Approved NSW
Recovery Plan

Pseudomys oralis
(Hastings River Mouse)

April 2005

Department of **Environment & Climate Change** NSW

Queensland Government
Environmental Protection Agency
Queensland **Parks and Wildlife Service**

Australian Government

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Recovery Plan for the Hastings River Mouse (*Pseudomys oralis*)

Foreword

The Department of Environment and Climate Change NSW (DECC) is a new agency formed on 27 April 2007. DECC continues the role of the former Department of Environment and Conservation (DEC) in managing the biodiversity and threatened species of NSW. Responsibility for the preparation of Recovery Plans now rests with this new Department.

This document constitutes the formal National and New South Wales State Recovery Plan for the Hastings River Mouse (*Pseudomys oralis*) and, as such, considers the conservation requirements of the species across its known range. It identifies the actions to be taken to ensure the long-term viability of the Hastings River Mouse in nature and the parties who will undertake these actions.

The Hastings River Mouse is included as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999, and Endangered under the NSW *Threatened Species Conservation Act* 1995. It is currently listed as Vulnerable on the *Nature Conservation* (*Wildlife*) *Regulation* 2006 under the Queensland *Nature Conservation Act* 1992 (NC Act). The Hastings River Mouse is restricted to upland open forests and woodlands with grass, heath or sedge understorey in north-east New South Wales and south-east Queensland. Hastings River Mouse populations have been located across all land tenures with the majority of known populations recorded on public lands. The Hastings River Mouse is patchily distributed across its range. Based on genetic studies there are seven known genetically discrete populations and there is potential for the existence of two species.

The recovery actions detailed in this plan include: (i) research to clarify genetic differences and management requirements, (ii) research into threatening processes and mitigation measures, (iii) surveys to detect new populations, (iv) monitoring to detect trends in population, (v) management of populations, and (vi) consultation with private landholders regarding conservation management agreements.

It is intended that this Recovery Plan will be implemented over a five year period. The actions in this plan will be undertaken by DECC in NSW. The Environmental Protection Agency/Queensland Parks and Wildlife Service is responsible for wildlife conservation in Queensland under the NC Act, and is a potential contributor to the implementation of the Queensland actions.

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A draft Recovery Plan was prepared in 1998 by Dr Andrew Smith, guided by Andrew McIntyre (DECC) and the Hastings River Mouse Recovery Team. The Recovery Team members are Andrew McIntyre (DECC), Jim Shields (Forests NSW), Ian Gynther (Environmental Protection Agency/Queensland Parks and Wildlife Service), Dailan Pugh (Nature Conservation Council of NSW), Sally Townley (scientific expert) and Andrew Smith (scientific expert).

The plan has been revised by Lynn Baker and Josh Keating (DECC). Shane Ruming, Pamela Gray and Katrina McKay (DECC) have provided editorial and publication assistance. Josh Keating (DECC) redesigned and updated the Hastings River Mouse database.

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1 Introduction

The Hastings River Mouse (*Pseudomys oralis*) (Thomas 1921) is restricted in distribution to the upland open forests and woodlands with grass, heath or sedge understorey in north-east New South Wales (NSW) and south-east Queensland (Qld).

This document constitutes the formal National and State Recovery Plan for the Hastings River Mouse, and, as such, considers the requirements of the species across its known range. It identifies the actions to be taken to ensure the long-term viability of the Hastings River Mouse in nature and the parties who will undertake these actions. Attainment of the Recovery Plan's objectives will be subject to budgetary and other constraints affecting the parties involved.

2 Legislative Context

2.1 Legal status

The Hastings River Mouse is listed as Endangered under the NSW *Threatened Species Conservation Act* 1995 (TSC Act) and as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act). It is also listed as Vulnerable on the Queensland *Nature Conservation (Wildlife) Regulation* 2006 under the *Nature Conservation Act* 1992 (NC Act).

2.2 Legislative framework for threatened species, populations and communities in NSW

Responsibilities under the NSW Threatened Species Conservation Act 1995

Recovery plan preparation, exhibition and implementation

The TSC Act, the *Threatened Species Conservation Amendment Act* 2002 and the *Threatened Species Legislation Amendment Act* 2004 (hereafter referred to jointly as the TSC Act) provides a legislative framework to protect and encourage the recovery of Endangered and Vulnerable Species, Endangered Populations and Endangered Ecological Communities in NSW. Under this legislation the Director General of the DECC has a responsibility to prepare Recovery Plans for species, populations and ecological communities listed as Endangered or Vulnerable on the TSC Act schedules. The TSC Act includes specific requirements for both the matters to be addressed by Recovery Plans and the process for preparing Recovery Plans. This Recovery Plan satisfies these provisions.

The TSC Act requires that a government agency must not undertake actions inconsistent with a Recovery Plan. The actions identified in this plan for the recovery of the Hastings River Mouse are the responsibility of the DECC in NSW. The Environmental Protection Agency/Queensland Parks and Wildlife Service (EPA/QPWS) is responsible for wildlife conservation in Queensland under the NC Act, and is a potential contributor to the implementation of the Queensland actions. Other public authorities may have statutory responsibilities relevant to the conservation and protection of the Hastings River Mouse.

Critical Habitat

The TSC Act makes provision for the identification and declaration of Critical Habitat for species, populations and ecological communities listed as Endangered. Once declared, it becomes an offence to damage Critical Habitat (unless the action is specifically exempted by the TSC Act) and a Species Impact Statement (SIS) is mandatory for all developments and activities proposed within Critical Habitat.

Assessment of Critical Habitat will be undertaken as a recovery action in this plan.

Conservation Agreements

Owners of private property with significant habitat values for the Hastings River Mouse may enter into Voluntary Conservation Agreements (VCAs) under the NPW Act or a nature refuge agreement under the Qld NC Act whereby the DECC or EPA/QPWS can provide assistance in the protection and management of these values on the property.

Key Threatening Processes

As of March 2005 there are 25 Key Threatening Processes (KTP) listed on the TSC Act. Those relevant to the Hastings River Mouse include:

- anthropogenic climate change;
- bushrock removal;
- removal of dead wood and dead trees;
- clearing of native vegetation;

- ecological consequences of high frequency fire;
- predation by the European Red Fox (*Vulpes vulpes*); and
- predation by the Feral Cat (*Felis catus*).

All of these threatening processes have the potential to affect Hastings River Mouse populations through predation, or removal or degradation of habitat.

A NSW Threat Abatement Plan (TAP) for predation by the Red Fox was approved in December 2001. This TAP provides a strategy for the conservation of native species through control of the Red Fox and prioritises programs based on populations' predicted vulnerability to Red Fox predation. The TAP identifies the Hastings River Mouse as a low priority (NSW NPWS 2001). A draft NSW Threat Abatement Plan for the Feral Cat is currently under preparation.

In addition to these KTPs, a range of other processes are recognised as threatening the survival of the species in NSW.

Consultation with Indigenous People

Local Aboriginal Land Councils, Elders and other groups representing Indigenous People in the areas where the Hastings River Mouse occurs have been identified and copies of the draft Recovery Plan sent to them. Their comments on the draft were sought. It is the intention of the DECC to consider the role and interests of these Indigenous Communities in the implementation of the actions identified in this plan.

Relationship to other NSW legislation

Additional NSW legislation relevant to the conservation and recovery of the Hastings River Mouse includes the following:

- *National Parks and Wildlife Act* 1974;
- *Environmental Planning and Assessment Act* 1979;
- *Local Government Act* 1993;
- *Native Vegetation Act* 2003;
- *Rural Fires Act* 1997;
- *Forestry and National Park Estate Act* 1998; and
- *Rural Fires and Environmental Assessment Legislation Amendment Act* 2002.

2.3 Legislative framework for threatened species, populations and communities

Commonwealth Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act provides a legislative framework for the protection of threatened species across Australia. An important role of the EPBC Act is to facilitate the preparation and implementation of Recovery Plans for species listed under the Act in co-operation with the States and Territories in which populations of listed species occur. The Act also seeks to impose the obligation (arising from the listing) for responsible agencies (particularly Commonwealth) to adopt protective measures. This Recovery Plan will be submitted to the Commonwealth for approval under the EPBC Act.

Under the EPBC Act, an action which is likely to have a significant impact on a listed species is subject to referral and approval. In deciding whether or not to approve the taking of such an action, and any conditions that may apply to approval, the Commonwealth Minister for the Environment and Water Resources must not act inconsistently with a national recovery plan in force under the EPBC Act.As the Hastings River Mouse is listed Nationally under the EPBC Act, any person proposing to undertake actions likely to have a significant impact on this species should refer the action to the Commonwealth Minister for the Environment and Water Resources for consideration. The Minister will then decide whether the action requires EPBC Act approval. This is in addition to any State or Local Government approval required.

Administrative guidelines are available from the Department of the Environment and Water Resources to assist proponents in determining whether their action is likely to have a significant impact.

2.4 Legislative framework for threatened species, populations and communities in Queensland

Nature Conservation Act 1992

The Hastings River Mouse is listed as Vulnerable on the Qld *Nature Conservation (Wildlife) Regulation* 2006.

The object of the NC Act is to conserve nature, through the protection of native wildlife and its habitat, the ecologically sustainable use of

wildlife or an area, ecologically sustainable development and the application of internationally accepted criteria relating to the establishment and management of protected areas.

The NC Act also provides for an improved planning and management framework for nature conservation within and outside the reserve system. The Act establishes 11 classes of protected areas including nature refuges, co-ordinated conservation areas and wilderness areas to enable private landholders and other Crown landholders to provide protection and management of their land for nature conservation and wilderness purposes.

Critical Habitat

Critical Habitat is defined in Section 13 of NC Act as habitat that is essential for the conservation of a viable population of protected wildlife or community of native wildlife, whether or not special management considerations and protection are required. To date no Critical Habitat has been declared for the Hastings River Mouse in Qld.

