lofty Ranges. Although there is legislation protecting remnant vegetation (*Native Vegetation Act 1991)* there are also exemptions, within this legislation. The Recovery Team will discuss the adequacy of this legislation. If it is believed that, as a result of the existing exemptions, significant amounts of bandicoot habitat is being lost or further fragmented, then submissions should be made to review and amend the legislation accordingly.

Performance criteria: Review of existing remnant native vegetation legislation conducted, with submissions made, if necessary, to increase the level of protection afforded to this vegetation.

5.2 Target areas of suitable remnant vegetation for Heritage Agreement listing and conservation management activities.

Where suitable bandicoot habitat occurs on private property, landholders should be encouraged to conserve and manage this habitat for conservation purposes. If, following survey work (eg. Action 2.1), suitable bandicoot habitat is identified on private property that is adjacent or close to known bandicoot populations, the owners of this property should be notified of the significance of the habitat and advised of conservation management activities they could undertake to conserve and enhance it. These landholders should also be invited to participate in the Heritage Agreement Scheme to ensure the long-term protection of the habitat. This action provides an excellent avenue for public participation in the regional recovery program. Local natural resource management professionals should be advised of the importance of the habitat on these properties so that appropriate advise and support can be provided to the landowners.

***Performance criteria*:** Increasing number of new Heritage Agreement Scheme registrations and habitat conservation and restoration activities conducted on private land adjacent to known bandicoot populations.

5.3 Enhance habitat connectivity between Southern Brown Bandicoots populations

By examining recent bandicoot distribution records (e.g. Action 2.1), isolated habitat patches that could be feasibly linked to adjacent patches via habitat enhancement or revegetation activities should be identified. It is anticipated that increasing habitat links will enhance the dispersal capabilities of Southern Brown Bandicoots (see Action 5.4). Preference should be given to enhancing and linking existing remnant vegetation along natural landscape corridors such as drainage lines. Enhancing the connectivity between relatively close habitat patches should be prioritised over linking distant patches.

This action should be guided by the findings of Action 2.5 which will indicate the level of habitat connectivity required to facilitate bandicoot dispersal, and therefore gene flow. For example, discrete habitat patches that act as 'stepping stones' may be sufficient to allow dispersal between more distant blocks of habitat. Efforts should also be made to minimise further losses in habitat connectivity that may occur through actions such as broad-scale weed control (without associated habitat restoration).

The cooperative involvement of community conservation groups, private landowners, land management agencies, and local councils is imperative for this action to succeed. This action may also provide an avenue for local school groups to participate in Southern Brown Bandicoot conservation. Natural resource management professionals should be consulted on appropriate best practice habitat restoration techniques.

Performance criteria: Net gain in habitat connectivity through habitat restoration actions and minimisation of further habitat loss around bandicoot populations.

5.4 Monitor the use of rehabilitated or revegetated habitat links by Southern Brown Bandicoots

While bandicoots are known to utilise roadside vegetation to some extent (Rees and Paull 2000), research is required to identify the degree to which tracts of rehabilitated and revegetated habitat are able to facilitate the dispersal of bandicoots between habitat patches. Monitoring programs will be implemented to identify the distribution of bandicoots within an area prior to habitat restoration efforts aimed to 'link' habitat patches. Monitoring will continue periodically thereafter to track changes in the utilisation of these habitat links. In the longer-term, radio-tracking and further genetic studies may be used to determine if efforts to increase habitat connectivity have resulted in movement and genetic exchange between previously isolated populations.

***Performance criteria*:** Long-term monitoring programs established at habitat restoration sites that link known bandicoot populations to additional habitat.

6 Threat abatement strategies: Habitat degradation

6.1 Enhance existing habitat through targeted restoration programs

Areas of degraded bandicoot habitat that can be improved through the implementation of weed and grazing control will be identified. This will promote the regeneration of native vegetation and reduce soil compaction (through trampling by stock). Revegetation techniques may also be employed using plants propagated or seeds collected from the local area.

Habitat restoration programs will be developed in conjunction with community groups to encourage public participation and establish a sense of project ownership. Goals and benchmarks should be set against which the progress of habitat enhancement efforts can be measured. Benchmarks should be easy to identify and measure and may relate to things such as reductions in the percentage of weed cover (and corresponding increases in native vegetation cover), or increases in habitat patch size or vegetation density due to regeneration.

