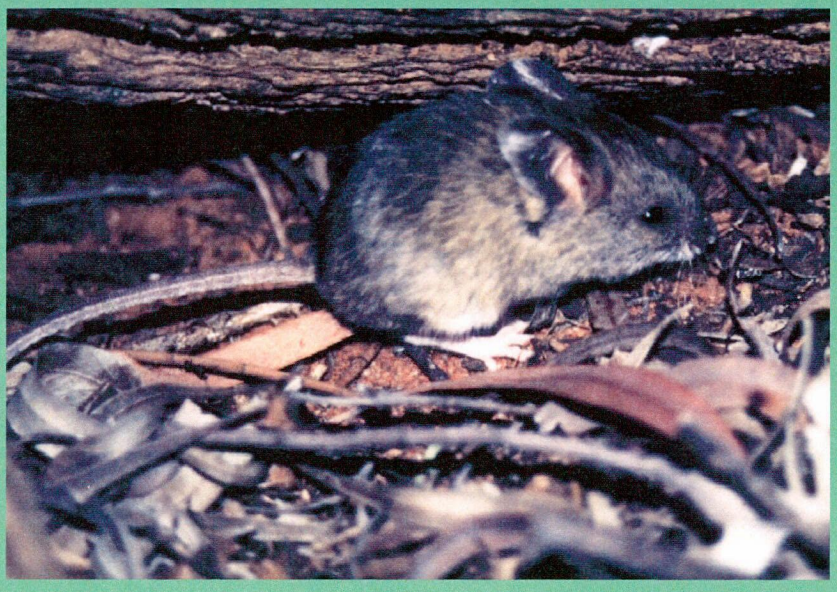
Approved Recovery Plan

Bolam's Mouse (*Pseudomys bolami*) Recovery Plan



July 2002

NSW
NATIONAL
PARKS AND
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SERVICE

NSW National Parks and Wildlife Service
43 Bridge Street
(PO Box 1967)
Hurstville NSW 2220
Tel: 02 95856444
www.npws.nsw.gov.au

For further information contact
Threatened Species Unit, Western Directorate.
NSW National Parks and Wildlife Service
P.O. Box 2111
Dubbo NSW 2830
Tel 02 6883 5358

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NSW National Parks and Wildlife Service Recovery Planning Program

Bolam's Mouse (*Pseudomys bolami*) Recovery Plan

Prepared in accordance with the New South Wales *Threatened Species Conservation Act* 1995

July 2002

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Foreword

The conservation of threatened species, populations and ecological communities is crucial for the maintenance of this State's unique biodiversity. In NSW, the *Threatened Species Conservation Act* 1995 (TSC Act) provides the framework to conserve and recover threatened species, populations and ecological communities through the preparation and implementation of recovery plans.

The preparation and implementation of recovery plans is identified by both the National Strategy for the Conservation of Australia's Biological Diversity and the approved NSW Biodiversity Strategy as a key strategy for the conservation of threatened flora, fauna and invertebrates. The object of a recovery plan is to document the research and management actions required to promote the recovery of a threatened species, population or ecological community and to ensure its ongoing viability in nature.

This plan describes our current understanding of the Bolam's Mouse, documents the research and management actions undertaken to date and identifies the actions required and parties responsible to ensure ongoing viability of the species in the wild.

NSW National Parks and Wildlife Service has prepared the Bolam's Mouse Recovery Plan with the assistance of a number of people. I thank these people for their efforts to date and look forward to their continued contribution to the recovery of the species.

BOB DEBUS MP
Minister for the Environment

Executive Summary

Legislative Context

The *Threatened Species Conservation Act* 1995 (TSC Act) is NSW's most comprehensive attempt at establishing a legislative framework to protect and encourage the recovery of threatened species, populations and communities. Under the TSC Act, the Director-General of National Parks and Wildlife has certain responsibilities including the preparation of recovery plans for threatened species, populations and ecological communities. This recovery plan has been prepared in accordance with the provisions of the TSC Act.

Preparation of Plan

This recovery plan has been prepared with the assistance of interested parties with relevant expertise. Components within the plan do not necessarily represent the views nor the official positions of all the individuals or agencies consulted. The information in this recovery plan was accurate to the best of the NPWS' knowledge on the date it was approved.

Current Species Status

The present distribution of *Pseudomys bolami* (Bolam's Mouse) is restricted and includes arid and semi-arid areas of southern and western Australia (Kitchener *et al,* 1984; Ayers *et al.,* 1996; Moseby and Read, 1998). In NSW, it is now known only from the extreme south-west, and the species was probably always marginal in western NSW (Dickman, 1994).

A number of authors contend that the species has declined in distribution. It was abundant in the Murray-Darling junction area in the 19th century (Wakefield, 1966). One individual was recently trapped near Mungo National Park (M. LeBreton, pers. comm.), however previous surveys along the Murray River and adjacent National Parks failed to locate any specimens (Simpson, 1973; Tidemann, 1988). Bennett *et al.* (1989) state that *P. bolami* has disappeared from the Sunset region of South Australia and Victoria, and subfossil evidence exists of a once wider distribution in South Australia (Robinson *et al.,* 2000) and NSW (Atlas of NSW Wildlife, 2000).

P. bolami is listed as an endangered species on Schedule 1 of the *Threatened Species Conservation Act* 1995, and is presumed extinct in Victoria (Stanger *et al.,* 1998). The species is not currently listed on the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 or in the IUCN (1994) Red List of Threatened Species. Dickman (1993; 1994) lists its status as rare and states that the species is of national conservation significance.

Recovery Objectives

The overall objective of this recovery plan is to identify and secure extant populations of *P. bolami.* This will increase the likelihood of an improvement in the species' conservation status in the long term.