Conservation Agreements

Part 4, Division 4 of the NC Act provides for the establishment of conservation agreements between the Minister and landholders. Lands subject to conservation agreements may be declared as nature refuges, co-ordinated conservation areas or wilderness areas.

Relationship to other Qld legislation

Additional Queensland legislation relevant to the conservation and recovery of the Hastings River Mouse includes the following:

- Local Government Act 1993
- *Integrated Planning Act* 2001
- *Qld Vegetation Management Act* 1999.

3 Species Information

3.1 Description and taxonomy

The Hastings River Mouse is one of 21 species in the genus *Pseudomys*, an Australasian endemic group of rodents in the tribe Conilurini, sub-family Hydromyinae of the family Muridae. The Hastings River Mouse was described from two specimens caught in the 1840s (Thomas 1921).

The fur of the Hastings River Mouse is brownish-grey above, greyish-white below and slate-grey below the tips when parted. The eyes are black, protruding and surrounded by a black eye-ring. The snout is rounded (Roman nose) and the tail is bicoloured with dark wispy hairs above and white below. The feet are covered with fine white hair and the fifth toe of the hind foot joins well backward of toes two to four, further back than in species from the *Rattus* genus. Body weight of adults is 80–120 g, head-body length is 130–170 mm and tail length is 110–150 mm (Read 1993; Kirkpatrick 1995).

The Hastings River Mouse is superficially similar to the Bush Rat (*Rattus fuscipes*) and, to a lesser extent, the introduced Black Rat (*R. rattus*) in size and general appearance. The Hastings River Mouse lacks the strongly "ringed" tail of the Bush Rat and its tail is more slender, finer textured and has bicoloured skin and hair. The Hastings River Mouse can also be distinguished from the Bush Rat through having four teats (two groin pairs) instead of 10 in females (two chest pairs and three groin pairs), and through the lack of the strong and distinctive smell of most *Rattus* (after Tweedie & York 1993).

The Hastings River Mouse is similar to the Eastern Chestnut Mouse (*Pseudomys gracilicaudatus*) but distinguished by having bicoloured skin and hair rather than just bicoloured hair, as in the Eastern Chestnut Mouse (S. Townley pers. comm.). The Eastern Chestnut Mouse is also usually smaller overall, has smaller, less bulging eyes and is more gingery in colour than the Hastings River Mouse (S. Townley pers. comm.).

3.2 Distribution

Historical distribution

Evidence from fossil and sub-fossil deposits indicate that, historically, the Hastings River Mouse occurred along the Great Dividing Range from eastern Victoria to south-east Qld during the late Pleistocene and early Holocene (approximately 13 000–150 years BP). Examination of the deposits suggest that the Hastings River Mouse range declined both prior to and after European colonisation of Australia (Read 1988, 1989; Tweedie & York 1993; Fox *et al.* 1994). Genetic studies undertaken by Jerry *et al.* (1998) support the proposition of both pre-European and post-European declines in distribution and increasingly fragmented populations.

Current distribution

The original Hastings River Mouse specimens were collected in the 1840s and no further

specimens were obtained until 1969 when the species was found near Warwick, south-east Qld (Kirkpatrick & Martin 1971). The species was re-discovered in NSW in Mt Boss State Forest in 1981 (now Werrikimbe National Park) and in Mount Royal State Forest (now Mount Royal National Park) near Muswellbrook in 1984 (Dickman & McKechnie 1985).

The Hastings River Mouse is patchily distributed and restricted to north-east NSW and south-east Qld within a biogeographic subregion referred to as the Macleay McPherson overlap zone. This subregion spans the Great Dividing Range from the Hunter Valley, south of Mt Royal, to the Bunya Mountains near Kingaroy in south-east Qld. It is characterised by mean annual temperatures of 12–16 degrees Celsius, mean annual precipitation of 1100–1500 mm, and altitude of 300–1100 m above sea level (Townley 2000a). There are a few unconfirmed records from the Sydney Basin that may require further investigation.

A predictive model of Hastings River Mouse distribution identified the importance of the above topographic and geographical factors (Smith *et al.* 1996a). The model also identified the impact of vegetation clearance in proximity to potential habitat. The presence of less than 10 percent vegetation clearing within 2 km of Hastings River Mouse habitat was considered an important variable in determining the likelihood of locating the species (Smith *et al.* 1996a). However, many sites are located within less than 200 metres of cleared or highly modified lands. These sites include the Mount Royal private land sites and all of the Border Ranges National Park and Mt Gipps sites (Gynther 2000; Sharpe 2000; Webster 2001). A Hastings River Mouse habitat quality model for public lands was derived for the Comprehensive Regional Assessment for the Upper North East and Lower North East regions of NSW (Figure 1). Predicted habitat for the Hastings River Mouse in Queensland is presented in Figure 2.

Between 1969 and 2002, 717 Hastings River Mouse captures have been recorded from 230 surveys. A total of 233 capture sites has been recorded; many of these sites are in close proximity. Based on genetic analysis there are currently seven populations that have different haplotype configurations indicating that each of the populations is genetically distinct (Jerry *et al.* 1998). These populations are identified as "management units" within the Recovery Plan (Figure 3).

3.3 Habitat

Hastings River Mouse habitat is located within open wet or dry sclerophyll forests and woodlands with native grass, sedge, rush, fern or heath understorey, however, the species appears to occupy only a subset of the available habitat (Smith & Quin 1997; Townley 2000a; Meek 2002). King (1984), Smith and Quin (1997) and Townley (2000a) found that the presence of a variety of food plants, in particular, native grasses and legumes, was an important factor in determining the presence of the Hastings River Mouse in an area. Suitable cover appears to be another significant factor in determining suitable habitat. Important structural qualities included dense ground cover of grass, sedge, rush or heath in the height range of 10–75 cm and the presence of shelter sites, including tree root hollows, butt cavities, ground holes, rock piles, boulders and fallen logs (Smith & Quin 1997; Townley 2000a; Meek 2002).

Hastings River Mouse abundance and breeding success has been found to increase significantly with the estimated time since fire indicating a preference for moderate to long unburnt (>10 years) sites. This preference appears to be related to increasing species richness of known food plants, density of vegetation cover below 1 m and the presence of fire refuges such as minor drainage lines, swamps, seepages or grass flats with seasonally good soil moisture (Smith & Quin 1997). However, Meek (2002) found that at Marengo State Forest the Hastings River Mouse was able to breed successfully and repeatedly in habitat that is burnt regularly (< 8 year cycles).

Townley (2000a, 2000c) also identified proximity of a site to rainforest on basaltic soils, possibly related to site productivity, was another characteristic of high quality Hastings River Mouse habitat.

Smith and Quin (1997) developed a Hastings River Mouse microhabitat survey technique and suitability model for identifying potential habitat in the field (Appendix 1). Kendall and Kendall Ecological Services (1999), Townley (2000b) and Meek (2002) have recommended modifications to the habitat assessment technique provided in this model.

3.4 Land tenure

Table 1 lists the number of capture sites and associated tenure for the Hastings River Mouse in NSW and Qld.

3.5 Life history and ecology

Genetics

Genetic studies using mitochondrial DNA (mDNA) have been undertaken on individuals from Lamington National Park and Gambubal in Qld and Styx River, Glen Elgin, Gibraltar Range, Enfield, and Billilimbra State Forests (including Timbarra), and Carrai and Mount Royal National Parks in NSW (Jerry *et al.* 1998; Elphinstone & Hinten 2001). All sample populations were found to be genetically isolated, with only one haplotype out of 11 being shared between the Gambubal and Lamington populations. The sharing of at least one haplotye between these two populations suggests a more recent restriction to gene flow than that found between the other genetically discrete populations.

The analysis also showed that there is a large break (in evolutionary terms) in maternal genetic lineages occurring somewhere between Gibraltar and Billilimbra State Forests. Sequence divergences among haplotypes from these two clusters of populations or 'clades' suggest that the actual period of separation may be millions of years (Jerry *et al.* 1998).

The Mount Royal National Park/private land and Carrai, Styx River, Gibraltar Range, Glen Elgin and Enfield State Forest sites constitute the southern clade while the Border Ranges and Lamington National Parks, Gambubal Forest Reserve, Timbarra and Billilimbra State Forest sites form the northern clade (Figure 2). The boundary between the two groups lies between the Gibraltar Range and Billilimbra State Forests, somewhere within Washpool National Park, a distance of around 30–40 km. The genetic differences between the two groups are sufficient to suggest that they may be different species (Elphinstone & Hinten 2001). Mitochondrial DNA data on its own cannot be used as definitive evidence of a species-level split between the two lineages; additional analysis using allozyme electrophoresis will be required to determine whether there are two species present.

A Hastings River Mouse database held by the DECC has incorporated all known survey data on the Hastings River Mouse to May 2003. Table 2 presents the proposed genetics based management units, the number of sites surveyed to date within each unit and the total number of known records. Management Sites are based on survey site names held in the database. Within each Genetic Management Unit one or two sites have been proposed as Hastings River Mouse management sites. It is proposed that these Management Sites will provide the focus for ongoing management programs and research projects. Proposed Management Sites based on private land would be subject to negotiation and a formal agreement with the landholder.

The fact that each population is genetically discrete means that each is also demographically independent and will need to be managed as a distinct management unit to maintain genetic diversity (Jerry *et al.* 1998). The management units proposed on this basis are identified in Table 2. The genetic basis of the Border Ranges National Park population and Washpool West population is currently not clear as genetic material has not been analysed.

Table 1. Hastings River Mouse sites and associated tenure in NSW and Qld.

