Recovery plan for the northern hairy-nosed wombat *Lasiorhinus krefftii* 2004-2008

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Queensland Government
Environmental Protection Agency
Queensland Parks and Wildlife Service

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Publication reference:
Horsup, A. 2004. Recovery plan for the northern hairy-nosed wombat *Lasiorhinus krefftii* 2004-2008. Report to the Department of Environment and Heritage, Canberra. Environmental Protection Agency/Queensland Parks and Wildlife Service, Brisbane.

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Contents

Summary

Species status
The northern hairy-nosed wombat (NHW) is listed as 'Endangered' (Queensland *Nature Conservation Act 1992;* Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Under the IUCN SSC (2001) Red List Categories, the NHW is 'Critically Endangered' (Criteria B2ab(iii) - single population occupying <10 km^2, declining habitat quality). The species is restricted to a single population on Epping Forest National Park (Scientific) near Clermont in central Queensland. The population was estimated to contain 113 individuals in 2000, of which as few as 25 may be breeding females (Banks *et al*. in press).

Distribution summary
The NHW has been recorded in only three localities: Deniliquin, southern NSW; St. George, southern Queensland; and Epping Forest, central Queensland. The species may already have been uncommon at the time of European settlement. The NHW is currently restricted to a single population at Epping Forest National Park (Scientific) in central Queensland.

Threat summary
The available evidence suggests that the NHW was uncommon prior to its very rapid decline over the past 200 years (Crossman 1988). Overgrazing by cattle and sheep, in combination with drought and perhaps predation by dingoes, appear to be the main factors that have contributed to the species' decline. The current major threat to the Epping Forest population is its small size which makes it vulnerable to demographic and environmental stochasticity, inbreeding and consequent loss of genetic variation, predation, competition, disease and wildfire. In addition, the sex ratio is highly skewed towards males, with only 35 females (including perhaps only 25 breeding females) in the population of 113 wombats. A recent major threat, predation by dingoes, resulted in the deaths of nearly 10% of the population in 2000-01 This has been addressed by constructing a dingo-proof fence around all wombat habitat on Epping Forest National Park (EFNP).

Recovery Plan Objectives
The overall goal of this recovery plan is to achieve a total population of a minimum of 150 northern hairy-nosed wombats in two wild populations and at least one captive population by 2007. Because of the biology and level of endangerment of the NHW, medium and long-term objectives are also presented.

Specific objectives (5 years)
1. Identify and control threats and manage habitat to optimise conditions for wombat survival at EFNP.
2. Facilitate community involvement and education in NHW conservation.
3. Accurately monitor wombats.
4. Finalise reintroduction site selection.
5. Prepare and manage reintroduction site.
6. Translocate northern hairy-nosed wombats.
7. Develop captive techniques in other wombat species.
8. Establish northern hairy-nosed wombats in captivity.
9. Increase understanding of wombat biology and ecology.
10. Effectively manage the recovery program.

Performance Criteria (for specific objectives)
1. Wombat habitat is optimised and threats to the wombats minimised on EFNP.
2. Increased community awareness and involvement.
3. Increased population size, improved population composition and extended distribution are detected.
4. A translocation site is selected.

5. The translocation site is procured and prepared.
6. A second wild population of northern hairy-nosed wombats is established.
7. Improved captive breeding success has been achieved in other wombat species.
8. A captive population of NHW has been established to support the wild population.
9. Management related aspects of wombat biology and ecology are better understood.
10. The recovery program is managed effectively to ensure implementation of all actions on schedule.

Medium-term objectives (10 years)

1. Increase the range and abundance of northern hairy-nosed wombats on EFNP, increasing the population to 200.
2. Establish a minimum captive population of four northern hairy-nosed wombats and have them breeding.
3. Breed northern hairy-nosed wombats in captivity to supplement the EFNP population and the second wild population.
4. Have the second wild population expanding in range and abundance.

Long-term objective (50 years)

Establish viable metapopulations of NHW throughout their historic range, such that the risk of extinction is less than 1% over 100 years.

1. General information

Species

The NHW, *Lasiorhinus krefftii*, is the largest herbivorous burrowing mammal in the world. *L. krefftii* is a nocturnal marsupial that previously inhabited native perennial grassland and open woodland in the semi-arid zone of eastern Australia. *L. krefftii* is the largest member of the family Vombatidae, which contains two other extant species, the common wombat, *Vombatus ursinus*, and southern hairy-nosed wombat, *L. latifrons*. Adult *L. krefftii* attain an average weight of 32 kg, with females slightly heavier than males (Johnson and Crossman 1991).

The two hairy-nosed wombat species are morphologically similar, however, *L. krefftii* has nasal bones that are shorter than the frontal bones, whereas this is reversed in *L. latifrons* (Dawson 1983). The species also differ by 3.4% of DNA sequence at a mitochondrial gene commonly used to construct DNA phylogenies (Taylor *et al*. 1994). Both hairy-nosed species differ morphologically from *V. ursinus* in having broader, hairy noses, silkier fur and longer ears.

Diet, activity, and behaviour

The NHW is a grazer, with grass comprising more than 90% of its diet. Major changes have been detected in the diet of the NHW since dietary studies began. These are probably the result of major changes in the composition of available pasture species. Some of the changes can be attributed to the drought of the first half of the 1990s, but most result from the increase of the introduced buffel grass in the pasture (see Action 1.3). Buffel grass has increased in the wombat's diet from 2% in 1982/83 (Flosser 1986) to a mean 27% in the period 1993-1996 (Woolnough 1998). Woolnough reported that northern hairy-nosed wombats feed on at least 12 species of grass or sedge, with the bulk of the diet consisting of four species: three-awned grasses (*Aristida spp*., 35%), bottlewasher grasses (*Enneapogon* spp., 28%), buffel grass (*Cenchrus ciliaris*, 27%) and the sedge *Fimbristylis dichotoma* (4%).

The NHW leads an extremely conservative lifestyle. Activity above ground is closely related to ambient air temperature and is mostly restricted to the hours of darkness; however, wombats will sun themselves on winter afternoons (Woolnough 1998). In the dry seasons,

adult wombats occupy core feeding ranges of approximately 6 ha and are active above ground for about six hours per night. In the wet seasons, feeding range size is halved and activity decreases to about two hours per night (Johnson 1991). Feeding ranges of female wombats tend not to overlap, however, male ranges overlap those of females. Body condition and body composition is maintained throughout the year, indicating an impressive ability to survive on a food resource that undergoes wide fluctuations in productivity and is of a low quality for much of the year (Johnson 1991; Woolnough 1998).

L. krefftii probably possesses similar physiological adaptations to *L. latifrons* to help minimise time spent above ground. Wells (1973) has shown that the water requirements of free-ranging *L. latifrons* are extremely low, being approximately one quarter those of kangaroos and one-fifth those of sheep. Relative to size, wombats' energy requirements are also very low, using only 32% as much grass as grazing kangaroos and 25% as much as sheep (Barboza 1995). Recent research confirms that *L. krefftii* has extremely low water requirements (amongst the lowest known for any mammal) and low energy expenditures (Evans 2000).

The burrows of *L. krefftii* are usually located close to trees whose roots may provide support in the soft, sandy soil and crowns provide shade. Burrows are arranged in groups that are used by 4-5 wombats. Adjacent burrows are connected by well-worn paths and active burrows are regularly "sign-posted" with dung and urine. Each burrow may have several entrances, with 2-3 the average. Burrows are occupied by a single wombat 70% of the time. Burrow sharing may occur in the larger, multi-entrance burrows and usually involves females rather than a male and female. Although casual movements between burrow groups are rare, at least 50% of adult females change burrow groups at some time in their lives (Johnson 1991).

Population dynamics and reproduction

Demographic and life-history data are difficult to obtain on *L. krefftii* because of its burrowing and nocturnal habit, the low trappability of wombats, and the absence of breeding individuals in captivity. The following information comes from trapping studies undertaken in 1985-87, 1988-89 and 1993-1999 (Crossman 1988; Johnson 1991; Horsup 1998 and 2000) and the 2000 hair census (Banks *et al.*, in press):

- Population size was estimated at 113 in 2000 (95% C.L 96-150; minimum number alive 81). This was the first detectable increase since 1985 (1985-87 population size 67; 1988-89, 62; 1993, 65).
- Sex ratio was at parity from 1985-1989, however, since 1993 males have significantly out-numbered females (65:35 in 2000) and there were estimated to be only 25 breeding females.
- Breeding rate (measured as the proportion of females breeding in any one year) correlates closely with summer rainfall (Crossman et al. 1994). This averaged 50-75% in the period 1985-89, decreased to only 20% in 1993 during a major drought, and increased slightly to 25% in 1999.
- Annual recruitment rate in the period 1985-89 was estimated at 7% (Johnson 1991), and overall, at 5% (1985-93).
- The proportion of young wombats (<22 kg) in the population declined from 71% in 1985-87 and 57% in 1988-89 to just 27% in 1993, during a major drought. However, following the breaking of the drought, in 1996-97), the proportion of young wombat increased to 34% in 1999.
- Females are seasonally polyoestrous, however, most females trapped with young appear to have given birth in the wet season (November to April).
- Pouch life ranges from 8-9 months, although little data are available. This is followed by a period when the young remains in the burrow while the mother goes out to feed.