Specific objectives are to:

1. locate extant populations or potential habitat of *P. bolami*;
2. monitor the known populations to identify trends;
3. protect known populations, and any populations discovered in the future, from the major threatening processes of habitat destruction and feral animals;
4. achieve a greater understanding of the biology of *P. bolami*, particularly with regard to its ability to compete with the introduced House Mouse (*Mus domesticus*);
5. inform relevant stakeholders and involve them in the recovery process where appropriate.

Recovery Performance Criteria

Recovery performance criteria for *Pseudomys bolami* are that:

1. monitoring of the population in Tarawi NR, Mallee Cliffs and Mungo NP continues. Selected populations located in the future are monitored in line with Tarawi NR, Mallee Cliffs and Mungo NP;
2. targeted surveys within the species' former range are completed;
3. populations of *P. bolami* remain stable or increase in numbers;
4. a measurable reduction in the abundance of feral animals is maintained in Tarawi NR, Mallee Cliffs and Mungo NP and surrounding area;
5. relevant and interested stakeholders are aware of the species and its conservation through their involvement in recovery actions.

Recovery Actions

Recovery actions will be to:

1. identify and survey habitat for new extant populations of the species;
2. monitor the population of *P. bolami* at Tarawi NR and Mungo NP;

3. maintain an ongoing program of feral animal management;

4. maintain an appropriate fire regime;

5. involve and inform relevant and interested stakeholders.

Biodiversity Benefits

Of the seventeen native rodents which have been recorded from arid NSW, eleven are regionally extinct, three (including *P. bolami*) are rare, two are sparse and one is common in limited habitat (Dickman, 1993). It is clear from such figures that the diversity of rodents in arid NSW has been severely reduced. In view of this, the biodiversity value of the remaining taxa, including *P. bolami*, is considerable.

As well as aiding the recovery of Bolam's Mouse, the actions in this recovery plan will have benefits for biodiversity in general. Actions such as control of feral animals and application and monitoring of appropriate fire regimes have benefits for a host of native species (Dickman, 1993; Willson, 1999). Similarly, surveys and ongoing monitoring aimed at *P. bolami* will yield data which will be useful in the management of other native species.

Other threatened species which utilise similar habitat to that of *P. bolami*, and will benefit from the actions contained in this recovery plan include the Western Pygmy Possum (*Cercartetus concinnus*), Southern Ningaui (*Ningaui yvonneae*), Little Pied Bat (*Chalinolobus picatus*), Greater Long-eared Bat (*Nyctophilus timoriensis*), Inland Forest Bat (*Vespadelus baverstocki*), Mallee Worm-lizard (*Aprasia inaurita*), Western Blue-tongued Lizard (*Tiliqua occipitalis*), Bardick (*Echiopsis curta*), Malleefowl (*Leipoa ocellata*), Bush Stone-curlew (*Burhinus grallarius*), Pink Cockatoo (*Cacatua leadbetteri*), Shy Hylacola (*Hylacola cauta*), Purple-gaped Honeyeater (*Lichenostomus cratitius*), Pied Honeyeater (*Certhionyx variegatus*), Southern Scrub-robin (*Drymodes brunneopygia*), Chestnut Quail-thrush (*Cinclosoma castanotus*) and Gilbert's Whistler (*Pachycephala inornata*).

BRIAN GILLIGAN
Director-General

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1 Current Conservation Status

Bolam's Mouse (*Pseudomys bolami*) is listed as an endangered species on Schedule 1 of the *Threatened Species Conservation Act* 1995 (TSC Act), and is presumed extinct in Victoria (Stanger *et al.,* 1998). The species is not currently listed on the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) or in the IUCN (1994) Red List of Threatened Species. Dickman (1993; 1994) lists its status as rare and states that the species is of national conservation significance (as defined by a range of less than 100,000km^2, or rare or very sparse distribution throughout range).

The species has declined in some areas of its former distribution, including the Murray-Darling junction area of south-western NSW and adjacent areas of South Australia (Dickman, 1993).

2 Description

2.1 Taxonomy

Scientific Nomenclature:	*Pseudomys bolami* Troughton, 1932
Family:	Muridae
Common Name:	Bolam's Mouse
Recent Synonyms:	Sandy Inland Mouse
	Pseudomys hermannsburgensis bolami

Bolam's Mouse was first described by Troughton (1932b) as *Pseudomys hermannsburgensis bolami*. Based on electrophoretic and external, cranial and dental morphometric characters, Kitchener *et al.* (1984) re-described *P. bolami* as a separate species. Despite their similar outward appearance, *P. bolami* and *P. hermannsburgensis* differ substantially under electrophoretic analysis (approximately 30% difference for the proteins analysed) (Kitchener *et al.,* 1984).

2.2 General

Pseudomys bolami is a nocturnal, burrowing rodent similar in appearance to *P. hermannsburgensis*. The fur is a dull umber-brown to olive-brown with dark tips above, and white below (Dickman, 1993). *P. bolami* may be distinguished from *P. hermannsburgensis* by its larger ears and hind feet, longer, more heavily furred tail (Kitchener *et al.,* 1984), and by its darker, duller fur (Dickman, 1993). *P. bolami* is also similar in appearance to the House Mouse (*Mus domesticus*) but may be distinguished by its more prominent eyes, relatively longer ears and tail, lack of a musty odour and generally more slender appearance (Dickman, 1993). *P. bolami* also lacks the notched upper incisors which are characteristic of the House Mouse (Watts, 1995).

Adult males weigh 10-12g. Non-pregnant females weigh 9-12g and pregnant females 12-17g (Moseby and Read, 1998). Dickman (1993) reports that individuals may weigh up to 21g. Head and body length is 57-77mm and tail length 79-96mm (Dickman, 1993).

3 Distribution

The present distribution of *P. bolami* is restricted and includes arid and semi-arid areas of southern and western Australia (Kitchener *et al,* 1984; Ayers *et al.,* 1996; Moseby and Read, 1998). In NSW, it is known only from the far south-west and the species was probably always marginal in western NSW (Dickman, 1994). *P. bolami* is generally found further south than *P. hermannsburgensis*, although some overlap of the ranges does occur (Moseby and Read, 1998). Figure 1 shows the distribution of *Pseudomys bolami* in NSW.