Tenure:	No. of capture sites	% of total capture sites
New South Wales		
DECC estate	68 (20 WHA**)	29%
Forests NSW estate	111	48%
Crown lands (Department of Lands NSW)	4	1.7%
Mining Lease (Department of Primary Industries -Mineral Resources)	5	2.2%
Local Government	7	3%
Freehold	10	4.3%
NSW subtotal:	**205**	**89%**
Queensland		
EPA/QPWS	7 (7WHA**)	3%
State Forest	2	0.9%
Forest Reserve	6 (3 WHA**)	2.6%
Road Reserve	1	0.4%
Freehold	12	5%
Queensland subtotal:	**28**	**12%**
Total World Heritage Area sites:	**30**	**14%**
Total:	**233**	

** World Heritage Area

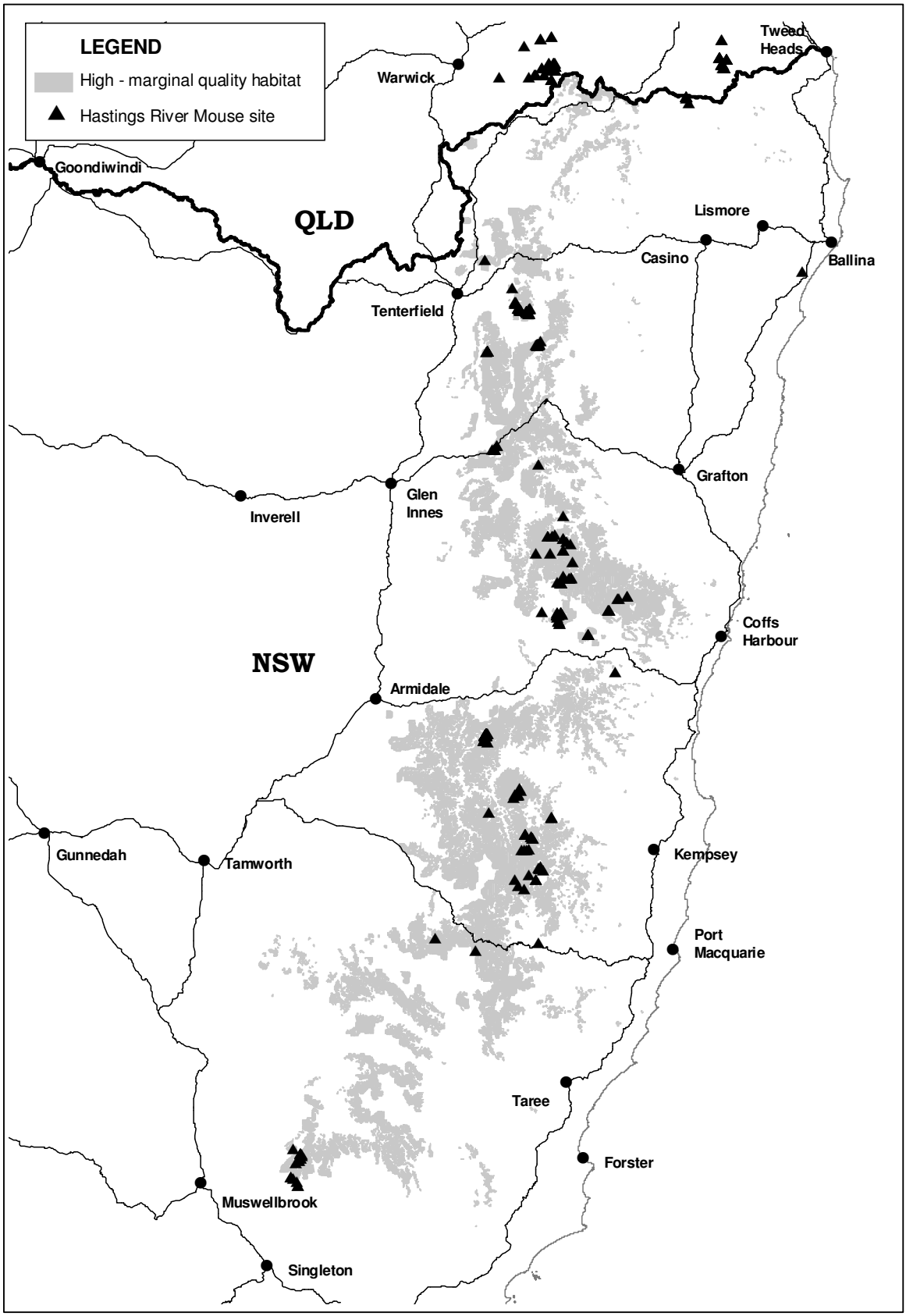

Figure 1. NSW predicted Hastings River Mouse habitat and records to 2002.

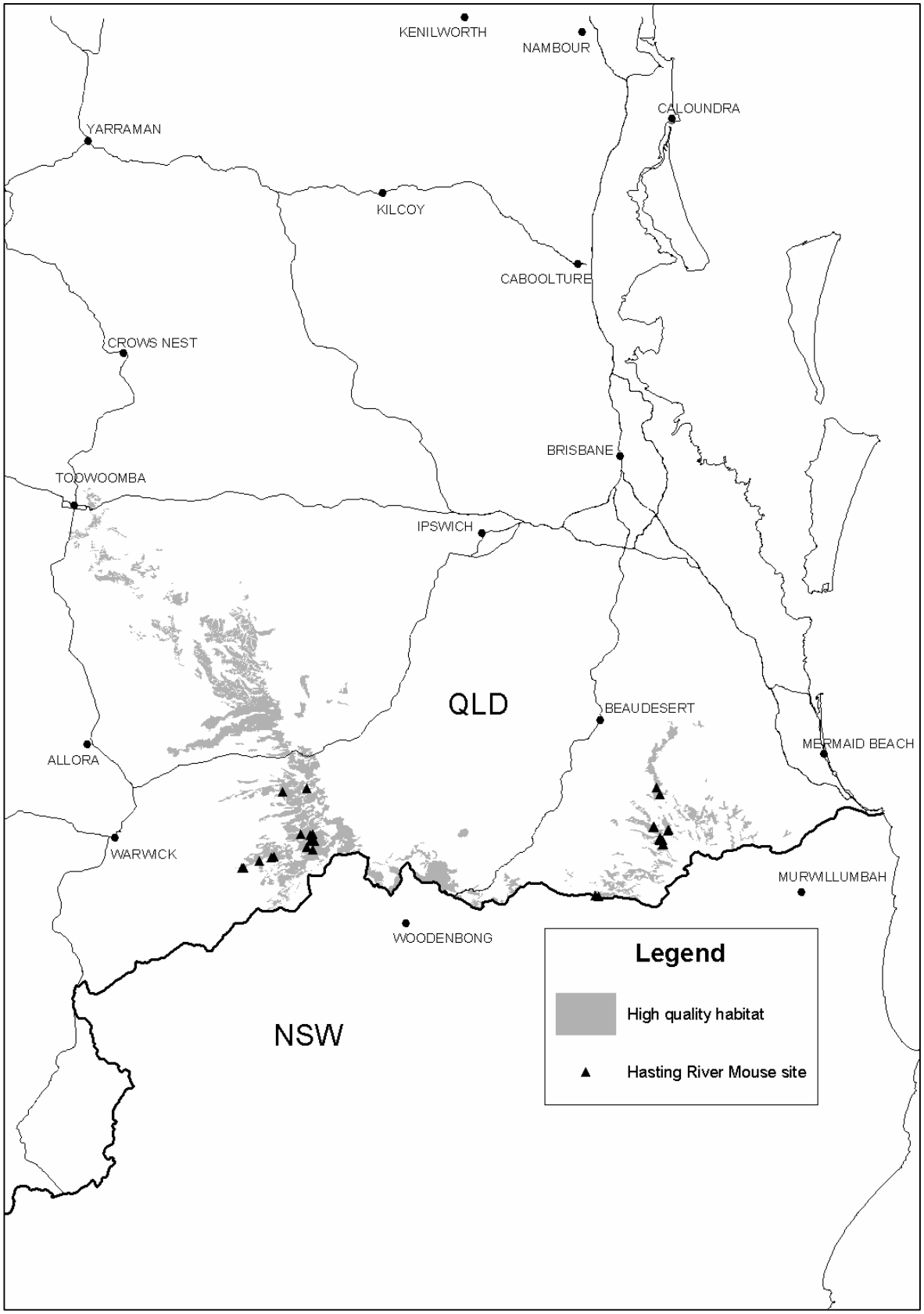

Figure 2. Queensland predicted Hastings River Mouse habitat and records to 2002.