- Weaning occurs around 12 months of age, although little data are available. As most young are born in the wet season, independence occurs during the next favourable grass growing period.
- Adult mortality levels are low and were estimated at less than 8% per year (Johnson 1991). Recent estimates using mark-recapture methods indicate adult mortality levels of around 5% in good years (range 0-14%; S. Hoyle, pers. comm.).
- Life span in the wild is unknown, although one wombat trapped in 2003 was at least 20 years old, having been captured as an adult (ie. more than three years old) in 1986. The oldest captive NHW was more than 30 years old when it died (J. Dennis pers. comm.).
- At least 50% of adult females undertake long-term dispersal to other burrows on EFNP at some time in their lives. This factor would appear to reduce the possibility of close inbreeding between wombats within burrow groups.

Research on the closely related southern hairy-nosed wombat, *L. latifrons*, has shown that gestation lasts for 21 days and a single young is usually born. There is no evidence for a post-partum oestrous. Wells (1973) has shown that the water requirements of a lactating *L. latifrons* female may increase by a factor of five from the beginning to the end of pouch life. Gaughwin (1981) found a significant correlation between pasture biomass and quality and reproductive status in *L. latifrons*. A similar relationship occurs between summer rainfall and breeding rate in *L. krefftii* (Crossman *et al*. 1994). In *L. latifrons*, sexual maturity is reached at 2-3 years in males and 3 years in females (Gaughwin 1981).

Distribution

The NHW is currently represented by only a single population of approximately 113 individuals on EFNP (Scientific) in central Queensland (Figure 1). The current range of the species on the park is estimated at only 300 ha (Johnson 1991). EFNP, which is located 120 km north-west of Clermont in the Belyando River drainage system, was gazetted in 1971 to protect the population (Gordon *et al.* 1985).

Historically, the NHW has only been collected at two other localities, Moonie River in southern Queensland and Deniliquin in New South Wales. The Deniliquin population has recently been confirmed as being *L. krefftii* by genetic analysis of museum skins (Taylor *et al*. 1994). Only a few specimens were ever collected from these sites, and both populations were believed to be extinct by 1908.

The key habitat variable linking the current population with the two extinct southern populations is the species' preference for deep sandy soils. For this reason, its distribution may have been coincident with the patchy distribution of sandy soils through inland Queensland and New South Wales. Crossman (1988) identifies unconfirmed Queensland reports from the Balonne-Maranoa River system, Mt Douglas and Highland Plain (dates unknown), Carnarvon Gorge NP (1930s), Injune (1927), Tambo (1917), Baralaba (1984) and Oombabeer (1979) (refer to Figure 1).

The population at EFNP was formerly more widespread. Gordon *et al*. (1985) describe the present colony as having previously extended a few kilometres along several watercourses in the area. A second colony may have existed along the Belyando River as far north as Mt Douglas (80 km north of Epping Forest) until the late 1930s. This colony is believed to have been geographically distinct from the Epping Forest site as it was separated from it by a belt of unsuitable habitat dominated by gidgee scrub and eucalypt forest on clay soils (Crossman 1988). The present colony underwent several contractions during droughts (Figure 2), the most recent in the mid 1960's (Crossman 1988).

Habitat critical for survival
EFNP is situated in semi-arid cattle grazing country on the Belyando river system in the upper reaches of the Burdekin River catchment. The climate is warm to hot with a mean annual rainfall of 576 mm that is summer-dominated (72% falls from November to March) and unpredictable. Several long-term droughts, lasting up to 6 years, have been recorded in the area (Gordon *et al*. 1985). The park was excised from two cattle stations in 1971, although the station owners enjoyed grazing rights on the park until 1981 when it was fenced to exclude cattle. Competition with domestic stock has been suggested as one of the major reasons for the decline of *L. krefftii* (Gordon *et al*. 1985).

The EFNP habitat appears to be of high quality for *L. krefftii* mainly due to the stability of pasture biomass through the dry season (Johnson 1991). The drought-resistant nature of the area (Crossman 1988) and low grazing pressure may account for the survival of this colony when other colonies of *L. krefftii* disappeared in the greater Epping Forest area (see Figure 2).

The park is dominated by brigalow *Acacia harpophylla*, and gidgee *A. cambagei* scrubs on heavy grey non-cracking clay soils. Deep alluvial sand deposits occur along an ancient watercourse that was formerly part of Fox Creek. This gully area runs the length of the park from north to south and supports an association of long-fruited bloodwood *Corymbia clarksonia*, Moreton Bay Ash *C. tessellaris*, and bauhinia *Lysiphyllum hookeri*, with a fringing band of Brown's box *E. brownii* (Catchpoole 1988) (Figure 3). Most wombat burrows are constructed in the deeper soils along the banks of this gully (often under bauhinias) rather than in the gully, which is periodically waterlogged following heavy rain (Gordon *et al*. 1985).

Three-awned grasses *Aristida spp*., bottle-washer grasses *Enneapogon spp*., and golden beard grass *Chrysopogon fallax* are the dominant native grasses in wombat feeding areas, although more than 20 native grass species are present (Woolnough 1998). Buffel grass *Cenchrus ciliaris*, a species introduced to the area by the grazing industry, has become a major species on EFNP in the last 10-15 years. The mean contribution of *C. ciliaris* to pasture yield along five permanent transects on EFNP increased from 13% in 1987 to 54% in 1994. By frequency along these transects, buffel grass increased from 8% in 1987 to 54% in 2000 (Back 2000). The expansion of buffel grass on EFNP parallels the decline of some native grass species. For example, in the period 1987 to 2000, black speargrass *Heteropogon contortus*, decreased in frequency along the five permanent transects from 22% to 1%.

Buffel grass is abundant in disturbed areas, particularly around burrows and along fire control lines, and is spreading into wombat feeding areas. Its solid, clumpy growth form is probably unsuitable for the wombats, but it is a difficult species to control, and in dense, dry patches increases the threat of fire. Buffel grass is eaten by northern hairy-nosed wombats at a frequency roughly equal to its availability on EFNP. This suggests that buffel grass may not currently be of any dietary or vegetation management concern (Woolnough 1998), however, ongoing monitoring of trends is essential.

Monitoring by the Queensland Department of Primary Industries and Fisheries (DPIF) indicates that since the removal of cattle in 1982, there has been no major increase in woody plants on EFNP (P. Back pers. comm.).

Potential habitat
A map of potential habitat has been produced for the NHW (Figure 4). These sites are distributed from Charters Towers in the north to southeast of St George. Potential wombat habitat sites are based on the current or past distribution of the wombat and the presence of alluvial soils and deep sands. The existing population of the NHW at EFNP occurs in Regional Ecosystem (R.E) 11.3.7. This R.E. (Tall woodland of *Corymbia clarksoniana*, *C.*

tessellaris and *C. dallachiana* on Cainozoic alluvial plains. Sandy soils) also occurs around Charters Towers, although there have been no definitive sightings of the NHW from this area.

RE 11.3.19 (Woodland of *Callitris glaucophylla*, *Corymbia tessellaris*, *C. clarksoniana* ± *E. melanophloia*, *Acacia excelsa*, *Angophora melanoxylon* on Cainozoic alluvial plains. Deep sands of levees and higher alluvial plains and terraces) is the southern equivalent of R.E. 11.3.7. Queensland Museum specimens of NHW have been collected from this R.E., in the Moonie River area, in the past.

RE 11.3.39 (*Eucalyptus melanophloia* ± *E. chloroclada* grassy woodland on Cainozoic to Proterozoic consolidated, medium to coarse grained sediments. Shrub species are usually absent and the ground layer usually has a moderate to dense cover dominated by grasses. Occurs on flat to undulating wide valley floors within dissected sandstone residuals. Deep sandy colluvial soils) is less likely but still potential habitat for the NHW. There have been anecdotal reports of wombat sightings from around the Carnarvon National Park area (see Figure 1) in the past.

Important populations
The only known population of northern hairy-nosed wombats exists on EFNP in Central Queensland.

Threats
The available evidence suggests that *L. krefftii* was uncommon prior to its very rapid decline over the past 200 years (Crossman 1988). Overgrazing by sheep and cattle, drought, and perhaps predation by dingoes, appear to be the main factors contributing to the species' decline. The Epping Forest area was first settled in 1860 and relatively high stocking-rates in the early 1900s led to intense grazing pressure during a series of droughts. Considering the restricted feeding range of *L. krefftii* and the significant dietary overlap between wombat and cattle, severe competition for food would probably have occurred during these droughts.