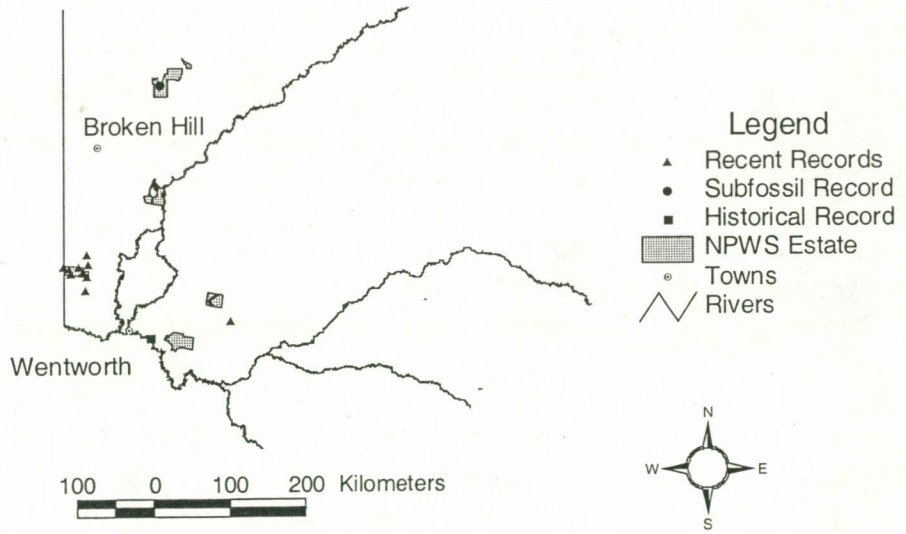

Figure 1: The distribution of *Pseudomys bolami* in NSW.

The majority of recent records of *P. bolami* in NSW are from Tarawi Nature Reserve, which adjoins the South Australian border approximately 150km north-west of Wentworth (Atlas of NSW Wildlife, 2000). The species has also been recorded on the nearby Nanya Station (M.E. Westbrooke, pers. comm.), Huntingfield Station (M. LeBreton, pers. comm.) and Scotia Sanctuary – a neighbouring reserve managed by Earth Sanctuaries Ltd. (G. Martin, A. Willson, pers. comm.). A single specimen was recently trapped on a property adjacent to Mungo National Park (M. LeBreton, pers. comm.). *P. bolami* has also been recorded in Danggali Conservation Reserve and surrounding properties in South Australia which adjoin Tarawi Nature Reserve and Scotia Sanctuary to the west (Forward, 1996).

A number of authors contend that the species has declined in distribution. It was once abundant in the Murray-Darling junction area, forty-six specimens having

been collected between 1856 and 1857 (Wakefield, 1966). The recent capture near Mungo National Park confirms the persistence of the species in this area. However, previous surveys along the Murray River and adjacent National Parks failed to locate any specimens (Simpson, 1973; Tidemann, 1988). Bennett *et al.* (1989) state that *P. bolami* has disappeared from the Sunset region of South Australia and Victoria, and Robinson *et al.* (2000) report subfossil evidence of a once wider distribution in South Australia. Subfossil remains have also been found in Mutawintji National Park in the north-west of NSW (Atlas of NSW Wildlife, 2000). *P. bolami* has not been recorded in Mungo or Mallee Cliffs National Parks despite apparently suitable habitat (Simpson 1973, Tidemann 1988, A. Parson pers. comm. in Dickman 1993).

4 Ecology

4.1 Life cycle

Breeding of *P. bolami* has been recorded in all seasons. However, juveniles were recorded more frequently in winter and spring (Moseby and Read, 1998). This coincides with the flowering of plants such as *Maireana astrotricha* and it is thought that the seeds of these plants may provide a food source which facilitates breeding (Moseby and Read, 1998). Fewer plants flower in late summer, and this may lead to a reduction in food availability. *P. bolami* may only be able to extend its breeding period into late summer and autumn when high rainfall has produced more abundant resources (Moseby and Read, 1998).

There is also evidence of opportunistic breeding at times of the year other than spring and summer following periods of high rainfall (Dickman, 1993). However, the time lag from rainfall to an irruption may not be uniform as the preference for spring and summer breeding adds a further complication (Moseby and Read, 1998).

Seasonal breeding is well suited to moderately moist or mesic areas where resource availability is relatively predictable and there are reliable winter rains (Breed, 1990). Conversely, opportunistic breeding is suited to the arid zone where resource availability and rainfall are unpredictable (Morton, 1990). The distribution of *P. bolami* at the southern edge of the arid zone may have led to selection for a combination of these two strategies (Moseby and Read, 1998).

Two pregnant females dissected by Moseby and Read (1998) each had four foetuses in the uteri, and Bennett *et al.* (1989) state that the maximum litter size is six. Little has been published on the development of *P. bolami* juveniles, however, Moseby and Read (1998) consider that reproductive maturity is reached at a body mass of 9g. The smallest independent individual trapped in their study weighed 5g. Moseby and Read (1998) estimate that longevity may be as low as two years.

Individuals are highly mobile and movements over linear distances of up to 334m have been recorded in a few hours. Animals released in swales moved to burrows or

shelters on dunes. Animals that were followed travelled relatively long distances to shelter with a directness that suggested intentional choice of destination. Males have been recorded moving greater distances than females and this may account for a 3:1 male bias in capture rate (Moseby and Read, 1998). High mobility may be important in utilising patchy resources in an unpredictable environment (Moseby and Read, 1998). Individuals were recaptured within a trapping period but rarely in successive trapping periods, suggesting short-term residency, high transience or high mortality (Moseby and Read, 1998).