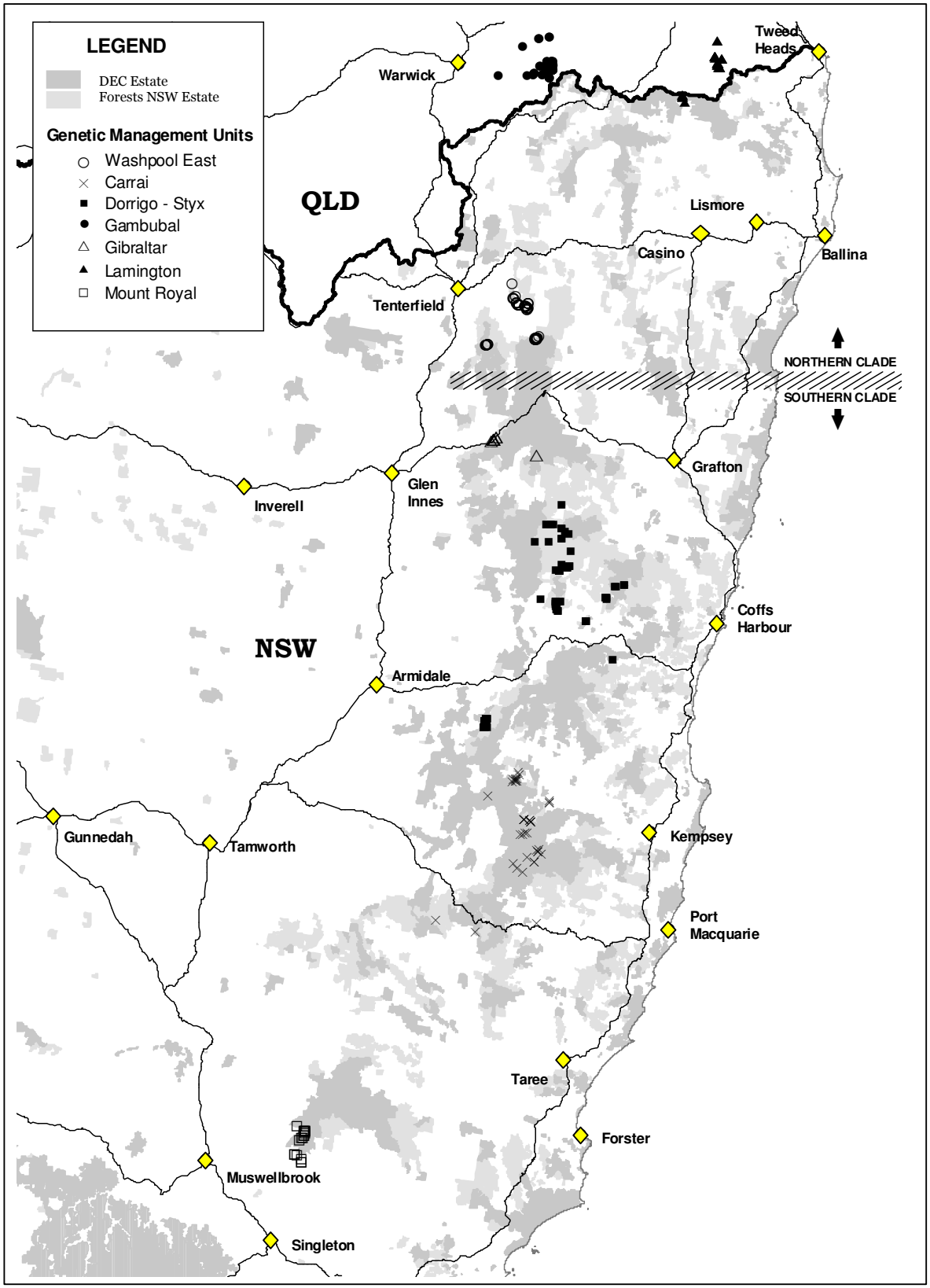

Figure 3. Proposed management units

Table 2. Proposed Hastings River Mouse Genetic Management Units and Sites

Genetic Management Units	No. of Sites	No. of DECC & EPA/ QPWS Sites	Total No. of Records	Management Site	Justification	Last Survey Date
SOUTHERN CLADE						
Mount Royal	13	11	38	Forest Site – Private land*	Recent trap records, breeding population, 9 records	1997
Carrai Plateau	32	26	37	Carrai Road Site – Oxley Wild River NP	Recent trap records, 4 captures	1999
Dorrigo-Styx River	81	13	97	(1) Blicks River 4 – Mt Hyland NR	4 captures including juvenile	1987
				(2) Styx River SF	38 captures	2000
Gibraltar Range	6	0	8	Gibraltar 4 – Glen Elgin SF	Recent trap data, 4 captures, juvenile	2000
NORTHERN CLADE						
Washpool East (Billilimbra, Timbarra)	60	25	156	Stewarts Creek 5 – Washpool NP	Multiple captures 1992-1996, juveniles	1996
Washpool West (Boundary Creek) **(waiting on analysis)**	3	3	9	Boundary Creek - Washpool (west) NP	Recent trap data, 2 captures, fire disturbance post capture	2001
Border Ranges **(waiting on analysis)**	10	6	31	Border Loop - Border Ranges NP	6 permanent monitoring sites established. Breeding population.	2001
Lamington	7	5	63	Duck Creek Road - Lamington NP/ Freehold land	Multiple records including juveniles, 1995-2002. Nil records last two years. Some fire disturbance	2002
Gambubal	18	8	278	Gambubal 1 - Gambubal Forest Reserve	Multiple records, juveniles, 1993-1995	1995

Note: NP – National Park, NR – Nature Reserve, SF – State Forest *subject to landholder agreement.
Due to new surveys and ongoing review of existing data, the DECC Hastings River Mouse Database is constantly being revised. Information presented here is based on records received by DECC to 2002.

Population biology

Townley (2000a) described the population dynamics of Hastings River Mouse populations at Billilimbra, NSW and Gambubal, Qld. The average litter size at the two sites was between two and three, and up to three litters could be produced in a season. Breeding ceased during winter and commenced between August and October. Individuals did not breed in the year of their birth and were observed to live up to three years.

The Billilimbra population appeared to be stable, characterised by low abundance and density, and long life, particularly for females. Gambubal was characterised by a relatively abundant population with a more rapid turnover of individuals. Population levels and differences between sites appeared to be the result of local environmental factors (Townley 2000a).

Numbers of Hastings River Mouse captures recorded at individual capture sites are relatively small. Around 54 percent of sites recorded only one capture per trip. Other sites range from two to 47 individuals per survey, with sites such as Styx River and Gambubal producing regular multiple captures.

Diet

The Hastings River Mouse forages across a wide range of food resources. Diet varies between season and location. Leaf material forms the bulk of the winter diet while seeds become more prevalent in summer. Other dietary items include insects, fruit, ferns, moss, flowers and fungi (Fox *et al.* 1994; Smith *et al.* 1996b; Townley 2000a).

Several plant food species are common across all Hastings River Mouse sites, including *Glycine clandestina, Poa labillardieri, Entolasia marginata, Oplismenus aemulus, Dianella caerulea, Lomandra longifolia, Solanum densevestitum, Viola* spp., *Pratia pedunculata, Oxalis corniculata* and *Hydrocotyle pedicellosa*. These recognised food species are all relatively common understorey components in the tall open forests favoured by the Hastings River Mouse (Fox *et al.* 1994; Smith *et al.* 1996b; Townley 2000a).

3.6 Ability of species to recover

The modern distribution of the Hastings River Mouse is strongly defined by genetic, climatic and vegetation factors. The species apparently occupies only a small sub-set of the available modelled habitat. The reasons for this lack of utilisation of all available habitat are unknown.

Trapping success has increased in recent years due to improved knowledge regarding site selection and trapping technique and some larger populations have been located. It is possible that new and larger populations will be located over time.

During the life of this plan, knowledge of the distribution and biology of the species will be increased and threats identified and managed. Implementation of this Recovery Plan will significantly improve the species' ability to recover.

4 Threats and Management Issues

4.1 Disjunct, genetically distinct populations

The Hastings River Mouse has a limited distribution and disjunct populations which are genetically distinct and need to be managed as discrete management units. The Hastings River Mouse also has a low reproductive rate for a rodent species (Read 1993; Townley 2000a). All known populations of the Hastings River Mouse are below the theoretical level required to maintain genetic diversity. Preliminary studies (Jerry *et al.* 1998) suggest that individual populations have a moderate degree of inbreeding. Populations appear to occur in small patches within a mosaic of unsuitable habitat exposing them to risk of extinction due to catastrophic disturbance or breeding failure. Based on available information, however, threats to the species from genetic problems do not pose as great a threat as habitat modification and predation (P. Baverstock pers. comm.).

4.2 Fire

High frequency fire is listed as a KTP under the TSC Act and is considered to be a threat to the Hastings River Mouse. Burning at intervals of less than five years is common in grassy open forests in northern NSW to promote pasture development and as a management tool to reduce the risk of wildfire. Frequent fire can simplify and alter understorey composition towards a proliferation of fire-dependent species (S. Townley pers. comm.). Pre- and post-logging burning to promote eucalypt regeneration adversely impacts on the Hastings River Mouse through the removal of shelter provided by hollow logs. Fire also removes critical resources such as food and nesting sites and increases exposure to predation. However,

at some sites fire is required by the Hastings River Mouse to prevent encroachment of rainforest species and shrubs into the grassy open forests altering the structure and reducing grass habitats. For example, at the Border Ranges sites mesic shrub and weed invasion has occurred (S. Townley pers. comm.). However, at Billilimbra no mesic encroachment has been documented even after 20 years (S. Townley pers. comm.). Meek *et al* (2003) described high Hastings River Mouse population levels across sites in seven State Forests which had fire intervals of less than 10 years and mostly between 2 and 5 years. Forests unburnt for over 20 years are likely to need some burning to maintain Hastings River Mouse habitat (Keating 2000; Townley 2000b).

No experimental work on the response of the Hastings River Mouse to fire regimes is known. Current information is based on captures within sites that have been burnt by wildfires or by leaseholders for stock grazing. Thirteen individuals were captured at Boundary Creek in Forestland State Forest in 1986. The site was subsequently burnt by wildfire and three trapping surveys over eight years post-fire failed to trap any Hastings River Mouse. However, some 16 years later the Hastings River Mouse was captured in the area during 2001-2002. At Werrikimbe National Park three trapping surveys of a previously known Hastings River Mouse site have failed to locate individuals after fire. The Billilimbra study site had not been burnt for at least 10 years and then was burnt by an intense wildfire in 1996. No Hastings River Mouse were captured despite continuing surveys until 1998 when six individuals were captured (Townley 2000a). Meek (2002) found that in Marengo State Forest, the Hastings River Mouse was able to breed successfully and repeatedly in habitat that is burnt regularly (< 8 year cycles). Webster (2001) trapped Hastings River Mouse at a Border Ranges National Park site four days after fire.

At Border Ranges National Park, six long-term small mammal monitoring sites have been established to provide information on the population dynamics of Hastings River Mouse and other species particularly in response to fire (Webster 2001). Vegetation monitoring is also undertaken at 54 plots to provide data on habitat changes over time.