***Performance criteria*:** Improved habitat quality at sites identified as requiring restoration.

6.2 Monitor the effect of staged weed removal and habitat restoration programs on resident Southern Brown Bandicoots

Removal of weed species may result in the loss of shelter and food resources required by Southern Brown Bandicoots. While it is predicted that staged weed removal techniques that allow the gradual regeneration of native vegetation will minimise impacts on Southern Brown Bandicoots, this has not been investigated. To address this, standardised bandicoot monitoring programs will be established at sites employing different weed management strategies. This will allow changes in bandicoot distribution, abundance and habitat use in response to the weed control to be assessed. Resulting best-practice weed control protocols for bandicoot habitat will be documented and distributed to all relevant land management agencies and organisations. These protocols will incorporate existing best-practice weed control techniques designed to maximise native vegetation regeneration.

This action will be undertaken in conjunction with established community groups that are undertaking ongoing weed control and habitat restoration work.

***Performance criteria*:** Best-practice weed control protocols for Southern Brown Bandicoot habitat determined, documented and adopted in areas identified as providing key habitat links between bandicoot populations.

6.3 Adopt Phytophthora cinnamomi hygiene guidelines at sites near Southern Brown Bandicoot populations

Phytophthora cinnamomi is likely to degrade habitats occupied by Southern Brown Bandicoots through the destruction of select plant species, and a reduction in overall cover. Management of *P. cinnamomi* is currently restricted to preventing its spread. All personnel and community group members undertaking and supervising work in Southern Brown Bandicoot habitat should ensure they are familiar with the status of *P. cinnamomi* at that site, that they are aware of the symptoms of *P. cinnamomi*, and that they comply with the Standard Operating Procedures for *P. cinnamomi* threat management (DEH 2002).

***Performance criteria*:** *Phytophthora cinnamomi* hygiene procedures adopted by all personnel working in Southern Brown Bandicoot habitat.

6.4 Support research into the identification, control and management of Phytophthora cinnamomi.

The spread of *Phytophthora cinnamomi* may affect the distribution and abundance of Southern Brown Bandicoots. It is therefore important to support research that aims to identify affected sites and to develop methods of management and control. The Recovery Team will establish and maintain communication with relevant researchers and land-mangers, offering in-kind support where possible.

***Performance criteria*:** Co-operative links established between Southern Brown Bandicoot Recovery Team and the primary *Phytophthora cinnamomi* research and management personnel.

6.5 Support research into the identification, control and management of Mundulla Yellows

There is no evidence that habitat degradation caused by Mundella Yellows is currently affecting the distribution or abundance of Southern Brown Bandicoots. However, to minimise further habitat degradation, the Recovery Team will establish communication with researchers of Mundulla Yellows to support work investigating the cause, identification and control of this syndrome.

***Performance criteria*:** Co-operative links established between Southern Brown Bandicoot Recovery Team and the primary Mundulla Yellows research and management personnel.

7 Implement Threat Abatement Strategies: Road Mortality

7.1 Investigate the need for road-kill mitigation measures and determine the efficacy and feasibility of potential mitigation measures.

Based on local knowledge and past records, identify sites of frequent bandicoot road mortality and monitor these sites over the course of at least a year. This action may be undertaken by local community groups with data collated by DEH. If, based on the above information and that from Action 3.1, mortality rates are considered sufficient to warrant the implementation of mitigation measures, conduct a review to determine the efficacy of various techniques used at other sites in Australia and overseas (for small terrestrial fauna). Investigate the feasibility of installing effective mitigation measures at sites with high bandicoot mortality.

***Performance criteria*:** Bandicoot road-mortality 'hot spots' identified and monitored. Review of wildlife road-kill mitigation measures completed with the most effective and feasible technique/s identified.

7.2 Implement and monitor road-kill mitigation measures.

Implement mitigation measures identified in Action 7.1 at sites with high bandicoot road-mortality. This process will be conducted in association with local councils and road authorities. These sites will be monitored prior to (see Action 5.1) and after the implementation of the mitigation measures to determine the effectiveness of the measures. If mitigation measures are implemented at only a sample of the sites originally identified in Action 5.1, then sites without intervention should also continue to be monitored as control sites. Alternatively, equivalent lengths of road on either side of the mitigation site should be used as controls.

***Performance criteria*:** Road-mortality mitigation measures implemented and monitored at identified 'hotspots'.

8 Threat abatement strategies: fire regimes

8.1 Investigate the distribution and abundance of bandicoots in the Mount Lofty Ranges in relation to fire history

Suitable fire regimes have not yet been identified for the various vegetation communities in the Mount Lofty Ranges, or for the Southern Brown Bandicoots occupying them. Following the bandicoot distributional survey (Action 2.1), data should be analysed to determine if any correlation exists between the presence of bandicoots and the fire history and vegetation successional stage of the inhabited vegetation.