During a study period of six years an elevenfold fluctuation in numbers of *P. bolami* was observed at Roxby Downs in northern South Australia. Numbers began to increase six months after a high rainfall event and peaked after twelve months. The population was observed to peak after above-average rainfall that followed two consecutive years of low rainfall (Moseby and Read, 1998). This supports the suggestion of Southgate and Masters (1996) that high rodent numbers will occur when significant rains follow two consecutive years where rainfall is less than 85% of the long term average. The population at Roxby Downs remained high for the following two years, peaking each spring. The persistence of the Roxby Downs population was high, with animals being present even in dry years (Moseby and Read, 1998).

4.2 Diet

Dietary samples were taken by Moseby and Read (1998) from twelve individuals near Roxby Downs. Items found in the diet included invertebrates such as beetles and spiders, plant material and seeds. Some scats also contained skink scales. The species shows an apparent preference for the seeds of *Maireana astrotricha* and one individual was observed eating fifteen or more of these seeds while foraging under a single bush. *M. astrotricha* cover was positively correlated with trap success, while *Atriplex vesicaria* cover was not. This suggests that *M. astrotricha* is an important source of food as well as shelter (Moseby and Read, 1998).

Murray *et al.*, 1999 analysed faecal pellets from nine *P. bolami* and scored the contents by frequency of occurrence. The pellets contained approximately 53% seed, 34% plant material (stem, leaf, root and flowers), 12% invertebrates and 1% fungus. Bennett *et al.* (1989) state that the diet comprises seeds, fruits, blossoms, grass and herbs.

4.3 Habitat

P. bolami is found in a variety of arid and semi-arid habitats, frequently associated with Mallee, particularly on sandy or loamy soils (Moseby and Read, 1998). In NSW it has been recorded in Mallee-spinifex, Mallee-shrubland, Belah woodland, mixed open shrubland/woodland and Wilga woodland (Willson, 1999; D. Ayers, pers. comm.; M. LeBreton, pers. comm.; B. Roberts, M.E. Westbrooke, pers. comm. in Dickman 1993).

The four broad vegetation classes listed by Willson (1999) are from Tarawi Nature Reserve in south-western NSW. Detailed descriptions of these are as follows:

Mallee-spinifex: Tall Mallee shrubland, dominated by *Eucalyptus socialis* and *E. dumosa*, with an understorey characterised by Spinifex (*Triodia scariosa*). Shrub layer species include *Beyeria opaca*, *Acacia* spp. and *Olearia* spp. Also present in patches are Mallee Cypress Pine (*Callitris verrucosa*) and Desert Poplar (*Codonocarpus cotinifolius*). In swales, where the texture of the soil is heavier, shrub species such as *Acacia colletoides, Senna* and *Eremophila* species and Hopbush (*Dodonaea viscosa angustissima*) occur in place of Spinifex. Belah (*Casuarina cristata*) also occurs in the larger swales (Willson, 1999).

Mallee-shrubland: This community occurs in large red sandy plains, and consists of tall Mallee shrubland with the overstorey dominated by *Eucalyptus socialis* and *E. gracilis*. The understorey of mixed scrub comprises mainly perennial shrubs, including *Acacia, Olearia* and *Pimelia* species, *Grevillea heugelii* and *Beyeria opaca*, as well as herbs (*Zygophyllum* spp.) and various chenopods (Willson, 1999).

Belah woodland: Occurs on brown calcareous soils of heavy texture, often associated with Rosewood (*Alectryon oliefolius*). The understorey is varied, and may contain a variety of chenopods, herbs and shrubs, or may be sparse with little diversity. Structure may vary from dense to very open (Willson, 1999).

Mixed open shrubland/woodland: This community occurs in broad areas on calcareous clay soil, and has an overstorey comprising Belah or Mallee trees. Patches of other trees such as Wilga (*Geijera parviflora*) may also occur. Open patches of Pearl Bluebush (*Maireana sedifolia*) and Black Bluebush (*Maireana pyramidata*) are present, and the ground layer is very sparse or absent. In areas near water holes, where grazing pressure has been high, patches of Hopbush and *Eremophila* spp. are present (Willson, 1999).

In Western Australia, the habitat has been described as Mallee areas, particularly plains with loams on clay. (Kitchener *et al.,* 1984). In the Western Australian goldfields, *P. bolami* was found in low areas such as the bottoms of valleys, spillways and saltpans with alkaline, calcareous soils supporting succulent chenopod shrubs (Kitchener *et al.,* 1984). On the plains, the habitat ranged from low woodland to open low woodland, characterised by *Eucalyptus* on gravelly soils or loam on clay. There was often an understorey of Mallee and a sparse shrub layer including *Acacia hemiteles, Eremophila decipiens, Exocarpos aphyllus, Santalum acuminatum* and *Scaevola spinescens* (Kitchener *et al.*, 1984). One site situated in a low valley was only lightly wooded and lacked both eucalypts and *Triodia*. This site was dominated by Bluebush (*Maireana sedifolia*) and the ephemerals *Helipterum tenellum* and *Angianthus tomentosus* were prominent (Kitchener *et al.,* 1984). Other low-lying sites support a greater richness of chenopods which, in addition to

Bluebush, include *Haloscaria undulata, H. halocnemoides, Atriplex vesicaria, Rhagodia drummondi* and *Sclerolaena diacantha* (Kitchener *et al.*, 1984).

Bennett *et al* (1989) write that the species is found in tall Mallee shrubland with an understorey of shrubs (e.g. *Acacia, Beyeria, Casia* and *Eremophila*) or hummock grass (*Triodia*) as well as *Casuarina* woodland. Dickman (1993) also states that it is associated with chenopod shrubs such as Bluebush and Saltbush. This is supported by Boscacci *et al.* (1987) who recorded *P. bolami* in chenopod shrubland on heavy, poorly drained soils.