Further information is required to determine the optimal fire regime to maintain Hastings River Mouse habitat and populations. It is apparent that the aim should be to implement fire regimes that maintain diverse grass/sedge/rush understorey and protect features such as hollow logs. Sufficient burning is required to avoid the risk of large, intense wildfire while a suitable interval is required to maintain a diverse understorey. Appropriate season, fuel and weather conditions are required to protect large hollow logs. Research will be encouraged to clarify the threats and preferred fire regimes and fire management for the Hastings River Mouse.

4.3 Grazing

Large areas of eucalypt forest are managed by SFNSW for multiple uses, including cattle grazing which is an integral part of the management system. Some Hastings River Mouse populations are located on private land and may be subject to grazing pressure. Grazing may impact on the Hastings River Mouse by removing or trampling palatable herbs and grasses and, in some cases, encouraging the proliferation of woody shrubs. In addition, fire is frequently used as a management tool to promote feed for grazing stock in many areas in northern NSW and south-east Qld.

4.4 Loss of habitat

Habitat alteration and fragmentation of Hastings River Mouse habitat is predominantly a result of frequent fire, forestry activities, clearing activities, grazing and weed infestation (Keating 2000). Clearing of habitat poses a potential threat to Hastings River Mouse populations on freehold land and public lands through development of infrastructure such as roads and mining developments. Hastings River Mouse populations are generally absent from potential habitat where areas with more than 10 percent clearing occur within a 2 km radius of the potential habitat (Smith *et al.* 1996a). This pattern can be attributed to edge effects associated with clearing and agriculture, particularly the penetration of forest edges by Red Foxes and Rabbits (*Oryctolagus cuniculus*). The abundance of Red Foxes in forests is known to decline with increasing distance to cleared agricultural land (Catling & Burt 1995). The Hastings River Mouse has been recorded near clearing on an inholding in Lamington National Park, however, Foxes are known to be absent from this site (I. Gynther pers. comm.). Several other sites are known to occur within less than 200 metres of cleared or highly modified lands. These sites include the Mount Royal private land sites and all of the Border Ranges National Park sites and Mt Gipps sites (Gynther 2000; Sharpe 2000; Webster 2001). The Border Ranges population

was initially discovered via remains in a Fox scat (Meek and Triggs 1999). Foxes are known to be present on the cleared and semi-cleared lands surrounding the known Border Ranges populations (D.Charley pers. comm.).

Hastings River Mouse habitat was cleared as part of the Timbarra Plateau gold mine project. Fifteen individuals were captured from 1993 to 1998 on the site prior to clearance (S. Townley 2000a). The mining has now ceased and rehabilitation commenced however no individuals have been captured on the rehabilitation site.

4.5 Predation

The Hastings River Mouse is included in the Critical Weight Range group proposed by Burbidge and McKenzie (1989) and the Vulnerable Terrestrial Vertebrate classification suggested by Smith and Quin (1997). Vertebrate species in these categories are considered to be the species most susceptible to decline and extinction through predation by introduced predators such as the Cat and Fox. Predation events have been recorded during radio-tracking work in Billilimbra and Gambubal. Meek (2002) recorded one potential Feral Cat predation event during radio-tracking and two potential owl predation events. Red Foxes and Feral Cats were also seen on site.

Remains of the Hastings River Mouse have been found in Fox scats at several sites (Meek and Triggs 1999) and in a Feral Cat's stomach (B. Nesbitt pers. comm.). Hastings River Mouse remains have been recorded from owl pellets in Wardell and Mt Royal and from Dingo/dog (*Canis lupus dingo/Canis lupus familiaris*) scats in Werrikimbe (A. McIntyre pers. comm.).

The Red Fox TAP (NSW NPWS 2001) identifies the Hastings River Mouse as being a low priority species for Fox control. The plan uses a priority ranking system to predict Fox impact. The low priority score of the Hastings River Mouse is based primarily on its microhabitat preference (forests/woodland with dense understorey), weight range of 80–120 g, which is smaller than the preferred prey size for Red Foxes of 450–5000 g and breeding rates (5–9 per year). However, clearing of land potentially allows increased access for Red Foxes and Feral Cats to Hastings River Mouse populations, increasing the risk of predation at some sites (Catling & Burt 1995). The occurrence of a reliable food source such as Rabbits or large numbers of Bush Rats may also assist Foxes and Cats to become established and subsequently impact upon Hastings River Mouse populations (Smith & Quin 1996).

The loss of cover through fire or clearing may also lead to severe predation on animals dispersing between remnant patches. Hence, predation may be a minor source of mortality in continuous habitat, but a major source of mortality where habitat is fragmented.

Feral Cats are likely to be a significant predator, particularly where Red Fox, Dingo and wild dog numbers are low, because they can breed all year round and they are less likely to take poison baits. Vertebrates with a refugial distribution like that of the Hastings River Mouse are potentially less susceptible to decline in forests where Dingoes and Spotted-tailed Quolls (*Dasyurus maculatus*) are the dominant mammalian predators due to their suppression of Cat numbers and possibly Fox numbers (NSW NPWS 2001). The Hastings River Mouse is likely to be more vulnerable to predation by Feral Cats where there is a lack of suitable cover, particularly rock cover (A. Smith pers. comm.)

4.6 Forestry activities

Timber harvesting impacts adversely on the Hastings River Mouse by reducing shelter provided by hollow logs and old-growth stems with butt cavities. Harvesting activities also open up the understorey and create roads and tracks potentially leading to increased predation pressure. The Hastings River Mouse has been found in logged areas (Meek *et al* 2003), however, the largest and most stable populations located to date occur in unlogged old-growth forest (Townley 2000a).

In NSW, an Integrated Forestry Operations Approval (IFOA) granted under part 4 of the NSW *Forestry and National Park Estate Act* 1998 (FNPE Act) regulates the carrying out of certain forestry operations, including logging, in the public forests of a region. The terms of the Threatened Species Licence of the IFOA outline the minimum protection measures required to limit the impact of forestry activities on threatened species and their habitats and forms the basis for DECC regulation of those activities. The Threatened Species Licence for the Upper North East and Lower North East Regions include measures for the protection of the Hastings River Mouse.

Specific prescriptions for the Hastings River Mouse state that where there is a record of the species in a compartment or within 800 m outside the boundary of the compartment the following must apply:

a) Within 800 m of a record of the Hastings River Mouse, 'specified forestry activities' as defined in the IFOA, are prohibited from all areas assessed as moderate or high suitability Hastings River Mouse habitat.

b) An exclusion zone of at least 200 m radius must be implemented around all records of the Hastings River Mouse.

The prescriptions dictate how targeted surveys for the Hastings River Mouse and habitat suitability assessments must be conducted. Hastings River Mouse microhabitat models (Smith & Quin 1997) used to determine the level of habitat suitability are included in the prescriptions (See Appendix 1).

There are potential threats from logging to Hastings River Mouse sites on private property. Issues relating to timber harvesting include road construction, use of heavy machinery, timber removal and burning to stimulate regeneration and limit wildfires (Smith *et al.* 1994).

Many of the identified threats to the Hastings River Mouse are intrinsically linked and the magnitude of the effect of one threat is often related to the presence or absence of other threatening processes.

5 Previous Recovery Actions

5.1 Recovery Team

The Hastings River Mouse Recovery Team was established in 1992. The Recovery Team has overseen a substantial research program (e.g. see Fox *et al.* 1994; Jerry *et al.* 1998; Smith *et al.* 1996a, 1996b; Smith & Quin 1996, 1997; Townley 2000a). An interim habitat guide (Hastings River Mouse Recovery Team 1993) was prepared and the Recovery Team assisted in the preparation of the draft Recovery Plan.

5.2 Surveys and monitoring

Over 230 surveys have been conducted for the Hastings River Mouse between 1969 and February 2003 (DECC database). Recent surveys have included the Border Ranges National Park (Keating 2000; Sharpe 2000; Townley 2000c; Webster 2001) and Marengo and Hyland State Forests (Meek 2002). Surveys conducted in Lamington National Park in January 2001 and 2002 failed to locate the Hastings River Mouse on a site where they have previously been recorded (I. Gynther, pers. comm.).

Many areas supporting what is considered to be quality Hastings River Mouse habitat have been trapped extensively with no detection of the species (Keating 2000). In NSW, SFNSW are required to undertake surveys for the Hastings River Mouse as part of their pre-roading and pre-logging surveys according to the Upper North East Region and Lower North East Region IFOAs.

A new DECC database was established in April 2002 to contain site records, habitat description, tenure, management regimes and disturbance history. This database will be updated on a regular basis.

5.3 Habitat protection and management

Measures for the conservation of the Hastings River Mouse habitat in wood production areas of State Forest are detailed in the Threatened Species Licence for the Upper North East Region and Lower North East Regions of NSW. SFNSW are required to implement the conditions, whilst the DECC is required to monitor compliance with the conditions.

New codes of practice are being developed for native forest timber harvesting and management on State lands in Queensland. Gambubal State Forest (SF 661) supports one Hastings River Mouse site and management prescriptions for the site are included in a species management profile.

DECC is required to undertake surveys for the Hastings River Mouse in areas of potential habitat prior to undertaking certain activities, including hazard reduction burns.

5.4 Research

Research has been conducted on habitat requirements, diet, population biology and genetics of the Hastings River Mouse. For examples, see Fox *et al.* 1994; Smith *et al.* 1996a, 1996b; Smith & Quin 1996, 1997; Jerry *et al.* 1998; Keating 2000 and Townley 2000a, 2000b, 2000c.

5.5 Genetic studies

Genetic studies undertaken by Jerry *et al.* (1998) identified that, within the samples analysed to date, there exist seven genetically discrete units and two discrete clades. To maintain maximum genetic diversity of the Hastings River Mouse, populations with independent evolutionary histories must be conserved (Jerry *et al.* 1998). To achieve this

target monitoring and management needs to be undertaken at the appropriate scale based on the genetically discrete units and clades.