The current major threat to the Epping Forest population is its small size, which makes it vulnerable to local catastrophes (such as disease or wildfire), demographic and environmental stochasticity, inbreeding and the consequent loss of genetic variation. Predation by dingoes has recently been a major problem (which has been rectified by the construction of a dingo fence around all wombat habitat on the park) and competition with native herbivores poses a potential threat. The major threats to *L. krefftii* are summarised below.

Loss of genetic diversity
The Epping Forest population is estimated to have declined to as few as 35 individuals in the early 1980s (Johnson 1991), and has therefore been through a genetic bottleneck. Even if the population size increases substantially it is unlikely to reach the stage where genetic problems can be safely ignored. Genetic threats fall into two broad categories. Firstly, random events ("genetic drift") cause gradual loss of genetic variation between individuals in small populations and this loss can diminish a species' ability to adapt to changed environmental conditions and novel pathogens (O'Brien and Evermann 1988). Recent research indicates loss of genetic variation: the expected Hardy-Weinberg heterozygosity in the Epping Forest population is only 41% of the corresponding estimate for the closely related southern hairy-nosed wombat (Taylor *et al*. 1994). Genetic variation can only be regenerated by immigration and/or mutation, the first of which is impossible in the absence of other populations, and the second of which will occur only very slowly (on an evolutionary scale).

Secondly, the small size of the population could impede mechanisms that normally reduce levels of inbreeding. Inbreeding depresses heterozygosity below Hardy-Weinberg expectations, and is often accompanied by reduced fitness of offspring as recessive deleterious genetic traits are expressed in homozygotes (Reed *et al*. 1988). The evidence of high female dispersal within the population (Johnson 1991) and the lack of heterozygote deficits (Taylor *et al*. 1994) alleviate the concern of inbreeding to some degree. Conversely, one of the expected adverse effects of inbreeding - a male-biased sex ratio – has been evident since the 1993 trapping study (1998; Banks *et al*., in press). The skewed sex ratio could be simply random occurrence, such as is common in small populations, or a result of biases in sampling methods. However, the highly skewed sex ratio was also detected during trapping in 1999 (Horsup 2000) and a sex-bias in the hair sampling method used for DNA censusing in 2000 is unlikely (Banks *et al*. in press). Thus, this trend should be viewed with concern and monitored accordingly.

Demographic stochasticity

Important demographic variables such as average annual reproduction and the normal sex ratio may fluctuate in response to environmental variation; these fluctuations may be accentuated in small populations (Lande 1988). The enhanced fluctuation because of small population size increases the likelihood of extinction. The sex ratio at Epping Forest has been significantly biased towards males since 1993 (Horsup 1998; Banks *et al.*, in press), and this will obviously reduce the reproductive output of the population relative to the same sized population with an equal sex ratio.

Disease and parasites

There is currently no data on the “normal” prevalence of clinical or sub-clinical disease in the Epping Forest population. It is possible that the ability of the wombats to resist disease, especially during times of stress, such as droughts, has been reduced by inbreeding. Disease may be normally present in the population, or it may be passed on to wombats by vectors such as feral cats and pigs. To date no life-threatening diseases have been detected in *L. krefftii*. Hair loss has been recorded on several individuals in late summer, although the condition has always disappeared by winter (Crossman 1988). This was initially suspected to be mange (possibly sarcoptic). However, there was no evidence of the mite responsible for sarcoptic mange in skin scrapings taken from two wombats with major hair loss in 1995 (J. Phelan pers. comm.).

There is currently little data available on “normal” levels of parasite infestation in northern hairy-nosed wombats, although ectoparasite load is scored on all trapped wombats. In addition, studies of the parasites of northern hairy-nosed wombats have identified several species, including one new species of nematode (Smales 1994; Gerhardt 1996). These data will be extremely useful in the event of disease or parasite outbreaks in the Epping Forest population, or for captive management and when translocating wombats to other sites.

Wildfire

A major wildfire has the potential to eliminate small isolated populations such as that at Epping Forest by destroying the wombats food supply, which includes *Aristida spp*., *Enneapogon* spp., *Cenchrus ciliaris* and *Fimbristylis dichotoma* (see Section 1), and through other changes in habitat. Fire management strategies at EFNP include regular maintenance of fire control lines and patch burning to reduce fuel loads (EPA/QPWS 1997). These strategies ensure that the likelihood of a major wildfire is reduced.

In the event of wild fire destroying part of or the entire park, it would be unlikely any wombats would be hurt. However, starvation would become an issue over the following months, particularly if rainfall did not occur post-fire, further highlighting the importance of developing supplementary feeding systems (see Action 1.6).

Drought

The lack of a detectable increase in wombat numbers between 1985 and 1993 has been attributed to the major drought from 1991-1996 (Horsup 1998). This follows the demonstrated correlation between summer rainfall and breeding rate in *L. krefftii* (Crossman *et al*. 1994). Foot print monitoring in March 1998 (following the best wet season, 1996/97, at Epping Forest for 17 years, and a better than average 1997/98 wet season) revealed signs of 15-17 juveniles on EFNP (Stenke 2000). Drought should not normally be a major problem for a long-lived species such as *L. krefftii*. However, the combination of small population size and a major drought can have serious consequences, especially in combination with other threats such as demographic stochasticity, wildfire and disease.

Predation

Dingoes are predators of *L. krefftii*. In 2000-2001, dingoes killed at least ten northern hairy-nosed wombats. This was despite an intensive 1080 baiting program that had been in operation since 1996. To prevent a repeat of predation on this scale, a 20 km dingo fence was completed around all wombat habitat on EFNP in December 2002.

Feral cats have not been implicated in the death or illness of any northern hairy-nosed wombats. However, cats can transmit diseases such as toxoplasmosis to native wildlife (Cross 1990). Feral cats were implicated in the deaths of two common wombats that were under stress because of habitat loss and succumbed to toxoplasmosis (Van Tiggelen 1992). One captive southern hairy-nosed wombat at the Waite Institute in Adelaide contracted toxoplasmosis but recovered (G. Shimmin, pers. comm.). A large cat could potentially injure or even kill a juvenile wombat. Feral cats are therefore shot whenever encountered on EFNP.

Competition

The major potential competitor with *L. krefftii* on EFNP since the removal of cattle is the eastern grey kangaroo, *M. giganteus*. The diets of kangaroos and wombats overlap closely, especially during dry periods (Woolnough 1998). Kangaroo densities have been monitored on the park since 1993 and are currently high. With the removal of dingoes following the construction of the dingo fence, there is a potential for kangaroos and rabbits to increase in density. These species could then compete with *L. krefftii* during times of drought, particularly if supplementary feeding of wombats is occurring.

Loss of habitat

All known northern hairy-nosed wombats are currently protected on EFNP. However, a major objective of this recovery plan is to establish new wild populations. Loss of wombat habitat, particularly through tree clearing, will reduce the quality and quantity of potential sites at which new populations of NHW can be established. Tree clearing is occurring across large areas of eastern Australia, particularly in central and southern Queensland. Therefore, in the Brigalow Belt Biogeographic region, no broadscale mechanical tree-clearing is allowed in the regional ecosystem that wombats occupy on EFNP (11.3.7; *Corymbia* species on alluvial plains; sandy soil). This regional ecosystem is currently considered to be “not of concern” under the *Vegetation Management Act 1999*. There are other similar regional ecosystem types that wombats could (and probably, did) potentially occupy.

Threats summary

All threats, except loss of habitat, occur at the same location:

Location:	Epping Forest National Park (Scientific)
Coordinates:	146^0 42’ 00”E; 22^0 21’ 20” S.

Population size: 113
No. reintroduced: 0
Land tenure: National Park (Scientific)

Type of threat	Current actions to reduce threats	Future actions to reduce threats
Predation	Monitor predator signs Bait regularly	Continue regular monitoring and baiting Maintain dingo fence
Wildfire	Maintain firebreak system Reduce fuel loads	Continue maintenance of firebreak system and reduction of fuel loads
Competition	Monitor kangaroo density Control numbers when necessary	Continue to monitor and control kangaroo density when necessary
Drought	Develop a supplementary water delivery system Trial supplementary foods	Continue trials until food and water systems are refined Provision near wombat burrows
Disease and parasites	Monitor baseline levels by trapping Maintain strict hygiene when handling wombats	Continue three-yearly trapping studies
Loss of genetic diversity	Reduce threats, particularly to females	Continue to reduce threats
Demographic stochasticity	Reduce threats, particularly to females	Continue to reduce threats
Loss of habitat	Prevent clearing of wombat habitat	Identify potential wombat habitat and prevent clearing of those areas

Affected interests
Organisations that have direct ownership or management responsibilities for NHW habitat and their responsibilities are:

- Environmental Protection Agency/Queensland Parks and Wildlife Service (EPA/QPWS) – responsible for managing wombat populations and managing EFNP, where the last population of the NHW survives. EPA/QPWS is also responsible for providing information and comment to the Queensland Department of Natural Resources and Mines (DNRM) when tree clearing applications are assessed.