Near Roxby Downs, *P. bolami* is found in an area of orange sand dunes with vegetation characterised by *Acacia* and *Dodonaea* and swales with chenopod shrubs, Bladder Saltbush and Low Bluebush. Individuals show a preference for areas of dense vegetation cover and appear to favour *M. astrotricha* in particular. The animals move quickly from one bush to the next and small, open areas of gibber are avoided. Shelter is also provided by disused goanna burrows (often under dead shrubs), abandoned rabbit warrens, or fallen *Acacia* or *Dodonaea* shrubs. The animals appear to shelter on dunes but forage in swales and this mixed habitat may be important in determining the distribution of the species (Moseby and Read, 1998).

5 Relevant Legislation

5.1 *Threatened Species Conservation Act* 1995

P. bolami is listed on Schedule 1 of the *Threatened Species Conservation Act* (TSC Act) as an Endangered species. It is an offence to harm, pick or damage the habitat of a threatened species unless the damage is the result of activities which have been licensed under section 91 of the TSC Act, or have otherwise gained approval under the *Environmental Planning and Assessment Act* 1979.

5.2 *Environment Protection and Biodiversity Conservation Act* 1999

P. bolami is not listed in the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act). The EPBC Act protects threatened species in Commonwealth areas and regulates the activities of Commonwealth agencies.

5.3 *National Parks and Wildlife Act* 1974

P. bolami has been recorded in Tarawi Nature Reserve, an area gazetted under the *National Parks and Wildlife Act* 1974 (NPWS Act) and in the care and management of the NSW National Parks and Wildlife Service.

5.4 *Environmental Planning and Assessment Act* 1979

Land use and development on leasehold land in NSW is subject to evaluation in accordance with the *Environmental Planning and Assessment Act* 1979 (EP&A Act). Threatened species are to be taken into account by consent authorities when they are considering development applications under Part 4, and by determining authorities undertaking or approving activities under Part 5 of the Act. Under the *Western Lands Act* 1901 the Department of Land and Water Conservation is the determining authority for activities on Western Lands leases which invokes the *Environmental Planning and Assessment Act* 1979.

5.5 *Native Vegetation Conservation Act* 1998

The clearing of vegetation in NSW is subject to consent from the Department of Land and Water Conservation in accordance with the *Native Vegetation Conservation Act* 1998. The Act is integrated with the *Environmental Planning and Assessment Act* 1979, and requires that threatened species are taken into account by the consent authority when considering clearing applications under Part 4 of the EP&A Act.

6 Management Issues

6.1 Threats and reasons for decline

Chenopod shrublands in the southern arid zone have been severely affected by cattle and sheep grazing. Reduction in perennial shrub cover may have severely affected populations of *P. bolami* by reducing the range or by forcing changed use of habitat (Moseby and Read, 1998). This is in agreement with Dickman (1993), Dickman *et al.* (1993) and Ayers *et al.* (1996), all of whom point to habitat damage by stock as a threat to the species. As well as causing reductions in shelter and food, grazing can lead to compaction of the soil, making burrowing difficult or impossible (Dickman, 1993).

Dickman (1993) and Ayers *et al.* (1996) add that reduction in cover may increase the vulnerability of *P. bolami* to predation by foxes (*Vulpes vulpes*) and feral cats (*Felis catus*). In addition, clearing for agriculture may lead to habitat fragmentation, preventing movement of individuals between areas (Dickman, 1993; Ayers *et al.*, 1996). Rabbits (*Oryctolagus cuniculus*) are also likely to have contributed to damage of habitat (Dickman, 1993). Competition from the introduced House Mouse (*Mus domesticus*) may dampen irruptions of *P. bolami* following high rainfall. However, such competition is unlikely to be important during dry periods, when House Mice are generally absent (Moseby and Read, 1998). Inappropriate fire regimes are listed by Dickman *et al.* (2000) as a threat to all native rodents.

Several aspects of the biology of *P. bolami* may render this species susceptible to decline. Species which are specialised in terms of habitat and diet are more prone to

decline than generalist species (Dickman *et al.*, 2000). The reliance of *P. bolami* on the plant *Maireana astrotricha* (Moseby and Read, 1998) may represent a degree of specialisation which renders the species vulnerable to habitat modification. *P. bolami* also has specialised habitat requirements due to its pattern of sheltering in dunes and foraging in swales (Moseby and Read, 1998). The small body weight of *P. bolami* may also render the species more susceptible to decline (Dickman *et al.*, 2000).

Lunney *et al.* (1997) also list ecological attributes which are associated with decline in the fauna of NSW. A number of these are characteristic of the biology of *P. bolami.* These include omnivorous diet, presence in arid or semi-arid regions, and ground-dwelling or subterranean lifestyle.

6.2 Scientific and taxonomic value

The taxonomy of *P. bolami*, and in particular, its similarity to *P. hermannsburgensis* (Kitchener *et al.*, 1984), render this a species of considerable scientific interest. The differences in geographic distribution and breeding strategies between these similar species provide a potential insight into the adaptations of Australian rodents to arid, semi-arid and mesic habitats.

6.3 Biodiversity value

Of the seventeen native rodents which have been recorded from arid NSW, eleven are regionally extinct, three (including *P. bolami*) are rare, two are sparse and one is common in limited habitat (Dickman, 1993). It is clear from such figures that the diversity of rodents in arid NSW has been severely reduced. In view of this, the biodiversity value of the remaining taxa, including *P. bolami*, is considerable.

As well as aiding the recovery of *P. bolami*, the actions in this recovery plan will have benefits for biodiversity in general. Actions such as control of feral animals and application of appropriate fire regimes have benefits for a host of native species (Dickman, 1993; Willson, 1999). Similarly, surveys and ongoing monitoring aimed at *P. bolami* will yield data which will be useful in the management of other native species.