***Performance criteria*:** Relationships between bandicoot distribution and fire history examined and documented.

8.2 Develop interim fire management protocols for bandicoot habitat

Until sufficient information is available to determine optimal fire regimes for Southern Brown Bandicoot habitat (see Action 8.1 and 8.3), conservative habitat management protocols will be developed and implemented. These protocols will outline strategies to minimise the risk of wildfires burning entire habitat patches. They may include restrictions on the timing, size and frequency of fuel reduction burns and ensure that large areas of habitat are not rendered uninhabitable to bandicoots. Measures to maintain the structural complexity of understorey habitat, such as rolling rather than slashing vegetation to create fire breaks, may also be included.

Incorporated within these protocols will be a contingency plan for dealing with widespread

bushfire in key bandicoot habitat. This should include procedures that allow the immediate post-fire implementation of an integrated fox, cat and rabbit control program to minimise the impact of these species on any remaining bandicoots and their habitat.

***Performance criteria*:** Interim fire management protocol for bandicoot habitat in the Mount Lofty Ranges written and accepted by stakeholders.

8.3 Implement monitoring programs to determine the effect of fire management regimes on bandicoot populations

Where prescribed burns of known bandicoot habitat are deemed necessary for habitat enhancement or property protection purposes, the immediate and long-term impacts of these fires on bandicoot populations will be monitored. Sufficient planning is required to ensure that pre-fire data collected.

Due to the magnitude of this issue, potential collaboration will be sought with government and research agencies from other states that are working on addressing similar issues.

Data from this research, and from that conducted in Action 8.1, should be used to develop appropriate fire management regimes for bandicoot habitat in the Mount Lofty Ranges.

***Performance criteria*:** Responses of bandicoot populations to prescribed burns documented and used to develop best practice fire management procedures.

9 Enhance the public profile of Southern Brown Bandicoots and encourage community participation in the recovery program

9.1 Disseminate educational information to the community on Southern Brown Bandicoot conservation.

A variety of pamphlets, fact-sheets, interpretive signs and spoken presentations on Southern Brown Bandicoots in the Mount Lofty Ranges have already been developed, distributed and presented. Local media (newspapers, radio, websites) have also run stories or conveyed information about the conservation of bandicoots (eg. *Sunday Mail* Nov./Dec. 2001, Feb 2003; *Messenger* papers 2002, 2004; *The Times* 2002; Onkaparinga local paper, Feb. 2003). Along with the continuation of these activities, targeted education activities will occur to advise the community and natural resource management professionals of the threat mitigation actions and protocols identified in this recovery plan (see actions 2.2, 4.2, 4.4, 5.2, 5.3, 6.1, 6,2, 6,3, 7.1 and 8.2). The DEH website will also be updated periodically to provide the community with information on newly developed threat mitigation and accepted best-practice protocols.

***Performance criteria*:** On-going dissemination of educational material to a broad section of the community with targeted information provided to groups or individuals likely to assist in the adoption of threat mitigation actions and protocols identified above.

9.2 Encourage community participation in local conservation programs

Community participation in conservation based programs creates the opportunity to enhance the community's understanding and appreciation of conservation programs and native wildlife. The success of other actions identified in the recovery plan may also be enhanced through community participation and support. Invitations for community involvement in recovery actions could be made through the media, community projects, and by directly approaching local residents or community groups.

Action 9.1 identifies a number of actions from the recovery plan in which community involvement is anticipated. The following community projects would also directly benefit the Southern Brown Bandicoot recovery program.

- Establish a freecall number for bandicoot sightings (including road kills)
- Establish suitable bandicoot monitoring programs that may be conducted by community groups. These are likely to include the use of standardised, non-invasive monitoring protocols to track changes in bandicoot distribution or abundance in response to management actions.
- Training provided to enable community groups to conduct monitoring programs.
- Provide support and advise to community groups and natural resource management

professionals to assist with habitat restoration works. Many community groups have already commenced weeding and revegetation programs to assist with habitat recovery and regeneration. It is hoped that such programs will increase habitat quality and connectivity.

***Performance criteria*:** New community conservation initiatives implemented, and established initiatives with on-going agency support provided.

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Appendix – Summary biological information

Table 1: Average male and female weights and standard error (where available) from studies conducted within the Mount Lofty Ranges.

	Average Weight (g)		
Location	**Male**	**Female**	**Source**
Belair NP	927.9 ± 15.3	612.0 ± 11.3	DEH
Cleland CP	793.5 ± 11.7	626.2 ± 16.2	DEH
Cox Scrub CP	623.0 ± 42.9	458.1 ± 22.8	Haby 2000
Scott Creek CP	747.4 ± 59.9	525.8 ± 20.2	Petersen 2002
Mt Lofty Ranges	927.7 ± 55.9	578.3 ± 6.9	Paull 1992

Table 2: Breeding season of the Southern Brown Bandicoot.