5.6 Captive breeding

Individuals have been kept in captivity (Townley 2000a). However, there are currently no individuals held in captivity.

6 Proposed Recovery Objectives, Actions and Performance Criteria

The overall objective of this Recovery Plan is to recover the species to a position of viability in nature. To achieve this overall objective, recovery actions will include the identification of significant populations and appropriate actions to protect and secure these populations. Where possible, actions to enhance populations will be implemented. The success of these actions will be evaluated through monitoring. New populations will be searched for in areas of potential habitat, especially in areas where there are no or very few records of the species. Targeted research will be supported.

Specific objectives of the Recovery Plan for the Hastings River Mouse are listed below. For each of these objectives recovery actions are listed, each with a justification and performance criterion.

6.1 Coordination and implementation of the Recovery Plan

Specific Objective: To ensure a coordinated and efficient approach to implementation of the Recovery Plan

Action 1.1: Maintain regular correspondence between the responsible agencies and other relevant parties to ensure a coordinated approach to the implementation of the plan.

The role and membership of the Hastings River Mouse Recovery Team should be reviewed now that the Recovery Plan has been prepared.

Justification: The main role in implementing the plan will lie with the two responsible agencies, the DECC and EPA/QPWS. A coordinated approach between these two agencies and other relevant parties will be essential to ensuring that the recovery actions are implemented in an efficient and effective manner.

Performance Criterion: That regular correspondence occurs between the two responsible agencies and other relevant parties through the life of the plan.

6.2 Research

Specific Objective: Increase understanding of the genetic differences between Hastings River Mouse populations and continue to identify appropriate management units.

Action 2.1: Clarify the genetic differences between the northern and southern clades to determine whether there are two species.

Genetic researchers will be consulted in order to design optimal sampling strategies before proceeding. Preliminary consultation has indicated that blood samples will need to be collected from sites representing the northern and southern distribution limits of the northern and southern clades and other sites where possible. Samples will be sent to the South Australian Museum Evolutionary Biology Unit for allozyme analysis. Tail tips or ear clips from the same individuals will be analysed for mDNA, as per previous samples, by Southern Cross University, Animal Conservation Genetics.

Justification: The potential for the existence of two species has significant implications for the conservation status, as well as management of the species and individual populations.

Performance Criterion: Genetic differences between the northern and southern clades are clarified.

Action 2.2: Extend collection of mDNA genetic material to Hastings River Mouse populations not yet sampled. Samples will be analysed to establish whether each population is genetically distinct or is related to one of the previously identified genetically distinct populations.

Justification: Genetic research to date has identified seven genetically distinct populations of the Hastings River Mouse. Each of these populations needs to be managed as a discrete management unit to ensure that genetic diversity is maintained. Additional populations need to be tested to determine whether they belong to one of the seven units identified to date, or whether they represent a separate management unit.

Performance Criterion: Tail tips or ear clips are collected and mDNA analysed from all populations not previously sampled.

Specific Objective: Increase understanding of the ecology and management of the Hastings River Mouse, particularly in relation to disturbance and threatening processes.

Action 2.3: Give priority to research projects that focus on the impact of disturbance, threatening processes and the development of mitigation measures.

Justification: Although significant research has been conducted on the Hastings River Mouse, aspects of the species' ecology and causes of rarity remain unclear. Additional knowledge of the species' ecology and response to disturbance and threatening processes will assist in refining and directing recovery actions.

Performance Criterion: Research leads to an improvement in the management of Hastings River Mouse populations.

Action 2.4: Initiate an investigation of the impact of fire regimes on Hastings River Mouse habitat and populations. The research will be directed towards identifying the most appropriate fire management regime and management practices required for protecting and enhancing Hastings River Mouse populations.

Justification: The impacts of fire on Hastings River Mouse habitat and populations are unclear. A number of populations have disappeared after fires of varying intensity burned through their habitat, whereas other populations have reappeared two or more years after the fire. There is a wide range of possible fire regimes that may benefit or disadvantage the species and the data available to date are insufficient to be able to develop detailed management guidelines. Any experimental disturbance research will be undertaken following cautious selection of potential research sites and will consider issues such as the potential for recolonisation of the site from adjacent or nearby populations.

Performance Criterion: Fire research leads to an improvement in the management of Hastings River Mouse populations.

Action 2.5: Undertake research that refines the macro and microhabitat models.

Justification: The models were designed in the knowledge that they would need to be tested and refined over time. A number of researchers have noted aspects of the models that need refining.

Performance Criterion: The habitat models are refined.

Action 2.6: Undertake research on the impact of Cat predation through establishing a trial Cat exclosure experiment in small core breeding areas.

Justification: A. Smith (pers. comm.) and Smith and Quin (1996) have recommended an experimental trial of small mammal refuges whereby Hastings River Mouse core breeding areas are protected from predation by Feral Cats and Foxes by fencing which allows the mice to move freely but precludes predators from entering.

Performance Criterion: That research on the impact of Feral Cat predation on the Hastings River Mouse leads to an improvement in the management of Hastings River Mouse populations.

6.3 Population surveys and mapping

Specific Objective: Identify new Hastings River Mouse populations, particularly in areas with natural refuges and secure tenure.

Action 3.1: Conduct strategic surveys for new Hastings River Mouse populations in poorly surveyed regions within the species' predicted distribution, particularly in areas with natural refuges and conservation tenure.

The Hastings River Mouse database, models of predicted range and habitat, gap analysis and expert and local knowledge will be used to design a survey strategy and identify survey sites. Standard habitat assessment and survey techniques will be used to locate sites and conduct surveys. Data will be entered into the database on a six monthly basis.

Justification: Recent trends in discovery of new sites for the Hastings River Mouse indicate that there are likely to be significant populations within the predicted range that have not yet been located.

Performance Criterion: Five new populations are identified within the life of the plan.

Specific Objective: Define the boundaries of the Hastings River Mouse management units.

Action 3.2: Use predictive habitat modelling in conjunction with genetic analysis and ground

truthing surveys to map the boundaries of Hastings River Mouse management units.

Justification: Each Hastings River Mouse management unit must be managed as a discrete unit to ensure maintenance of genetic diversity. Information on the habitat available to each unit and actual usage will assist in determining appropriate management strategies.

Performance Criterion: Boundaries of the known Hastings River Mouse Genetic Management Units are defined.

Specific Objective: Identify and map potential dispersal corridors between known Hastings River Mouse populations within management units.

Action 3.3: Investigate potential dispersal corridors between selected management sites.

Predicted habitat mapping, key habitats and corridors mapping, topographic maps and air photos will be used to identify potential dispersal corridors for selected populations. Surveys will be conducted to determine the quality of habitat and some selected surveys will be conducted during the dispersal phase of breeding season to test the functionality of the identified corridors.

Justification: Dispersal corridors which maximise opportunities for genetic diversity to be maintained need to be identified and managed appropriately. Knowledge about the existence of dispersal corridors will be important in assessing extinction risks for populations that are significantly affected by disturbance factors, and to ensure appropriate management and protection of those dispersal corridors.

Performance Criterion: Dispersal corridors are identified.

6.4 Monitoring

Specific Objective: To ensure that standard monitoring procedures are used to monitor Hastings River Mouse management sites.

The monitoring program will be targeted towards regular monitoring of the identified management sites (Table 2) to establish baseline data on the population dynamics of the Hastings River Mouse at the sites. Additional monitoring surveys may be triggered by a disturbance event such as the site being burnt. Regular updating of the Hastings River Mouse database will assist in the review of the monitoring program results over time.

Action 4.1: Develop standard procedures for monitoring surveys.

Justification: Standard monitoring procedures will allow comparisons of survey effort and success across all populations and will assist in identifying changes in Hastings River Mouse populations.

Performance Criterion: Standard population monitoring procedures are developed within the first year of the commencement of the plan.

Action 4.2: Monitor the Hastings River Mouse Management Sites annually unless additional monitoring is triggered by a disturbance event. Habitat assessment and trapping surveys will be conducted to provide estimates of Hastings River Mouse habitat usage, density and abundance at each of the selected Management Sites.

Justification: Restricting detailed surveys to one or two management sites per unit will allow for efficient and effective use of resources. Regular monitoring will allow for a constant review of the conservation status of individual populations and the species. Data from the monitoring program will assist in refining management actions.

Performance Criterion: A monitoring program is developed and implemented within one year of the commencement of the plan.

Action 4.3: Update the Hastings River Mouse database regularly.

Justification: The database will need to be updated on a regular basis to enable research and monitoring survey programs to be appropriately designed. Maintaining an up to date database will ensure that the effects of recovery actions are regularly monitored.

Performance Criterion: The database is updated every six months during the life of the plan.

6.5 Management

Specific Objective: To implement effective management of Hastings River Mouse populations.

Action 5.1: Develop Hastings River Mouse population management programs based on the best available knowledge and the Interim Management Guidelines provided in Appendix 3.

Justification: To ensure that populations of the Hastings River Mouse are actively managed using the most recent and available knowledge.

Performance Criterion: Populations are actively managed and information on management programs for the Hastings River Mouse is provided regularly for the database updates and integrated into monitoring studies.

Specific Objective: To ensure that Hastings River Mouse populations and habitats are identified and managed to minimise impact from developments and activities.

Action 5.2: Develop and provide Environmental Impact Assessment (EIA) guidelines to councils and development control authorities to assist in the assessment of potential impacts from activities on Hastings River Mouse populations or habitat.

Justification: To adequately assess the likelihood of presence of Hastings River Mouse populations or habitat in an area, specific survey and assessment techniques are required. Guidelines should have modelled habitat maps attached. Interim guidelines are provided in Appendices 3 and 4.

Performance Criterion: Guidelines are developed within the life of the plan.

Action 5.3: Develop guidelines for the management of Hastings River Mouse populations and habitat and provide to public authorities, land management agencies and private landholders associated with the management of the Hastings River Mouse.