- Queensland DNRM– responsible for assessment of tree clearing applications under the *Vegetation Management Act 1999* and *Land Act 1994*. Requires assistance from EPA/QPWS to ensure past or potential NHW habitat is not cleared.

Consultation with indigenous people
Implementation of recovery actions under this plan will include consideration of the role and interests of indigenous communities in the region. To date, indigenous communities involved in the regions affected by this plan have not yet been identified. The Gurang Land Council Aboriginal Corporation is the aboriginal representative body that will need to be consulted with respect to EFNP and its surrounds. There are currently no native title claims lodged over EFNP.

Benefits to other species or communities
The major benefit to biodiversity of the actions identified in this plan is the protection of remnant vegetation in the Brigalow Belt Biogeographic region, including endangered brigalow and gidgee communities.

Social and economic impact
The implementation of this recovery plan is unlikely to cause significant adverse social and economic impacts.

International obligations
This species is not listed under any international agreements.

2. Objectives and performance criteria

Overall objective
The overall objective of this recovery plan is to achieve a total population of a minimum of 150 northern hairy-nosed wombats in two wild populations and at least one captive population.

Specific objectives
1. Identify and control threats and manage habitat to optimise conditions for wombat survival at EFNP.
2. Facilitate community involvement and education in NHW conservation.
3. Accurately monitor wombats.
4. Finalise reintroduction site selection.
5. Prepare and manage reintroduction site.
6. Translocate northern hairy-nosed wombats.
7. Develop captive techniques in other wombat species.
8. Establish northern hairy-nosed wombats in captivity.
9. Increase understanding of wombat biology and ecology.
10. Effectively manage the recovery program.

Performance criteria (for specific objectives)
1. Wombat habitat is optimised and threats to the wombats minimised on EFNP.
2. Increased community awareness and involvement.
3. Increased population size, improved population composition and extended distribution are detected.
4. A translocation site is selected.
5. The translocation site is procured and prepared.
6. A second wild population of northern hairy-nosed wombats is established.
7. Improved captive breeding success has been achieved in other wombat species.
8. A captive population of NHW has been established to support the wild population.
9. Management related aspects of wombat biology and ecology are better understood.
10. The recovery program is managed effectively to ensure implementation of all actions on schedule.

Evaluation of recovery plan
In five years, by independent reviewer in consultation with the NHW Recovery Team.

3. Recovery actions

Objective 1 Control threats and manage habitat

Action 1.1 Dingo control
Justification
Despite the presence of a regular baiting program, dingoes killed nearly 10 percent of the NHW population at EFNP in 2000-01. A 20km dingo fence has therefore been built around all wombat habitat on the park.

Methods
The dingo fence will be monitored regularly to ensure the barrier is not compromised in any way. Permanent sand plots will be established and monitored at least every two weeks on

both sides of the fence to determine dingo presence. Baiting and trapping will be carried out the moment there is any evidence of dingoes inside the fence. An experienced shooter will be engaged if required.

Potential contributors
EPA/QPWS, partner organisations, volunteer caretakers

Action 1.2 Monitor and control competitors
Justification
Eastern grey kangaroos are the main potential competitors for northern hairy-nosed wombats on EFNP. Other potential competitors include the swamp wallaby, rufous bettong, European rabbit and feral pig. The potential for competition is higher now that populations of these species are contained inside the dingo fence and more intensive management of competitors will be required in the future.

Methods
A kangaroo management plan will be prepared that prescribes the monitoring technique, the maximum allowable density and methods of control. It is not expected that swamp wallabies and bettongs will pose a major problem, although their numbers may increase in the absence of dingoes. Rabbits are relatively common in wombat feeding areas and their numbers will also be monitored. Pigs will be controlled opportunistically.

Potential contributors
EPA/QPWS, partner organisations

Action 1.3 Habitat management
Justification
This aim of this action is to increase the reproductive output of the wombat population at EFNP by improving the yield, quality and diversity of pasture species available to the wombats. This is particularly important with the increase in introduced buffel grass in the period 1987 to 2000 from 8 percent by frequency to 55 percent (Back 2000).

Methods
Dense stands of buffel grass will be selected for manipulation to create space for native grasses, reduce the amount of rank grass and produce green “pick”.
Ten metre wide strips, adjacent to all burrow groups, will be slashed at least four times each year. Other areas near burrows will be burnt opportunistically. Manipulation areas will be seeded with native grass seed collected on the park.

Potential contributors
EPA/QPWS, partner organisations

Action 1.4 Pasture monitoring
Justification
Pasture biomass patterns and tree dynamics on EFNP in the absence of cattle are being monitored in a long-term study. Monitoring has been undertaken in 1987, 1988, 1989, 1993, 1994, 1996, 1997 and 2000. The major change detected has been the increase in introduced buffel grass (see Action 1.3). There has been no detectable increase in the shrub layer, which includes *Eremophila mitchellii*, *Acacia excelsa* and *Geijera parviflora*. This might have been expected since the removal of cattle from the park.

Methods
Monitoring along six permanent QGraze sites (five on the park, one reference site on an adjacent cattle property) will be carried out every two years at the end of the growing season (April-June). In this recovery plan, monitoring is scheduled for 2003, 2005 and 2007. Data will be analysed and compared for significant trends against previous information.

Potential contributors
DPIF (Queensland), partner organisations

Action 1.5 Fire management
Justification
An intensive fire break system at EFNP is required to protect the wombat population and habitat from wildfire. Regular burning of large blocks on the park is required to ensure that fuel loads do not become excessive.

Methods
Fire management will be carried out according to the approved EFNP Fire Management Strategy (EPA/QPWS 1997). This specifies annual grading of fire breaks and burning of large park blocks on a 4-6 year cycle dependant on prevailing weather conditions.

Potential contributors
EPA/QPWS

Action 1.6 Develop supplementary feed and water provision
Justification
This action aims to improve the quality and amount of nutrition available to wombats on EFNP by providing supplementary feed and water, particularly during dry seasons and periods of drought or following a major wildfire. Habituation to supplementary feed and water will also be an advantage for wombats that may be destined for new wild populations or for captivity.

Methods
Several unsuccessful supplementary feeding trials have been carried out over the last decade at EFNP. Many foods have been trialed (including fresh/hay lucerne, fresh/hay grass, goat and kangaroo pellets, pollard, mill run, mash, sweet potato, pumpkin, oat and corn kernels, horse licks, peanut butter and oats, molasses and liquorice). Lack of success reflects the difficulty that wild wombats have adapting to a captive diet. With plans for a permanent management presence on EFNP (see Action 1.8), longer trials are planned. Several different water trough designs have been trialed without success. The latest technique involves filling troughs with wet sand to stimulate digging for water. The results have been promising with wombats digging in these troughs, apparently in search of water. Wombat use of supplementary food and water will be monitored by remote infra-red cameras.

Potential contributors
EPA/QPWS, partner organisations

Action 1.7 Park infrastructure and integrity
Justification
Maintenance of infrastructure on EFNP is crucial to the success of the recovery program. This includes regular park visits by ranger staff to maintain cattle and dingo exclusion fences, buildings and equipment.

Methods
The EFNP Management Plan (EPA/QPWS 1998) outlines the requirements of park maintenance.

Potential contributors
EPA/QPWS, volunteer caretakers

Action 1.8 Permanent management presence on Epping Forest National Park
Justification

Although the NHW is one of the world's most endangered species until dingo predation became a serious issue in 2001 there was no permanent management presence on EFNP. Since then, a volunteer caretaker program has been established, primarily to monitor and maintain the integrity of the dingo fence that was built to protect the wombat population in 2002. Other management and research actions have also benefited from a permanent presence on the park. These include the provision of supplementary feed and water to wombats (this action suffered from a lack of continuity), slashing in pasture manipulation areas, monitoring wombat activity with remote cameras, and collecting faecal and hair samples to monitor reproductive activity and wombat numbers.

Methods
The volunteer caretaker program requires funding and co-ordination. The main costs include fuel for park vehicles (four-wheel motorbike to monitor dingo fence, tractor to slash manipulation areas) and generators, gas for fridges and cooking, and phone charges. Costs for these consumables in 2002-03 were $8,000. The volunteer caretaker program also requires co-ordination and caretakers must be inducted at the beginning of their stay on the park. These require a QWPS officer to spend one day every month on the park inducting the caretakers and another one day per month provisioning consumables.

Potential contributors
EPA/QPWS, partner organisations, volunteers

Objective 2 Facilitate community involvement and education

Action 2.1 Community and volunteer involvement
Justification
The community plays an important role in assisting with recovery of the NHW. By fostering community and volunteer involvement, financial and material contributions and intellectual benefits will be maximised (i.e. communication and understanding of the problem and what is being done to address it). The volunteer caretaker program at EFNP is a good example of how members of the public can make a major contribution to the recovery program (see Action 1.8). Volunteers have also played a big part in assisting with fieldwork at EFNP (see Action 10.3) and at Rockhampton Zoo (see Action 7.1).