Subspecies	State/Location	Breeding season	Source
I. o. obesulus	SA – Mt Lofty Ranges	June to December (predominantly)	Paull 1992
	SA – Cleland CP	June to September	DEH database
	SA – Belair NP	continuously	Reese 2000 and Kovac 2002
	VIC	July to December	Lobert and Lee 1990
	VIC	July to December	Stoddart and Braithwaite 1979
I. o. nauticus	SA – Franklin Islands	continuously (peak spring)	Copley *et al.* 1990
I. o. fusciventer	WA	July to September	Thomas 1990
I. o. affinis	TAS	August to February	Heinsohn 1966

Table 3: Recorded home range sizes of Southern Brown Bandicoots

Standard errors are shown where available. F = fluorescent pigment tracking, RT = radio telemetry, S = Spool and line tracking, T = trapping.

Subspecies	*State*	*Male (ha) mean ± se*	*Female (ha) mean ± se*	*Method*	*Source*	*Original reference*
I. o. obesulus	SA, Scott Ck CP	3.0	None studied	RT		Paull 1992
	VIC	2.2	2.2	Not stated	Paull 1992	McKenzie 1967
	VIC	1.6	1.1[1]	RT[2]		Lobert 1990
	VIC	0.9	1.1[1]	T[2]		Lobert 1990
I. o. nauticus	SA, Franklin Is.	2.2 ± 0.2	1.6 ± 0.2	T		Copley *et al.* 1990
I. o. fusciventer	WA	2.34 ± 1.89	1.8 ± 1.4	T , S & F		Broughton and Dickman 1991
	WA	19.9	1.8	Not stated	Paull 1992	Sampson 1971
I. o. affinis	TAS	0.5	0.4	Not stated	Paull 1992	Buchmann (unpub.)
	TAS	5.3	2.3	T		Heinsohn 1966
	TAS	1.2 ± 0.4	0.6 ± 0.1	T	Paull 1992	Maloney 1982

[1] This is the home range size of a single female

[2] This study compared home range estimates from the same bandicoots (3 males and 1 female) using different techniques - trapping and radiotracking. Trapping was generally found to underestimate home range size particularly if one or more of the animal's nests were near the edge or off the trapping grid (Lobert 1990). This should be taken into consideration when interpreting trap-derived home range estimates from other studies.

Table 4: Data sources used for the overview of projects and the illustration of the historical and current distribution of Southern Brown Bandicoots in the Mount Lofty Ranges.

HT = Hair Tube Survey, SS = Sign Survey, TS = Trapping Survey, SLT = Spool Line Tracking, C = Cage, SC = Small Cage, NC = Nested Cage, El = Elliott, All = all data available to enter into database, SC = only successful Southern Brown Bandicoot captures available to enter into database, SD = select data has been entered into the database (ie only trap locations).

	Date	Parks Investigated	Method	Trap Types	Data Available	*Accuracy*
Undergraduate Student Projects (9)						
Fuhlbohm and Parkin	1995	Belair NP	TS	C?	SC	± 200 m
Regel *et al.*	1995	Belair NP	TS	C	All	± 250 m
Gibbons	1996	Belair NP	TS	C	All	± 200 m
Fisher *et al.*	1997	Belair NP	HT, TS	C, SC, El	SC	± 200 m
Bellamy *et al.*	1998	Belair NP	TS	C	SC	± 200 m
Bellamy and Bellamy	1999	Belair NP	TS	C	SD	± 200 m *
Bellamy and Bellamy	1999	Brownhill Creek CP	TS	C	SD	± 200 m *
Dunstan	1995	Cleland CP	TS	C	SC	± 200 m
Gaans	1996	Scott Creek CP	TS	C, El	SC	± 200 m
Honours Projects (5)						
Richardson	1999	Belair NP	TS	C, NC, El	All	± 200 m
Reese	2000	Belair NP	TS	C	SC	± 200 m
Haby	2000	Cox Scrub CP	SLT, TS	C, El	All	± 100 m
Alessio	2000	Scott Creek CP	TS	C	SC	± 200 m
Petersen	2000	Scott Creek CP	TS, SS	C, El	All	± GPS error
Masters Projects (1)						
David Paull (excl. SAM and FNS records)	1995		SS, TS	C, El	SC	50 – 250 m
Green Corps (1)	1998	Belair NP	TS	C	SC	< 200 m
Mammal Club Surveys (FNS) (330)	1967-2000	Various	TS, SS		All	not assigned
South Australian Museum (SAM)	1890-	Various				
DEH (1)						
Gooch	1995-2000	Cleland CP	TS	C	All[#]	± 100 m
DEH - Biological Surveys	2000-2001	Various	TS, SS, HT	C, El	All	± 100 m
DEH Databases						
Opportune		Various	na	na		
Reserves		Various	na	na		

*entered by J. Kraehenbuehl 2001.
[#]for data with a location provided (1999, 2000)