Justification: Provision of guidelines will assist in the management of Hastings River Mouse populations being incorporated into existing planning and management processes. Interim guidelines are provided in Appendix 3.

Performance Criterion: Guidelines are developed and provided to relevant land managers, public authorities and land holders within three years of the commencement of the plan.

6.6 Community and public authority involvement

Specific Objective: To increase public authority and land manager awareness and involvement in the management of the Hastings River Mouse through the provision of an information brochure.

Action 6.1: Prepare an information brochure for public authorities, land management agencies and private landholders on conservation of the Hastings River Mouse.

Justification: Hastings River Mouse populations are located on private as well as public lands. Education and involvement of the land managers in issues relating to clearing vegetation, wildfire prevention, and feral animal and weed control would assist in the conservation of the Hastings River Mouse.

Performance Criterion: An information brochure is prepared and distributed within the life of the plan.

Action 6.2: Consult with private landholders regarding conservation management agreements for protecting the Hastings River Mouse on their properties.

Justification: Eight percent of known Hastings River Mouse sites are located on private land. There is a high probability that additional populations are located on private land. Long-term protection for the Hastings River Mouse on these properties would be provided through NSW landholders entering into agreements such as VCAs under the NPW Act, Property Management Plans under the TSC Act or Property Agreements under the NVC Act. Similar provisions for voluntary conservation agreements (nature refuge agreements) exist under the Qld NC Act. Such agreements could provide support and incentives to private landholders in their contribution to the conservation of the species. The landholders must voluntarily enter any such agreement. Where a landholder indicates a desire to enter into a conservation agreement, advice and assistance from the relevant agency (either DECC or EPA/QPWS) will be provided to ensure the best-practice land management is employed. Where a private conservation agreement is not appropriate or is not sought by a landholder, the relevant agency may be able to offer advice and assistance to the landholder on the development of conservation strategies and best-practice land management for Hastings River Mouse habitat protection. On-site management plans will be promoted to landholders as the best method of planning for future conservation of the species on their property.

Performance Criterion: Consultation has commenced with private landholders within the life of the plan.

7 Implementation

Table 3 outlines the implementation of recovery actions specified in this plan for the period of five years.

8 Social and Economic Consequences

The total cost of implementing the recovery actions will be $461 750 over the five year period covered by this plan.

The Recovery Plan may have social benefits for local communities through conservation initiatives with associated government support on private land. Management of populations within NSW and Qld protected area estate will be undertaken by the DECC and EPA/QPWS.

Aboriginal Communities that have Hastings River Mouse populations or potential habitat within their areas were provided opportunity to comment on the draft Plan. Where possible, Aboriginal Communities will be engaged in the Recovery Plan implementation.

Under current forestry practice in NSW, the IFOA applies prescriptions to harvesting operations where Hastings River Mouse habitat or records occur on State Forest estate. Implementation of this Recovery Plan would not affect current SFNSW harvesting operations.

It is anticipated that there will be no significant adverse social or economic costs associated with the implementation of this Recovery Plan and that the overall benefits to society of implementation of the Recovery Plan will outweigh any specific costs.

9 Biodiversity Benefits

The Hastings River Mouse is primarily a herbivore and a granivore with a long evolutionary association with grassy open forests. It is an indicator of habitats with a high diversity of seed-producing grasses, sedges and ground-covering shrubs affected by a low level of disturbance by fire. Conservation of the Hastings River Mouse will assist in the conservation of a range of other grassy open forest and woodland species including the Eastern Chestnut Mouse listed as Vulnerable under the TSC Act. The Hastings River Mouse requires conservation actions to be undertaken across its distribution due to the genetic variation between populations. These actions will assist other species in similar habitats across the biogeographic subregion referred to as the Macleay McPherson overlap zone.

Rodent fauna species have undergone substantial reductions in Australia. Conserving the Hastings River Mouse will have a positive impact on the conservation status of Australian rodents, particularly the 'Old Endemics'.

10 Persons Responsible for Recovery Plan Preparation

A draft Recovery Plan was prepared by Dr Andrew Smith, guided by Andrew McIntyre (DECC) and the Hastings River Mouse Recovery Team in 1998.

This Recovery Plan has been revised by Lynn Baker and Josh Keating (DECC).

11 Review Date

This Recovery Plan will be reviewed five years from the date of publication.

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13 List of acronyms used in this document:

EPA/QPWS	Environmental Protection Agency/Queensland Parks and Wildlife Service
EPBC Act	*Environment Protection and Biodiversity Conservation Act* 1999
EP&A Act	*Environmental Planning and Assessment Act* 1979
ESD	ecologically sustainable development
FNPE Act	*Forestry and National Park Estate Act* 1998
IFOA	Integrated Forestry Operation Approval
KTP	Key Threatening Process
NC Act	*Nature Conservation Act* 1992 (Qld)
NP	National Park
NPW Act	*National Parks and Wildlife Act* 1974
DEC	Department of Environment and Conservation (NSW)
DECC	Department of Environment and Climate Change (NSW)
NR	Nature Reserve
NSW	New South Wales
NSW LG Act	NSW *Local Government Act* 1993
NV Act	*Native Vegetation Act* 1997
Qld	Queensland
Qld LG Act	Qld *Local Government Act* 1993
RF Act	*Rural Fires Act* 1997 (NSW)
FNSW	Forests NSW
SF	State Forest
SIS	Species Impact Statement
TAP	Threat Abatement Plan
TSC Act	*Threatened Species Conservation Act* 1995
VCAs	Voluntary Conservation Agreements
VM Act	Vegetation Management Act 1999 (Qld)

Table 3. Estimated costs of implementing the actions identified in the Recovery Plan are provided below.

Action no.	Action Title	*Priority	Cost Estimate ($'s/year)					Total Cost	Responsible Party/ Potential contributor	#In-kind	^Cash
			Year 1	Year 2	Year 3	Year 4	Year 5				
1.1 & 4.3	Recovery Plan coordination and database management	1	$1750	$1750	$1750	$1750	$1750	$8750	DECC	$8750	
2.1	Genetic Research into clades	1	$10000					$10000	DECC EPA/QPWS	$3000	$7000
2.2	mDNA genetic analysis new populations	1		$15000	$10000	$10000		$35000	DECC EPA/QPWS	0	$35000
2.3 &2.4	Research impact of disturbance, especially fire, threatening processes, mitigation	1	$25000	$25000	$25000	$25000	$25000	$125000	DECC EPA/QPWS	0	$125000
2.5	Refine habitat models	2		$10000				$10000	DECC EPA/QPWS	$7000 $3000	
3.1	Strategic surveys for new populations	2	$10900	$10900	$10900	$10900	$10900	$54500	DECC EPA/QPWS	$12500 $25500	$12500 $4000
3.2 & 3.3	Map boundaries management sites and dispersal corridors	2			$10000			$10000	DECC EPA/QPWS	$10000	
4.1& 4.2	Develop standard procedures and monitor 10 management sites	1	$16500	$39500	$39500	$39500	$39500	$174500	DECC EPA/QPWS	$117000 $52500	$5000
5.1	Implement Management Programs	1	$5000	$5000	$5000	$5000	$5000	$25000	DECC EPA/QPWS	$25000	
5.2 & 5.3	Develop EIA and management guidelines	1			$2000			$2000	DECC EPA/QPWS	$2000	
6.1	Prepare information brochure	2				$2000		$2000	DECC EPA/QPWS	$500	$1500
6.2	Consult private landholders re conservation agreements	2					$5000	$5000	DECC EPA/QPWS	$5000	
Total	**Annual cost of the Hastings River Mouse Recovery Program**		$69150	$107150	$104150	$94150	$87150	**$461750**		**$271750**	**$190000**

* Priority ratings are: 1 - action critical to meeting plan objectives; 2 - action contributing to meeting plan objectives; 3 - desirable but not essential action
#'In-Kind' Funds represent salary component of permanent staff and current resources
^'Cash' Funds represent the salary component for temporary staff and other costs such as the purchasing of survey and laboratory equipment

Appendix 1. Interim Microhabitat Survey & Mapping Protocols

Microhabitat Survey Protocols

(derived from the Integrated Forestry Operations Approval for the Upper North East and Lower North East Regions Threatened Species Licence Prescriptions).

The following protocol should be used to identify potential Hastings River Mouse habitat:

Step 1. Access the map of the Hastings River Mouse predicted range from the DECC Geographical Information System.

Step 2. If the area falls inside or within 1 km of the boundary of the species predicted range go to step 3.

Step 3. Classify vegetation cover in the survey region (from aerial photographs or existing mapped information such as forest type maps) into broad cover categories (eg rainforest, wet sclerophyll, dry sclerophyll, woodland, grassland, etc.).

Step 4. Examine topographic maps and aerial photographs to identify and map any areas with outcropping rock cover including escarpments, scree slopes, and boulder fields in or within 1 km of the survey area.

Any areas which contain:

- wet or dry sclerophyll forests with a grass, sedge or heath understorey;
- woodland with a grassy, sedge or heath understorey;
- wet or dry sclerophyll forest or woodland with dispersed patches of sedge, grass or heath, or
- any of the above which support outcropping rock cover or boulder fields or have rock outcropping within 1 km.

NB Maps should be at a scale of 1:25,000 or better.

Step 5. For every ten hectares of vegetation type identified in Step 4, one 100 m microhabitat transect will be established. Each transect must be located to sample a representative area within each ten hectare patch of vegetation type. Transects must be located to sample within 100 m of outcropping rock cover referred to in Step 3 where present. Transects should be orientated parallel to drainage lines or transects should sample areas of high total vegetation cover of sedges, rushes and grass. Where mapped vegetation type is patchy in distribution each patch greater than five hectares should be sampled.