Other threatened species which utilise similar habitat to that of *P. bolami* and will benefit from this recovery plan include the Western Pygmy Possum (*Cercartetus concinnus*), Southern Ningaui (*Ningaui yvonneae*), Little Pied Bat (*Chalinolobus picatus*), Greater Long-eared Bat (*Nyctophilus timoriensis*), Inland Forest Bat (*Vespadelus baverstocki*), Mallee Worm-lizard (*Aprasia inaurita*), Western Blue-tongued Lizard (*Tiliqua occipitalis*), Bardick (*Echiopsis curta*), Malleefowl (*Leipoa ocellata*), Bush Stone-curlew (*Burhinus grallarius*), Pink Cockatoo (*Cacatua leadbetteri*), Shy Hylacola (*Hylacola cauta*), Purple-gaped Honeyeater (*Lichenostomus cratitius*), Pied Honeyeater (*Certhionyx variegatus*), Southern

Scrub-robin (*Drymodes brunneopygia*), Chestnut Quail-thrush (*Cinclosoma castanotus*) and Gilbert's Whistler (*Pachycephala inornata*).

6.4 Social and economic considerations

P. bolami and its habitat provide aesthetic value for members of the public with an interest in the natural environment. Information regarding *P. bolami* has the potential to increase public awareness of threatened species, and rodents in particular.

The majority of locations from which *P. bolami* has been recorded in NSW lie within Tarawi Nature Reserve (Atlas of NSW Wildlife, 2000). As this area is already managed for nature conservation, no significant social or economic consequences are likely to arise from actions undertaken on the reserve.

Where *P. bolami* occurs on areas of leasehold land, grazing and clearing of Mallee present a threat to the species. This recovery plan does not propose the regulation of these activities. Rather, when populations of the species are located on leasehold land, a co-operative approach to management is advocated. This fact, as well as the limited known occurrence of the species at present, suggests that the social and economic costs to landholders will be minimal.

Control of feral predators may also be required in areas where *P. bolami* is located. However, such control is common practice and beneficial on agricultural land (Saunders *et al.*, 1995) and, as such may represent a minimal economic cost to landholders.

7 Previous Actions Undertaken

Regular trapping of small mammals has taken place in Tarawi Nature Reserve since 1997 using pitfall traps as part of a fire ecology study. Numerous captures of *P. bolami*, as well as the Threatened Southern Ningaui (*Ningaui yvonneae*) have resulted (Willson, 1999). Recently, sites have been established to monitor terrestrial vertebrate populations in Mallee Cliffs and Mungo National Parks.

A Fire Management Plan has been prepared for Tarawi Nature Reserve (Willson, 1999). The plan recognises inappropriate fire regimes as a threatening process and aims to ensure that fire regimes are compatible with the conservation of biodiversity, maintenance of species and habitat diversity.

Research is currently in progress at Tarawi to assess the effects of post-fire grazing on the biodiversity of the Mallee-spinifex community (Willson, 1999). Experiments have commenced, using exclosures and surveying vegetation twice per year (Willson, 1999.)

Feral goat and rabbit control programs are underway at Tarawi Nature Reserve, Mallee Cliffs and Mungo National Parks. At Tarawi Nature Reserve the program includes the closure of artificial watering points. Goats are mustered and removed by contractors at no expense to NPWS, and rabbits are controlled by warren ripping (NSW NPWS, 2000). Control of foxes is currently in progress, with trail baiting repeated every 2-3 months. Approximately 360 bait stations are in use at Tarawi Nature Reserve, and bait take has been reduced from 35% to 3% over a period of two years. Feral cats are removed opportunistically by shooting (H. Mangan, pers. comm.).

Control of feral animals has also been undertaken in Scotia Sanctuary, including the enclosure of some areas by predator-proof fencing (Earth Sanctuaries Ltd., 1999). Feral animals have been eradicated from one fenced area and removal is continuing in other areas (G. Martin, pers. comm.).

8 Species Ability to Recover

P. bolami may have declined in distribution as a result of changed land management practices since the arrival of Europeans. In particular, stock grazing and introduced predators are likely to have led to the decline.

The major threat of stock grazing does not affect the Tarawi NR where most records of the species occur. However, expansion into surrounding areas may be hampered by habitat damage due to stock. The localised distribution of the known population within NSW makes it susceptible to decline as a result of catastrophic events such as disease.

Most of the habitat of *P. bolami* remains intact but degraded. There is, therefore, potential for the species to recover with appropriate management of habitat, including control of feral predators.

9 Recovery Objectives and Performance Criteria

9.1 Objectives of the Recovery Plan

The overall objective of this recovery plan is to identify and secure extant populations of *P. bolami.* This will increase the likelihood of an improvement in the species' conservation status in the long term.

Specific objectives are to:

1. locate extant populations or potential habitat of *P. bolami*;

2. monitor the known populations to identify trends;

3. protect known populations, and any populations discovered in the future, from the major threatening processes of habitat destruction and feral animals;

4. achieve a greater understanding of the biology of *P. bolami*, particularly with regard to its ability to compete with the introduced House Mouse (*Mus domesticus*);

5. inform relevant stakeholders and involve them in the recovery process where appropriate.

9.2 Recovery performance criteria

Recovery performance criteria for *Pseudomys bolami* are that:

1. monitoring of the population in Tarawi NR, Mallee Cliffs and Mungo NP continues. Selected populations located in the future are monitored in line with Tarawi NR, Mallee Cliffs and Mungo NP;

2. targeted surveys within the species' former range are completed;

3. populations of *P. bolami* remain stable or increase in numbers;

4. a measurable reduction in the abundance of feral animals is maintained in Tarawi NR, Mallee Cliffs and Mungo NP and surrounding area;

5. relevant and interested stakeholders are aware of the species and its conservation through their involvement in recovery actions.

10 Recovery Actions

10.1 Action 1 – Identify and survey habitat for new extant populations of the species

Areas of potentially suitable habitat for *P. bolami* should be identified within the species' former range. Where recent records have not been obtained from those areas identified as suitable, qualified and experienced people should conduct a targeted survey.