Methods
Publicity for the recovery program, which in turn leads to community involvement will be facilitated through regular exposure in the media (e.g. Australian Geographic magazine (Oct 2003), story on Catalyst (ABC TV) (July 2003), updating the NHW page on the Environmental Protection Agency (EPA) website, through school and public talks, posters and brochures, the sale of merchandise (i.e. T-shirts, cards, posters)). Volunteers will be recruited by word-of-mouth or by advertising. For example volunteer caretakers have been accessed through an advertisement in the Australian Geographic newsletter. Landholders, particularly those in potential translocation areas will need to be informed and consulted about the site selection process to alleviate concerns they may have. Customised interpretive material will be produced for wombat displays at zoos involved in the recovery program (Actions 7.1 and 7.2).

Potential contributors
Environmental organisations, producer organisations (e.g. Agforce), Rockhampton City Council, Shire councils, Queensland Government departments (e.g. EPA/QPWS, DNRM, DPIF), Department of Environment and Heritage (DEH), Zoos, volunteers and the NHW Recovery Team.

Action 2.2 Communications strategy
Justification

To increase public and government awareness, a concerted effort is required to improve communications between the NHW Recovery Team, scientists and agencies and the general public. This should improve understanding of conservation of the wombats, remove inaccurate or misleading comments about wombats, lead to an increase in funds, both through grants, donations and sponsorships, and provide on going support for the actions of the Recovery Team.

Methods
Target groups would include local, state and federal governments, and the general public including community groups, schools, landholders and the media. The general public requires leaflets, posters, displays and viewing opportunities of live wombats. Educational kits for teachers would use existing scientific and audio-visual materials. Sponsoring a wombat, or even burrow, through an 'adoption' scheme could also increase publicity (and funding). Media releases on a regular basis will publicise recovery actions and recent research reports and target graziers with potential translocation sites on their properties. Specific events involving publicity, information and possibly live animals should occur on targeted occasions such as Threatened Species Day, World Environment Day and Queensland Day, and at the Rockhampton and Brisbane Shows. Collation of available visual materials will provide a centralised collection for communication purposes. Use of video and remote cameras through a web link in EFNP could provide live photographs.

Potential contributors
Recovery Team, volunteers, DEH, conservation groups (e.g. Wildlife Preservation Society of Queensland), Zoos, EPA/QPWS, partner organisations (e.g. CSR).

Objective 3 Accurately monitor wombats

Action 3.1 Hair census

Justification
A new low disturbance censusing technique, based on DNA "fingerprinting" of wombat hairs collected on sticky tape at burrow entrances, was finalised in 2000. Previously, trapping and burrow activity monitoring were the only census methods available and these were less accurate and/or involved much more disturbance to the wombat population. Hair censuses have been undertaken in 2000, 2001 and 2002. Once the results of all three censuses have been studied, we will have a good understanding of current population trends. It is proposed in future to undertake hair censuses every two to three years, depending on the results of the 2001 and 2002 censuses. This will require two censuses in the life of this recovery plan.

Methods
A technique based on DNA fingerprinting of wombat hairs collected remotely on sticky tape at wombat burrow entrances was developed over several years by Dr Andrea Taylor (currently at Monash University). The technique is used to sample all wombat burrows simultaneously to census the population and determine the sex ratio. The technique depends on amplifying hypervariable DNA markers to generate individual-specific DNA 'bar-codes' from wombat hairs. These 'bar-codes' can then be compared to blood DNA samples taken from trapped wombats to determine the identity of the wombat. Those samples that cannot be matched to a reference blood DNA sample can be assumed to be from unsampled wombats.

Each census requires a 10 day field trip to be undertaken to EFNP to collect the hair samples. Personnel required are one experienced person and at least six assistants/volunteers. Hair samples are sent to Monash University for processing and for analysis of the data.

Dr Taylor's laboratory has recently acquired a LiCor automated genotyping system. If the reliability of the current manual method of typing can be matched on the LiCor, its future use for NHW hair censusing will be highly beneficial because of anticipated savings in labour

costs. In addition, because the LiCor facility will operate on a semi-commercial basis, the recovery team will have improved access, relative to that for Dr Taylor's research laboratory, while still having the benefit of Dr Taylor's expertise in the overall management of this project.

Potential contributors
Research organisations (e.g. Monash University), EPA/QPWS, partner organisations

Action 3.2 Burrow monitoring

Justification
Burrow activity monitoring provides an index of wombat numbers that reflects long-term population trends. These trends have been confirmed by other techniques such as the hair census and trapping. Burrow monitoring is the best technique available for rapidly detecting major problems in the wombat population. Burrow monitoring started in 1974 on EFNP and has produced the longest-term data set on the NHW. The technique is dependant on a number of factors including observer experience and preceding rainfall.

Methods
Monitoring is carried out every six months by an experienced observer. Burrows are scored as 'active', 'visited' or 'inactive' according to the presence or absence of wombat tracks, digging, fresh dung and urine, and the state of the burrow (collapsed, partially collapsed, open). New burrows are marked, mapped and scored. Wombat footprint size is measured and this method currently provides the best confirmation of the presence of young wombats at a burrow (this can sometimes be confirmed by the presence of small faecal pellets).

Potential contributors
EPA/QPWS, partner organisations, volunteers

Action 3.3 Trapping

Justification
Trapping is the only method available to monitor the health, body condition and reproductive status of individual wombats and the age-sex structure of the Epping Forest population. The last trapping study in 1999 attempted to capture all wombats and all active burrows had traps placed over them. Forty-one wombats were captured, yet the 2000 hair census estimated the population contained 113 individuals, confirming that trapping misses a large proportion of the population. Because the hair census technique appears to work so well and because of the level of disturbance that trapping creates, trapping at all active burrows will not be attempted again. Instead, 'sample trapping' will be carried out at two burrow groups (i.e. $\leq$10% of all burrows) every three years in conjunction with intensive hair sampling at these burrows. This will allow monitoring of aspects of census methods, health and reproduction and allow radio-collaring of individuals for ongoing studies.

Methods
Two burrow groups will be trapped every three years. An experienced EPA/QPWS officer who will be assisted by a qualified veterinarian will supervise all trapping. Captured wombats will be sedated in the trap with Zoletil and anaesthetised with isoflourane while being processed. Data collected from individual wombats will include sex, weight, body dimensions and condition, reproductive condition, and parasite load. Samples of blood, hair, faeces, and parasites will be taken for subsequent analysis. A separate detailed trapping protocol exists.

Potential contributors
EPA/QPWS, partner organisations, volunteers

Action 3.4 Population modelling

Justification

This action has two major aims:

1. To monitor population trends in the Epping Forest colony.
2. To predict the number of individuals and strategy to use when establishing new populations by translocation (see 6.3).

Further population modelling prior to any translocation of northern hairy-nosed wombats is recommended by Hoyle *et al*. (1998). They suggest that a new model be designed to provide more accurate results based on known parameters and on the extra population data that would then be available. Population modelling should also be undertaken after each new hair census.

Methods

An experienced population modeller or post-graduate student at a university or similar institution will carry out the development of population models.

Potential contributors

Research organisations, partner organisations

Action 3.5 Population demographics

Justification

There is now a significant amount of population data available from studies undertaken at EFNP. These data need to be re-analysed to obtain a better summary of trends in the wombat population since studies began and of the current situation. The processed data will also then be available to feed into the population modelling action (see Action 3.4).

Methods

An experienced mathematician or post-graduate student at a university or similar institution will carry out the study of the population demographics of the Epping Forest wombat population.

Potential contributors

Research organisations, partner organisations

Objective 4 Finalise selection of translocation site

Action 4.1 Site suitability criteria

Justification

Selection of the best possible translocation site is crucial to the successful establishment of a second wild population of northern hairy-nosed wombats.

Methods

Site suitability criteria will be developed to assist in the selection of an appropriate translocation site. These criteria will cover factors such as optimal habitat, site tenure, willingness of owners to cooperate, location relative to towns/and or QPWS offices, presence of permanent water, appropriate infrastructure and access.

Potential contributors

EPA/QPWS, Recovery Team, partner organisations

Action 4.2 Site survey

Justification

The best potential translocation sites need to be located and thoroughly surveyed to ensure the best chance of success in establishing a second wild population of northern hairy-nosed wombats.

Methods
A desk-top survey that combines analysis of satellite imagery and maps (including topographical, soil, vegetation and regional ecosystems) and all wombat records will be undertaken to ensure that the best potential translocation sites are included in the search

Potential contributors
EPA/QPWS, partner organisations

Action 4.3 Site assessment and selection
Justification
Correct assessment of potential translocation sites is required to ensure that the best possible site is selected for the establishment of a second wild population of northern hairy-nosed wombats. This process will require a multifaceted approach, including assessment of attitudes of owners of land on which potential translocation sites have been identified, detailing of security risks and infrastructure needs.