Step 6. Conduct a microhabitat survey along each transect using the following procedures:

a) Grass, sedge and rush cover: at 10 m intervals along a 100 m transect (giving 11 samples) record in a circular plot measuring 3 m in radius at each sample point the percentage cover of grass, sedge or rushes within the plot. Average the percentage cover across the 11 samples.

b) Vegetation cover: within the 11 circular plots referred to above, record the number of times vegetation contacts a 1 cm diameter pole between 10 cm and 75 cm above ground orientated vertical at one point within the plot. Average the number of contacts across all 11 points along the transect.

c) Heath cover: record the presence of heath plants in the genera *Leucopogon, Epacris, Oxylobium, Pulteanaea, Daviesia, Dillwynia, Hakea, Leptospermum, Baeckia,* and *Callistemon*, along the transect.

d) Shelter index (SI): within 20 m either side of the entire length of the 100 m transect, conduct a random meander counting the following:

- the number of natural burrows (individual holes > 4 cm diameter and > 30 cm depth) to a maximum of 40 burrows;
- the number of large trees with basal cavities (holes > 4 cm diameter and > 30 cm depth),
- the number of rock cavities (> 4 cm entrance diameter and > 30 cm depth) to a maximum of 40 cavities,
- the number of logs (>30 cm diameter).

Sum the number of holes, tree cavities, rock cavities and logs and divide by four to give the shelter index.

Record the presence of any rock scree, escarpment or outcrop of more than 100 m length located within 500 m of the transect.

Step 7. Compare the resulting values with the ranges indicated in the model provided in Table 4 to give a score of 0, 1 or 2 for each variable. Sum the total scores and classify microhabitat at the site as unsuitable (0–1), moderate (2–4) or high quality (5–6) according to the model. This assessment technique is the same as required to be undertaken by State Forests of New South Wales under the Upper North East and Lower North East Region Integrated Forestry Operations Approvals.

Where a site has been recently burnt (within the past two years) scores for grass/sedge/rush cover and vegetation cover should be enhanced by one category (e.g. low to mod) if there is evidence from unburnt vegetation in the region that cover will increase to this level within 5 years of fire. Alternatively, habitat assessment should be deferred until at least 2 years after fire.

Hastings River Mouse microhabitat model

The Hastings River mouse microhabitat model recommended for use is the additive model (after Smith & Quin 1997) and is the same as the model applied by SFNSW.

Table 4. Hastings River Mouse Microhabitat Prediction Model

	LOW	**MOD.**	**HIGH**
SCORE	0	1	2
Grass/sedge/rush	<10%	>9% <30%	>30%
cover (GSRC): SCORE:			
Shelter Index (SI):	<17	>16	rock scarp
SCORE:			present
Vegetation Cover	<2.6 contacts	>2.5 contacts	
10 to 75 cm (VC): SCORE:			
Heath Cover (HC)	absent	present	
SCORE:			
Model TOTAL SCORE:	**0,1**	**2,3,4**	**5,6**
HABITAT SUITABILITY:	**Unsuitable**	**Moderate**	**High**

Appendix 2. Interim Hastings River Mouse Trapping and Population Survey Guidelines

These guidelines are derived from the Integrated Forestry Operations Approval for the Upper North East and Lower North East Regions Threatened Species Licence Prescriptions.

If microhabitat at a site is of moderate or high suitability for Hastings River Mouse (see Appendix 1), trapping surveys should be undertaken according to the following guidelines:

1) Trapping for Hastings River Mouse must be conducted by personnel familiar with identifying the species as it may easily be mis-identified. An appropriate licence from the DECC and Animal Care and Ethics Committee approval must be obtained prior to undertaking a trapping program.

2) The minimum specifications for trapping are as follows:

   a) The minimum trap effort at a locality must be 100 size A Elliott traps over four nights (400 trap nights) for areas up to 50 hectares of moderate or high quality habitat or both. An additional 400 trap nights (100 traps for four nights) per 50 hectares above the original 50 hectares.

   b) For each 400 trap nights four transects should be established. Twenty-five traps should be placed along each transect. Each trap should be placed at approximately ten metre intervals in sites where suitable microhabitat occurs.

   c) Transects should be placed in suitable habitat to maximise capture e.g. near fallen trees, adjacent to rock outcrops, trees with basal cavities, dense grass, burrows of suitable size (refer to Appendix 1). Trapping configuration may be varied to allow for local topographic conditions, however, the trap effort must remain the same. Traps should be placed to minimise exposure to morning sunlight to prevent animals overheating before being released.

   d) Traps should be baited with peanut butter and rolled oats. Meat products should not be included as this may increase the chance of non-target species being captured.

   e) All animals captured should be identified to species, weighed, sexed and their reproductive status assessed (juvenile, sub-adult, adult, breeding). If the identify of the species is uncertain, animals should be accurately measured (head-body, tail, hind foot ear length). Body characteristics should be recorded and a sample (5 mm square) of mid-body flank fur including at least 20 primary guard hairs should be collected. The fur should be clipped with a pair of scissors close to the skin for later microscopic examination. Each new animal should be given a temporary mark prior to release. Clipping fur or marking with a permanent-marking pen is recommended for short-term studies. For further details refer to Tweedie and York (1993).

   f) No voucher specimens should be collected, however, any Hastings River Mouse that dies accidentally should be frozen and the Hastings River Mouse coordinator contacted immediately to arrange for transport of the specimen to a suitable facility for storage.

3) Where possible, material for genetic material should be collected from all Hastings River Mouse captured by removing the tail tip. The material should be stored in individual vials of 70% ethanol and the DECC Hastings River Mouse Co-ordinator contacted with regard to sending the samples for analysis.

4) Surveys may be conducted at anytime of year, however cold, wet conditions should be avoided. Bedding of leaves or cotton wool should be placed in the trap and in wet conditions the trap covered by a plastic bag to keep the trap dry and the entrance placed facing across or downslope.

5) Capture data should be collected on all species caught in traps during each survey. Site data, capture data (including nil results) and the microhabitat data are to be forwarded to the Hastings River Mouse Co-ordinator, DECC, Locked Bag 914, Coffs Harbour, NSW, 2450.

Appendix 3. Interim Hastings River Mouse Management Guidelines

Development

Any development application including subdivision proposals that includes potential Hastings River Mouse habitat must undertake microhabitat surveys and trapping surveys if habitat is identified. Approval of the development or construction application in potential Hastings River Mouse habitat should be considered based on the results of the above surveys. Where medium or high quality habitat is located and/or individuals captured consideration should be given to not approving the application or providing consent subject to whether appropriate mitigation measures can be introduced and the preparation of an appropriate site management plan.

Fire Protection

Information on appropriate fire management prescriptions is limited. Research into fire management for Hastings River Mouse will be undertaken as part of the Recovery Plan.

In the absence of more detailed information, the following general prescriptions should be applied by agencies and landholders responsible for the management of land and vegetation surrounding known Hastings River Mouse populations to reduce the risk of too frequent burning and wildfire:

Fire Management: All reasonable precautions should be undertaken to protect Hastings River Mouse populations for a minimum of five years between fires and to exclude fire from some sites. This should include a fire buffer zone of 500 m. Information on fire history for known Hastings River Mouse populations should be provided to the DECC Hastings River Mouse coordinator to input into the Hastings River Mouse database.

The following range of proposed site management prescriptions are ranked below:

1. exclude fire (aim for an average fire interval of 20+ years);
2. exclude fire until mesic encroachment is obvious or burn is needed for hazard reduction (aim for average interval of 8 - 20 years);
3. actively manage for mesic encroachment (aim for average interval of 5-10 years); and
4. actively manage for hazard reduction (average interval < 5 years, according to local patterns).

In known sites that have been unburnt for many years and the dominant grass understorey is being overtaken by shrubs, cool mosaic management burns should be conducted to control the encroachment of shrubs and maintain a diverse grass understorey.

Where hazard reduction or management burns are required, it is preferable that a mosaic approach as above is taken across the Hastings River Mouse habitat to ensure that not all habitat is subject to the same fire regime. Monitoring of the Hastings River Mouse populations at the site should be undertaken before and after the fire.

Timber Harvesting

Surveys: Pre-logging habitat and population surveys (Appendixes 1 & 2) should be carried out by the relevant agencies in areas not covered by the Integrated Forestry Operations Approvals for the Upper North East and Lower North East Regions.

Timber Harvesting: Timber harvesting and associated activities should be excluded from areas of medium to high quality Hastings River Mouse habitat.

Within a 200 m buffer around medium to high quality Hastings River Mouse habitat and mapped Hastings River Mouse corridors the following should apply:

- if the area is unlogged or has not been logged since 1950 it will remain unlogged;
- in other areas a minimum of six mature trees with basal hollows, or trees likely to develop basal hollows, per hectare will be retained;
- all burning will be excluded; and
- no fire wood collection should occur within 200 m of a known Hastings River Mouse population.

Predator Control

Baiting for Dingoes/Dogs will not be undertaken within 5 km of known Hastings River Mouse populations. Specific programs targeting foxes and cats will be introduced on an experimental basis once appropriate methods have been developed.

Vegetation Clearing

The following conditions should apply to activities that involve the clearing of native vegetation:

- Habitat surveys and trapping for Hastings River Mouse (Appendices 1 and 2) should be applied in all areas of medium to high quality modelled Hastings River Mouse habitat (see attached map or contact DECC for a more detailed local map).
- clearing of native vegetation should not be permitted in Hastings River Mouse medium and high quality habitat and/or where surveys capture Hastings River Mice.

Grazing Mitigation

If a Hastings River Mouse population is located in an area subject to grazing, the landholder should be encouraged to de-stock and fence the site. The landholder should be encouraged to implement an appropriate burning regime to protect and enhance the Hastings River Mouse population.

Population Translocation, Captive Breeding and Re-introduction

In general, approvals to destroy Hastings River Mouse habitat should not be granted. However, where such approvals are unavoidable specific conditions should be developed in conjunction with the DECC.


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Climate Change NSW