Surveys should be conducted using a range of methods, including pitfall traps with drift fences, Elliott traps and analysis of predator scats and raptor pellets (Dickman, 1993; Moseby and Read, 1998). Surveys should span an extended period (Dickman (1993) suggests a minimum of ten days in each area) and should be carried out two or three times over a period of one year, preferably in spring, late summer and winter (Dickman, 1993).

Where possible, sampling should include mesic areas such as soaks which are likely to act as refuges for rodents (Dickman, 1993). Surveys should be intensive and should sample both dune and swale habitat (Moseby and Read, 1998).

Additional sites should be sampled opportunistically, using methods such as collection of predator scats and raptor pellets, and observation of animal signs such as diggings (Dickman, 1993). Aboriginal knowledge of the original distribution should also be sought (Dickman, 1993).

Outcome
This action will improve knowledge of the distribution of *P. bolami* and, therefore, lead to an increased understanding of the species' conservation status. In addition, identification of new potential habitat will shed light on the ability of the species to recover.

Action 1	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007
Survey	$49 400	Nil	Nil	Nil	Nil
Total					**$49 400**

NB: These surveys will be designed to yield valuable information on other threatened species such as the Bardick (*Echiopsis curta*) and the Western Pygmy-possum (*Cercartetus concinnus*). Costs will be shared as these species have Recovery Plans approved.

Agency responsible for implementation
NSW National Parks and Wildlife Service.

Funding source
NSW National Parks and Wildlife Service.

10.2 Action 2 – Monitoring populations of *P. bolami*

Feasibility Study
Monitoring of semi-arid zone rodents is considered difficult as they generally occur at very low densities. Trap success for a specific species can often be a single animal per thousand trap nights. Programs aimed at targeting species in the semi-arid zone generally require a very intensive effort in order to yield sufficient results. Therefore, a monitoring program aimed at determining status and trend for *P. bolami* in western NSW is likely to be expensive and time consuming. It is important that a thorough review of existing information is undertaken in order to design and implement an effective and cost efficient program.

This review will aim to establish the minimum effort and most appropriate methods required to obtain sufficient information to allow some assessment of population status and trends. The review should also identify the best locations in south-western NSW to undertake such monitoring.

Monitoring

Sampling of the terrestrial vertebrate population using pitfall traps has been in progress at Tarawi NR since 1997 (Willson, 1999) and similar monitoring programs have been established in Mallee Cliffs NP and Mungo NP in 2001 (A.Willson, pers. comm.). These programs will continue into the future, and may be integrated with further research into the biology of *P. bolami*, as per the recommendations of Dickman (1993), Lunney *et al.* (1997) and Moseby and Read (1998).

If possible, the competitive effects of post-rainfall irruptions of *Mus domesticus* should be investigated (Moseby and Read, 1998). Such relationships should only be investigated if sufficient data are gleaned from the monitoring program to provide statistically meaningful results.

Monitoring of Bolam's Mouse populations in Scotia Sanctuary would also be highly beneficial to the management of the species, particularly in view of the eradication of feral predators from parts of the sanctuary. A co-operative management approach is advocated between NPWS and Earth Sanctuaries Ltd. to encourage population monitoring on Scotia Sanctuary.

Any additional populations of *P. bolami* discovered during the targeted surveys should also be considered for monitoring. It is suggested that a further two populations, should they be found, be monitored in line with the Tarawi NR, Mallee Cliffs NP and Mungo NP program. Where possible, volunteers (e.g. tertiary biology students) should be sought to assist with trapping, under experienced supervision. This will reduce labour costs significantly (Dickman, 1993).

Currently, pitfall trapping is conducted on Nanya Station annually by the University of Ballarat (M.E. Westbrooke, pers. comm.). Co-operation has been sought from the University, and future captures of *P. bolami* at Nanya Station will be reported to NPWS.

Outcome

The size and viability of several populations can be assessed leading to a better understanding of the species' conservation status. Further insight can be gained into the biology of *P. bolami*, and the reasons for its decline in NSW.

Action 2	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007
Feasibility Study	$2 000	Nil	Nil	Nil	Nil
Monitoring:					
On-park *	Nil	Nil	Nil	Nil	Nil
Additional sites	Nil	$10 800	$8 000	$8 000	$8 000
Total					**$36 800**

* Monitoring currently occurs at Tarawi NR, Mallee Cliffs NP and Mungo NP and no further funding is required for the continuation of these programs. These surveys will be designed to yield valuable information on other threatened species

such as the Bardick (*Echiopsis curta*) and the Western Pygmy-possum (*Cercartetus concinnus*). Costs will be shared as these species have Recovery Plans approved.

Agency responsible for implementation
NSW National Parks and Wildlife Service.

Funding source
NSW National Parks and Wildlife Service.

10.3 Action 3 – Maintain an ongoing program of feral animal management

Introduced predators (cats and foxes) and herbivores (rabbits, cattle, sheep and goats) should be controlled in Tarawi Nature Reserve. If possible, control efforts should be conducted in collaboration with neighbouring conservation estates (Danggali Conservation Reserve and Scotia Sanctuary) and grazing properties; particularly those where *P. bolami* has been recently recorded. Monitoring of feral animal numbers should continue in order to assess the efficacy of the control measures used. Control of feral animals in the reserve should follow an integrated approach, and should be conducted by people with suitable qualifications and experience.

Feral animal management should also be considered a priority in all areas where *P. bolami* is located, both on and off conservation estate. NPWS should also consider providing assistance to private landholders to undertake feral animal management activities specifically for the conservation of *P. bolami.*

As a small rodent which utilises dense microhabitat, it is considered that *P. bolami* is likely to be at greater risk from predation by cats than by foxes (Mahon, 1999). Although foxes should not be disregarded, management techniques which target foxes but not cats (e.g. baiting with Foxoff ® or dried meat baits) are not considered sufficient for the protection of *P. bolami.*

At present, techniques are not available in NSW which provide effective, long-term reductions in the density of feral cats without an intensive, continuous effort. Reductions may be achieved with an intensive program of shooting and trapping (e.g. Mahon, 1999), however the labour costs of such a strategy can be prohibitive.