Methods
Sites will be assessed according to the criteria developed in Action 4.1. Negotiation will occur with landholders whose properties were identified in Action 4.2 in order to assess their interest and readiness to participate.

Potential contributors
EPA/QPWS, conservation groups (e.g. Wildlife Preservation Society of Queensland), Recovery Team, partner organisations

Objective 5 Prepare and manage translocation site

Action 5.1 Site procurement
Justification
The method of procurement will vary depending on the current status of the site. However, control of the site, including specifically limited access and efficient management, will be necessary to maximise the success of the translocation.

Methods
If the site is to be bought (freehold) for the project, all available channels will need to be explored to raise the funds required. If any other interested parties exist on the translocation site, a detailed deed of agreement will need to be written clearly stating the priorities for the site.

Potential contributors
EPA/QPWS, partner organisations, landholders

Action 5.2 Site infrastructure and security
Justification
The translocation site will need to be fenced (cattle and/or predator-proof fencing) to protect the wombat population. Installation of accommodation and camp infrastructure may be necessary and should be in place prior to the translocation to ensure monitoring of translocated animals is not compromised. A high level of site security will be imperative, particularly at the outset of this project. Access should be limited to only essential personnel.

Methods

Once the site has been procured, a management plan will be developed that specifies the required infrastructure and security. Funds for fencing to provide security for the site may be available from Landcare, NHT grants, donations/sponsorships or through processes such as the WPSQ Wildlife Land Fund or Australian Nature Conservancy.

Potential contributors
EPA/QPWS, landholders, partner organisations, volunteers

Action 5.3 Habitat management and threat control
Justification
The site selected will be the best available but may still need some degree of management of habitat, e.g. weed control, planting of native grasses. Competitor and predator control may be necessary and such intervention could increase the potential for habitat changes away from optimal.

Methods
Following site selection, a detailed survey (flora and fauna) will be undertaken to determine the current status of the site and to determine the levels of weed infestation and of potential competitors and predators. Management practices will then be put into place to control all weeds and potential predators and to monitor, and control, if necessary, competitors.

Potential contributors
EPA/QPWS, landholder, partner organisations

Objective 6 Translocate northern hairy-nosed wombats

Action 6.1 Southern hairy-nosed wombat translocation trials
Justification
Trials on the closely related but much more numerous southern hairy-nosed wombat are required to develop optimal translocation techniques without risking valuable individuals of the critically endangered NHW.

Methods
Trial translocations of southern hairy-nosed wombats in South Australia began in 2002 at Monarto Zoological Park. A range of trials will continue over the next few years until the optimum translocation strategy is devised. Various types of artificial burrow and supplementary foods will be trialed.

Potential contributors
Research organisations (e.g. Adelaide University, Monarto Zoological Park)

Action 6.2 Northern hairy-nosed wombat translocation trial in EFNP
Justification
Trial translocations of northern hairy-nosed wombats into unoccupied wombat habitat on EFNP will test the translocation techniques developed in South Australia. If there are problems, northern hairy-nosed wombats can be more easily returned to their home burrows than if the translocation had been off-park. If the translocations are successful, they will be useful in expanding the species' range on EFNP.

Methods
Translocation and monitoring methods developed on southern hairy-nosed wombats will be used. It is expected that translocation trials on the southern hairy-nosed wombat will show that an on-site holding facility is necessary. This would be built on EFNP to allow wombats destined for translocation to habituate to captive foods (so that these can be provisioned at the translocation site) and to allow the return of unsuitable individuals. DNA profiling methods developed in Actions 3.1 and 9.2 may also be employed to monitor individuals.

Potential contributors
EPA/QPWS, partner organisations

Action 6.3 Northern hairy-nosed wombat translocation to new site
Justification
The establishment of a second wild population of northern hairy-nosed wombats is a major objective of this recovery plan, with success greatly reducing the threat of rapid extinction of the species.

Methods
Methods used during the translocation will be based on those developed in the trial translocations of southern hairy-nosed wombats and the translocation within EFNP. Founder individuals will be selected based on aspects such as relatedness of individuals, age-sex structure and adaptability to a captive diet. These individuals will be acclimatised in the holding facility at EFNP.

Potential contributors
EPA/QPWS, partner organisations

Action 6.4 Monitor translocated wombats
Justification
Close monitoring of translocated northern hairy-nosed wombats will be essential to determine the success of the translocation and also to monitor the well being of individuals, and return any to EFNP, if necessary.

Methods
Methods developed in trial translocations of southern hairy-nosed wombats will be used. In addition, DNA profiling methods developed in Actions 3.1 and 9.2 may also be employed to monitor individuals.

Potential contributors
EPA/QPWS, partner organisations, volunteers

Objective 7 Develop captive techniques on other wombat species

Action 7.1 Refine husbandry techniques on other wombat species
Justification
Wombats are difficult animals to habituate to captivity and although there are many in zoos, there have been few instances of breeding. Little is known about how they reproduce so it is hoped that a better understanding of their basic biology can be used to develop and improve husbandry and breeding strategies for hairy-nosed wombats and the common wombat. Improvements in wombat husbandry, particularly in relation to diet, optimal holding environments and the age-sex composition of colonies, is crucial to the success of managing northern hairy-nosed wombats in captivity.

Methods
Several zoos in Australia keep large wombat populations. Zoos with direct involvement in the recovery program include Rockhampton Zoo, Australia Zoo, Currumbin Sanctuary, Melbourne Zoo and the University of Adelaide (southern hairy-nosed wombats) and Western Plains Zoo and Taronga Zoo (common wombat). These zoos are collaborating in writing and/or refining wombat husbandry manuals.

Potential contributors

Research organisations and zoos (e.g. Rockhampton Zoo, Australia Zoo, David Fleay Wildlife Park, Currumbin Sanctuary, Melbourne Zoo, the University of Adelaide, Western Plains Zoo, Taronga Zoo), EPA/QPWS, wombat care organisations

Action 7.2 Develop breeding techniques on other wombat species

Justification

There have been few wombat births in captivity and fewer follow-up births by the same female. This is probably a result of incompatibility between male and female wombats, inappropriate holding environments and incorrect diet. This action aims to encourage natural breeding in captivity and to develop assisted breeding techniques on southern hairy-nosed wombats and common wombats.

Methods

The zoos involved in Action 7.1 will assist with this action. Most assisted breeding research will be undertaken at the Wombat Research Centre at Rockhampton Zoo.

Potential contributors

Research organisations and zoos (e.g. Rockhampton Zoo, Australia Zoo, David Fleay Wildlife Park, Currumbin Sanctuary, Melbourne Zoo, the University of Adelaide, Western Plains Zoo, Taronga Zoo), EPA/QPWS

Objective 8 Establish northern hairy-nosed wombats in captivity

Action 8.1 Establish captive facilities for the northern hairy-nosed wombat

Justification

Custom-built facilities for northern hairy-nosed wombats will be required at EFNP (to acclimatise wombats before transfer off the park) and at a permanent site such as a zoo or other appropriate institution.

Methods

The design of the captive facilities for the NHW will be based on experience gained from captive studies of southern hairy-nosed and common wombats (Objective 7). This will include deciding on the best location (environmental conditions, zoo facilities, staff experience), building facilities that include state-of-the-art sleeping chambers, tunnels, yards and items of behavioural enrichment (for example, digging chambers), and providing an optimum diet and the best husbandry available.

Potential contributors

EPA/QPWS, zoos, partner organisations

Action 8.2 Selection and acclimatisation of the northern hairy-nosed wombat at Epping Forest National Park

Justification

Experience in establishing southern hairy-nosed wombats in captivity has shown that some individuals acclimatise to a captive environment and life style better than others. An interim holding facility at EFNP will allow wombats that are not settling well into captivity to be returned directly to their burrows. This would not be possible from off-park facilities because of quarantine concerns and the extra stress imposed on the wombats. Selection of individuals will also be dependant on factors determined in captive studies on the two other wombat species. These could include degree of relatedness, or familiarity with each other. It may be appropriate to attempt initial acclimatisation experiments with a juvenile male NHW.

Methods

The interim holding facility at EFNP will be built on a smaller scale than the permanent NHW facility. However, both designs will be the same so that wombats adjust as quickly as possible after transfer off EFNP. An EPA/QPWS officer or qualified external officer and a

veterinarian will be required to care for wombats while they are held at EFNP. Wombats that fall below a pre-determined weight (e.g. 20 percent less than capture weight), or whose behaviour is judged to be abnormal, will be returned to their burrows.

Potential contributors
EPA/QPWS, zoos, partner organisations

Action 8.3 Establishment of the northern hairy-nosed wombat at a permanent facility
Justification
The establishment of a captive population of northern hairy-nosed wombats will provide several important opportunities for the recovery program. These include the ability to carry out intensive studies, the potential to undertake captive breeding to supplement wild populations, and the opportunity to display northern hairy-nosed wombats to increase public awareness and support for the recovery program.