Densities of feral cats may increase locally following irruptions in prey species such as rabbits or House Mice (Mahon, 1999). At such times, the risk of predation to *P. bolami* may be increased, while the effectiveness of shooting and trapping is potentially great. Intensive periods of shooting and trapping cats following irruptions of prey species may provide a viable alternative to a continuous effort (P. Mahon, pers. comm.). Novel control techniques, such as new bait types, should be evaluated as they arise and utilised where appropriate.

Outcome
This action should maintain a measurable reduction in the density of introduced predators and herbivores in Tarawi Nature Reserve, Mallee Cliffs and Mungo National Parks, and the surrounding area. This will reduce the likelihood of further decline of *P. bolami*, and may increase the chances for recovery of populations.

Action 3	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007
Pest control	Nil	Nil	Nil	Nil	Nil
Total					**Nil***

*A program of feral animal management is currently underway at Tarawi NR, Mallee Cliffs NP and Mungo NP. Therefore, there are no additional feral animal management costs arising from this recovery plan. Provision of assistance to landholders carrying out pest control would be additional.

Agency responsible for implementation
NSW National Parks and Wildlife Service, contractors and landholders.

Funding source
NSW National Parks and Wildlife Service.

10.4 Action 4 – Maintain an appropriate fire regime

Mallee is considered a fire-dependent community (Willson, 1999), and fire regimes should be carefully managed in all areas where *P. bolami* has been recorded. On National Parks Estate, Fire Management Plans should be developed, where these do not already exist. On areas of private or leasehold land, landholders should be encouraged to implement suitable fire management.

The fire regime within Tarawi Nature Reserve should be managed according to the Fire Management Plan prepared by Willson (1999). The plan has been designed to manage fire regimes and avoid the extinction of any species known to occur naturally on the reserve. The plan contains four objectives for the conservation of biodiversity:

1. prevent consecutive fires within a 20 year period in any one area;
2. maintain the current diversity of age classes, ensuring that the desired age class ranges are not exceeded;
3. investigate and clarify the biodiversity value and regenerative capacity of long unburnt vegetation communities;
4. promote patchiness during wildfire (Willson, 1999).

Outcome
These guidelines are intended to ensure that a variety of communities and age classes exist, and that plants are able to reach post-fire maturity and reproduce before an area is re-burned (Willson, 1999). Patchiness is intended to ensure that fire does not cause localised extinction of fire-sensitive species (Willson, 1999).

Action 4	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007
Fire management	Nil	Nil	Nil	Nil	Nil
Total					**Nil***

* A Fire Management Plan is currently in place at Tarawi NR, which benefits a range of species and achieves other objectives. Therefore, there are no additional fire management costs arising from this recovery plan. Fire management on non-service estate should be achieved through a co-operative approach and costs are therefore included in Action 5.

Agency responsible for implementation
NSW National Parks and Wildlife Service.

Funding source
NSW National Parks and Wildlife Service.

10.5 Action 5 - Involve and inform relevant stakeholders

Land managers within the former range of the species, interested members of the public and other relevant stakeholders will be kept informed regarding the implementation of this recovery plan. Where appropriate, relevant stakeholders will be involved in the implementation process. Promotional leaflets should be distributed containing information about the biology and conservation significance of *P. bolami* and describing appropriate management practices for the species, such as feral animal control, fire management and reducing grazing pressure.

Outcome
Community awareness of *P. bolami*, and support for the conservation of the species within NSW.

Action 5	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007
Production of leaflets	$1 650	Nil	Nil	Nil	Nil
Total					**$1 650**

Agency responsible for implementation
NSW National Parks and Wildlife Service.

Funding source
NSW National Parks and Wildlife Service.

11 Alternative Management Strategies

11.1 *Ex-situ* breeding and reintroduction to Mallee Cliffs and Mungo National Parks

Simpson (1973), Tidemann (1988) and A. Parson (pers. comm. in Dickman, 1993) report that *P. bolami* was not found in Mallee Cliffs or Mungo National Parks, despite apparently suitable habitat. The recent capture of *P. bolami* from a property adjacent to Mungo National Park supports the idea that these areas are within the species' natural distribution.

Should the current monitoring programs fail to locate *P. bolami*, the suitability of the habitat should be assessed, and the need for and viability of reintroduction investigated.

Any translocation proposed would require the preparation of a Translocation Proposal that fully assessed the impacts of such an action in line with NSW National Parks and Wildlife Service policy.

11.2 No management action taken

As *P. bolami* has probably always been marginal in NSW (Dickman, 1994), an alternative strategy is not to undertake any management for the species.

This approach is not considered appropriate, as a stated objective of the TSC Act is the conservation of biodiversity and the recovery of threatened species within NSW. Furthermore, the species is considered by Dickman (1993; 1994) to be of national conservation significance and thus should be protected from decline in any area of its distribution.

12 Implementation

The following table allocates responsibility for the implementation of recovery actions specified in this plan to relevant government agencies for the period 2002 – 2007.

Implementation schedule

Section	Description	Responsibility for implementation	Timeframe	Priority
10.1	Survey of potential habitat	NPWS	2002/2003	High
10.2	Monitoring of the population	NPWS	Ongoing	High
10.3	Feral animal management	NPWS	Ongoing	High
10.4	Fire management	NPWS	Ongoing	High
10.5	Community education	NPWS	Ongoing	High

12.1 Review date

This recovery plan, and the conservation status of *P. bolami*, will be reviewed within five years of the date of publication.

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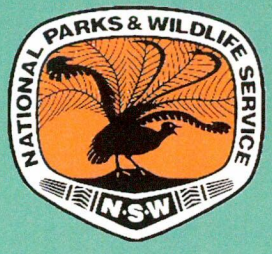

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NATIONAL
PARKS AND
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SERVICE

43 Bridge Street
Hurstville 2220
(02) 9585 6444