Methods
Methods similar to those used at the EFNP facility will be used to establish northern hairy-nosed wombats at the permanent facility, except that there will be no option of returning wombats to EFNP.

Potential contributors
EPA/QPWS, zoos, partner organisations

Objective 9 Increase understanding of wombat biology and ecology

Action 9.1 Dietary studies
Justification
Northern hairy-nosed wombats are primarily grazers (Woolnough 1998). Regular dietary monitoring is required because of the changing composition of pasture species on EFNP and to determine the effects of pasture manipulation on diet (see Action 1.3). Changing pasture composition has resulted from the expansion of introduced buffel grass, altered fire regimes and drought.

Methods
Wombat faecal samples will be collected every three months, dried and stored. The analysis of these samples will be contracted out to an experienced technician at a university or similar institution every five years. A three-year faecal collection is being analysed in 2002. The next analysis of faecal samples is due in 2007.

Potential contributors
Research organisations, EPA/QPWS, volunteers, partner organisations

Action 9.2 Monitoring reproduction
Justification
Previous reproductive studies as part of this recovery program have improved knowledge of reproduction in hairy-nosed wombats, mostly from studies of the closely related southern hairy-nosed wombat. Data on seasonality of reproduction in the southern hairy-nosed wombat and techniques for monitoring seasonal changes in wombat reproductive status have been developed and applied to animals in the field (Hamilton *et al.* 2000). Semen collection and cryopreservation techniques have been developed in northern hairy-nosed wombats and southern hairy-nosed wombats and methods for stimulating superovulation and facilitating oocyte collection are currently in progress as part of on-going studies to provide useful techniques for assisted reproduction for the NHW should this be required in the future.

Techniques to transport and transfer pouch young to surrogate mothers in southern hairy-nosed wombats have also been perfected.

Because of difficulty in accessing northern hairy-nosed wombats at EFNP there have been no detailed field studies of reproduction in the NHW. Using recently developed faecal monitoring techniques, such studies are now possible and should provide a better understanding of reproductive status and reproductive success of individual northern hairy-nosed wombats and the population in general.

The aim of this action is to extract steroid hormones and to obtain DNA profiles from wombat faeces to remotely monitor the reproductive status of individuals and determine population breeding rates. This information can currently only be obtained by trapping and by monitoring footprint and dung size near burrows. Determination of breeding is an important indicator that the population is performing well or responding to particular stimuli, such as good seasonal conditions, pasture manipulation, or supplementary food and water.

Methods

A technique to remotely monitor testosterone levels in the faeces of wild male southern hairy-nosed wombats has been developed by a team led by Professor Peter Temple-Smith. In the next phase of the study, the technique will be broadened to monitor oestrogen and progesterone levels in female southern hairy-nosed wombats. Faecal DNA techniques have been used for abundance estimates on common wombats (Banks *et al*. 2002), but much of this success may have been due to the ability to extract DNA from the faeces on the day of collection (i.e. without the need for storage) in the Monash University laboratory. For this method to be a viable option for NHW, various storage protocols will need to be trialed, and/or extraction protocols will need to be modified for field conditions. The method will also need to be one that will allow faecal steroids to be monitored in the same faecal pellet. Professor Peter Temple-Smith and Dr Andrea Taylor will develop this technique from captive and field-collected southern hairy-nosed wombat faeces.

Potential contributors

Research organisations (e.g. Melbourne University, Monash University), zoos, EPA/QPWS

Action 9.3 Habitat utilisation

Justification

Although NHW habitat preferences are understood at a ‘macro’ level, micro habitat parameters (e.g. soil depth and type, degree of shade over burrows) have not yet been recorded in detail. Accurate identification of suitable NHW habitat is crucial to the successful establishment of new wild populations.

Methods

In 2003, an Honours student will record vegetation and soil parameters in wombat and non-wombat habitat at EFNP. A set of habitat descriptors will be produced that will enable the rapid identification of NHW habitat.

Potential contributors

Research organisations, partner organisations

Action 9.4 Behavioural studies

Justification

Study of the behaviour of wild northern hairy-nosed wombats will provide important baseline data for captive studies and for monitoring translocated individuals.

Methods
Behavioural studies of NHW using traditional observational methods are extremely difficult because of the species' nocturnal habits and secretive nature and the complexity of the habitat they occupy. Behavioural studies will therefore combine basic behavioural observational techniques, undertaken from fixed platforms, with high technology such as radio-location of wombats, night-vision equipment and the insertion of infra-red cameras into burrows (see Action 9.5). Radio-collars will be fitted with newly developed temperature data loggers to continually log burrow occupancy, emergence times and duration of feeding. DNA profiling methods developed in Actions 3.1 and 9.2 may also be informative for identifying burrow usage by individuals.

Potential contributors
Research organisations, EPA/QPWS, volunteers, partner organisations

Action 9.5 Burrow architecture and environment

Justification
Hairy-nosed wombats construct large multi-entrance warrens where they spend up to 80% of their lives. These warrens reduce daily temperature variation to <2°C, provide an environment of increased humidity and, in general, offer a diversity of microclimates within a single tunnel. The architecture and microclimate of NHW burrows has not been studied. Potential physiological benefits conveyed to the animals or underground social interactions are therefore unknown. Such data is essential for the planning of the translocation events and understanding population limits within burrow clusters.

Methods
Six to ten NHW burrows will be portholed using the method developed for southern hairy-nosed wombat warrens (Shimmin *et al.*, in press). Portholing involves drilling a series of 50mm holes from the surface into the tunnel, casing the holes with PVC and then lowering a camera into the tunnel. Using this method, warrens can be mapped and the portholes can also be used for environmental sampling (temperature, humidity, air flow, oxygen and CO_2). Permanent infrared cameras can also be left in portholes to monitor burrow use and behaviour.

Potential contributors
Research organisations (e.g. Adelaide University), EPA/QPWS, partner organisations

Objective 10 Manage the recovery team

Action 10.1 Co-ordination of recovery program

Justification
The NHW recovery program is a complex process that requires a full-time person to undertake the following:

- coordinate/chair the NHW recovery team;
- facilitate the implementation of recovery plan actions;
- ensure the results of research are applied to maximise effective management;
- establish and maintain a database on all aspects of *L. krefftii* and the recovery program;
- develop contingency plans to cover emergencies such as predation, wildfire or disease;
- prepare funding submissions and reports for funding bodies;
- coordinate revision of the recovery plan;
- coordinate research and management assistance (EPA/QPWS staff, researchers, students, partner organisations, volunteers) with recovery program work;
- promote public support and education in connection with the recovery program; and
- maintain good relations between EPA/QPWS and land holders near EFNP.

Methods
Co-ordination of the recovery program should be undertaken by a full-time manager/coordinator.

Potential contributors
EPA/QPWS

Action 10.2 Operation of recovery team
Justification
The NHW recovery team provides advice and assistance to EPA/QPWS with the implementation of recovery program actions. The recovery team assists with the writing and revising of the recovery plan, monitors and assesses the progress of recovery plan actions, and develops new recovery strategies when required. Composition of the recovery team will be reviewed regularly to ensure new interests that can progress the recovery of the species are appropriately represented.

Methods
The recovery team needs to meet at least twice each year (once in person and once in teleconference).

Potential contributors
EPA/QPWS, various organisations with representatives on the recovery team

Action 10.3 Recovery program assistance
Justification
Most fieldwork (e.g. trapping, burrow monitoring, hair census) at EFNP could not be undertaken without the considerable assistance of volunteers, EPA/QPWS officers, partner organisations and university researchers. Food is sometimes provided to non-EPA/QPWS staff members to support these activities.

Methods
The recovery program coordinator is responsible for ensuring that adequate assistance is available whenever recovery actions are being implemented.

Potential contributors
EPA/QPWS, partner organisations

Action 10.4 Data management
Justification
Maintenance of centralised storage systems for all data, information (eg. publications, media stories, articles), and samples relevant to the NHW will allow efficient implementation of the recovery.

Methods
The recovery program coordinator will maintain databases, files and storage systems relevant to the NHW recovery program.

Potential contributors
EPA/QPWS

Action 10.5 Program funding and sponsorship
Justification
The NHW recovery program requires a high level of funding for its operations. Major funding currently comes from the Queensland and Australian Government. Other significant funding is provided by organisations involved in the recovery program (e.g. zoos, universities) and through corporate sponsorship and public donations.

Methods
Funding for the recovery program will be achieved by producing funding applications and progress reports on schedule, by seeking corporate assistance, and through public donations. A strategic plan will be developed to maximise the potential for funding and sponsorship.

Potential contributors
EPA/QPWS, organisations involved in the recovery program, threatened species trusts/funds

Action 10.6 Recovery plan evaluation and review
Justification
A major five-year review of the recovery plan will be undertaken in accordance with EPBC Act requirements. This review provides an excellent opportunity to monitor the progress of recovery actions with respect to the stated recovery objectives. In addition, the NHW recovery plan program will be reviewed annually at recovery team meetings.

Methods
An external reviewer will be contracted to undertake the major review and to provide an in-depth report including comments on progress of each action of the recovery plan and recommendations on future directions.

Potential contributors
EPA/QPWS, recovery team, partner organisations

4. Management practices

Although limited information is available on the past distribution of the NHW, its habitat preferences are reasonably well understood. To protect NHW habitat for the establishment of future wild populations, no broadscale mechanical tree-clearing is allowed in the Brigalow Belt Biogeographic region in the regional ecosystem that wombats occupy on EFNP (regional ecosystem 11.3.7; *Corymbia* species on alluvial plains; sandy soil).

5. Estimated cost of recovery ($000's)

Action No.	Action Description	2003	2004	2005	2006	2007	Total
1.1	Dingo control	8.5	8.5	8.5	8.5	8.5	**42.5**
1.2	Monitor and control competitors	3	3	3	3	3	**15**
1.3	Habitat management	8	8	8	8	8	**40**
1.4	Pasture monitoring	3	0	3	0	3	**9**
1.5	Fire management	11.5	11.5	11.5	11.5	11.5	**57.5**
1.6	Supplementary feed and water	1	1	1	1	1	**5**
1.7	Park infrastructure and integrity	7	7	7	7	7	**35**
1.8	Permanent presence on EFNP	8.3	8.3	8.3	8.3	8.3	**41.5**
2.1	Community and volunteer involvement	0	0	0	0	0	**0**
2.2	Communications strategy	5	5	5	5	0	**20**
3.1	Hair census	0	0	30	0	0	**30**
3.2	Burrow monitoring	9.3	2	2	2	2	**17.3**
3.3	Trapping	20	0	0	0	0	**20**
3.4	Population modelling	0	10	0	0	10	**20**
3.5	Population demographics	0	10	0	0	0	**10**
4.1	Site suitability criteria	0	0	0	0	0	**0**
4.2	Site survey	2	2	2	2	2	**10**
4.3	Site assessment and selection	3	3	3	3	3	**15**
5.1	Site procurement	U	U	U	U	U	U
5.2	Site infrastructure and security	U	U	U	U	U	U
5.3	Habitat management / threat control	U	U	U	U	U	U
6.1	SHW translocation trials	25	25	0	0	0	**50**
6.2	NHW translocation trial in EFNP	0	0	0	10	0	**10**
6.3	NHW translocation to new site	0	0	0	0	20	**20**
6.4	Monitor translocated wombats	0	0	0	0	40	**40**
7.1	Refine husbandry techniques	35	35	35	35	35	**175**
7.2	Develop breeding techniques	50	50	50	50	50	**250**
8.1	Establish captive facilities for NHW	0	0	0	150	0	**150**
8.2	Select and acclimatise NHW at EFNP	0	0	0	42.5	0	**42.5**
8.3	Establish NHW at permanent facility	0	0	0	0	30	**30**
9.1	Dietary studies	0	0	0	0	10	**10**
9.2	Monitoring reproduction	15	15	12	0	0	**42**
9.3	Habitat utilisation	10	0	0	0	0	**10**
9.4	Behavioural studies	0	18	0	0	0	**18**
9.5	Burrow architecture and environment	10	6	6	2	2	**26**
10.1	Coordination of recovery program	80	81.5	83	84.5	86	**415**
10.2	Operation of recovery team	5	5	5	5	5	**25**
10.3	Research assistance	5.5	5.5	5.5	5.5	5.5	**27.5**
10.4	Data management	0	0	0	0	0	**0**
10.5	Program funding and sponsorship	0	0	0	0	0	**0**
10.6	Recovery plan evaluation and review	0	0	0	0	5	**5**
Total	(less 5.1–5.3)	**325.1**	**320.3**	**288.8**	**443.8**	**355.8**	**1733.8**

U = Unknown at this time NHW = northern hairy-nosed wombat SHW = southern hairy-nosed wombat

6. Acknowledgments

I would like to acknowledge the contribution made by the following people to this revision of the recovery plan: Greg Edmed, Greg Gordon (EPA/QPWS), Andrea Taylor (Monash University), Peter Temple-Smith (Zoos Australia), Glenn Shimmin (Adelaide University), Catriona MacCallum (Western Plains Zoo), Jan Oliver (Wildlife Preservation Society of Queensland).

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8. Glossary

demographic stochasticity
Variability in population growth rates arising from random differences among individuals in survival and reproduction within a season. This may happen even if all individuals have the same expected ability to survive and reproduce from one generation to the next. Demographic stochasticity is important in small populations, particularly in threatened species.

environmental stochasticity
Variability in birth and death rates from one season to the next in response to weather, disease, competition, predation, or other factors external to the population. Environmental stochasticity can affect large populations but is particularly important in small populations and threatened species.

metapopulations
A set of semi-isolated populations (or "sub-populations") in which individual populations may become extinct but can be recolonised from other populations. In the case of threatened species such as the northern hairy-nosed wombat, recolonisation is often prevented by fragmentation of habitat and the isolation of sub-populations. For northern hairy-nosed wombats recolonisation would need to be facilitated by managers.

oestrous
A hormonally controlled cycle of activity of the reproductive organs in many female mammals.

phylogeny
Genetic family tree.

polyoestrous
Having more than one period of oestrous per year.

post-partum
Occurring soon after birth.

Appendix 1: Recovery team

Member	*Position/Role*	*Organisation*
Dr Alan Horsup Rockhampton	Chair, ecologist	EPA/QPWS,
Vicki Crichton	Ranger, Epping Forest NP	EPA/QPWS
Dr Peter Temple-Smith	Reproductive ecologist	Melbourne University
Dr Andrea Taylor	Conservation geneticist	Monash University
Dr Glenn Shimmin	Conservation biologist	Adelaide University
Dr Benn Bryant	Life Sciences Manager	Western Plains Zoo
Mr Paul O'Callaghan	Life Sciences Manager	Australia Zoo
Mr Andrew Dinwoodie	Council member, public representative	Wildlife Preservation Society Qld (Mackay)

Appendix 2: Recovery Plan Project Design

Overall Objective (short-term)		Specific Objectives		Performance Criteria		Actions
To achieve a total population of a minimum of 150 NHW in two wild populations and at least one captive population.	→	1. Identify and control threats and manage habitat to optimise conditions for NHW survival at Epping Forest NP.	→	Habitat optimised and threats minimised on Epping Forest NP.	→	1.1 Dingo control 1.2 Monitor and control competitors 1.3 Habitat management 1.4 Pasture monitoring 1.5 Fire management 1.6 Develop supplementary feed and water provision 1.7 Park infrastructure and integrity 1.8 Permanent management presence on Epping Forest NP
	→	2. Facilitate community involvement and education in NHW conservation.	→	Increased community awareness and involvement.	→	2.1 Community and volunteer involvement 2.2 Communications strategy
	→	3. Accurately monitor wombats.	→	Increased population size, improved population composition and extended distribution detected.	→	3.1 Hair census 3.2 Burrow monitoring 3.3 Trapping 3.4 Population modelling 3.5 Population demographics
	→	4. Finalise selection of translocation site.	→	Translocation site selected.	→	4.1 Site suitability criteria 4.2 Site survey 4.3 Site assessment and selection
	→	5. Prepare and manage translocation site.	→	Translocation site procured and prepared.	→	5.1 Site procurement 5.2 Site infrastructure and security 5.3 Habitat management and threat control
	→	6. Translocate NHW.	→	Second wild population of NHWs established.	→	6.1 SHW translocation trials 6.2 NHW translocation trial in Epping Forest NP 6.3 NHW translocation to new site 6.4 Monitor translocated wombats
	→	7. Develop captive techniques in other wombat species.	→	Improved captive breeding success achieved in other wombat species.	→	7.1 Refine husbandry techniques on other wombat species 7.2 Develop breeding techniques on other wombat species
		8. Establish NHW in captivity.	→	Captive population of NHW established to support wild population management.	→	8.1 Establishment of captive facilities for NHW 8.2 Selection and acclimatisation of NHW at Epping Forest NP 8.3 Establishment of NHW at permanent facility
	→	9. Increase understanding of wombat biology and ecology.	→	Wombat biology and ecology better understood.	→	9.1 Dietary studies 9.2 Monitoring reproduction 9.3 Habitat utilisation 9.4 Behavioural studies 9.5 Burrow architecture and environment
	→	10. Effectively manage the recovery program.	→	The recovery program is managed effectively to ensure implementation of all actions on schedule.	→	10.1 Coordination of recovery program 10.2 Operation of recovery team 10.3 Research assistance 10.4 Data management 10.5 Program funding and sponsorship 10.6 Recovery plan evaluation and review