

TABLE OF CONTENTS

Page

Summary	3
1. Introduction	7
Description	7
Distribution and Abundance	7
Habitat	8
Life History	8
Reasons for Listing	10
Existing Conservation Measures	12
2. Recovery Objectives	15
Overall Objective	15
Specific Objectives	15
Recovery Criteria	15
Recovery Actions	16
3. Implementation Schedule	30
Acknowledgments	31
References	32

SUMMARY

Current Species Status:

Endangered (Schedule 1, *Endangered Species Protection Act* 1992, IUCN Red List of Threatened Animals 1994, ANZECC 1991, CNR 1995). In Victoria, Leadbeater's Possum is listed as a threatened taxon on Schedule 2 of the *Flora and Fauna Guarantee Act* 1988. Leadbeater's Possum was thought to be extinct following no records for 50 years when it was rediscovered in the Central Highlands of Victoria (Wilkinson 1961). Since then it has been recorded at approximately 300 localities, over an area of approximately 80 km east to west and 65 km north to south (Macfarlane and Seebeck 1991). The species is now primarily restricted to the tall eucalypt forests of Mountain Ash, Alpine Ash and Shining Gum in the Central Highlands, where it occurs in numerous scattered patches throughout the area.

Habitat Requirements and Limiting Factors:

Optimum habitat of Leadbeater's Possum is young regenerating or mixed-aged ash forest that contains both wattles and an ample supply of old hollow trees. The occurrence and quality of habitat is primarily determined by patterns of successional change and stand development resulting from disturbance such as past wildfires and timber harvesting operations. Regrowth from the 1939 wildfires, combined with fire-killed remnants of mature forest, has provided abundant feeding and nesting habitat during the past 30 years.

Older-aged¹ and mixed-aged forest containing hollow-bearing trees also support populations of Leadbeater's Possum, although not in the same high densities that may be found in suitable regrowth forests. However, their role in the medium-term (50 - 105 years) will be critical for the conservation of the species because these forests are not subject to a rapid decline in habitat suitability as predicted in current high value habitat regrowth forests. Older-aged forest and mixed-aged forest with hollow-bearing trees and a low occurrence of wattles are defined as potentially optimum habitat because of their potential to become optimum in the short term (< 50 years), as a result of natural or deliberate disturbance.

Key threats are that fire-killed remnants are rapidly decaying and falling over and recruitment of hollows suitable for the species will not occur in 1939 regrowth forest for approximately another 140 years. The occurrence of large wildfires is also a key threat to the long term viability of habitat in older-aged forest and mixed-aged forest.

Overall Objective:

To downlist Leadbeater's Possum from endangered to vulnerable within 10 years based on the IUCN (1994) criteria of population trend and size, extent of occurrence, probability of extinction, and the management of habitat towards a target of no more than a 1% probability of extinction over 250 years throughout the forest within its current range.

Specific Objectives:

- 1. Identify and implement protection of optimum and potentially optimum habitat² throughout the known range of the species, including the establishment of a permanent reserve system. All references in this recovery plan to a permanent reserve system refer to a comprehensive, adequate and representative (CAR) reserve system established consistent with the JANIS³ criteria.
- 2. Apply strategies that address the development and continued availability of adequate high quality habitat in each Leadbeater's Possum Management Unit (LMU) for the future.
- 3. Implement population monitoring of Leadbeater's Possum throughout its range and assess the effectiveness of the reserve system for the species conservation, using rigorous experimental design.

¹Older-aged forests are defined as comprising stands of trees established prior to approximately 1900.

² Optimum habitat of Leadbeater's Possum is young regenerating or uneven-aged ash forest that contains both wattles and an ample supply of old hollow trees.

³ JANIS 1996. The proposed nationally agreed criteria for the establishment of a comprehensive, adequate and representative reserve system for forests in Australia. Joint ANZECC/MCFFA National Forest Policy Statement Implementation Subcommittee; Canberra.

- 4. Develop management guidelines for Leadbeater's Possum throughout its range. In particular develop and apply modified and alternative silvicultural systems that result in the continuing presence of high quality habitat, while providing for commercial timber production.
- 5. Implement training for all relevant field and planning staff involved with Leadbeater's Possum management and timber production within its range in relation to ecology, habitat assessment and progress towards implementation of Leadbeater's Possum management guidelines and this Recovery Plan.
- 6. Undertake research on the biology and ecology of the species with particular emphasis on the risk of wildfire reducing strategic populations, the dispersal and recolonisation capacities of the species and response to edge effects.

Recovery Criteria:

- 1. Identify all optimum and potentially optimum habitat within the known range of the species by 1997 and have this data scanned and entered onto NRE's Geographic Information System (GIS).
- 2. Establish a permanent reserve system in 10 Leadbeater's Possum Management Units (LMU) by June 1997 and the remaining LMU's by June 1998. The reserve system will include strategic areas of both existing optimum and potentially optimum habitat with a target of at least 600 ha of ash forest in each designated LMU.
- 3. Develop and implement a monitoring program based on rigorous experimental design to assess population status of Leadbeater's Possum throughout its range and the effectiveness of the reserve system for the conservation of the species.
- 4. Existence of management guidelines that address the conservation of Leadbeater's Possum throughout its range. Including the application of modified or alternative silvicultural prescriptions to protect and promote the availability of hollow-bearing trees, specifically in the Special Management Zone (SMZ) implemented through the Central Highlands Forest Management Plan.
- 5. Implement training for all relevant field and planning staff, and monitor and report annually on progress towards implementation of Leadbeater's Possum management guidelines as contained in the Central Highlands Forest Management Plan.
- 6. Establish research projects by 1997 addressing the dispersal and recolonisation capacities of the species, modelling of fire as it relates to the risks of reducing populations of Leadbeater's Possum and response to edge effects.

Actions Needed:

- 1. The Leadbeater's Possum Management Team (LMT) to continue to monitor and review recovery program and recommend further management actions.
- 2. Apply conservation strategies in each of the 21 Leadbeater's Possum Management Units (LMUs).
- 3. Complete habitat resource assessment across known range of the species.
- 4. Zone all areas of forest within known range of Leadbeater's Possum according to habitat suitability.
- 5. Establish a reserve system across the range of the species based on habitat suitability.
- 6. Implement population monitoring throughout known range
- 7. Apply guidelines during logging coupe planning and harvesting and adopt modified or alternative silvicultural systems
- 1.1 Assess development proposals which could affect Leadbeater's Possum for areas outside State forest.
- 8.2 Determine management objectives for the populations of Leadbeater's Possum in the Yellingbo State Nature Reserve and snow gum forests at Lake Mountain and Mt. Baw Baw
- 1. Implement training programs to ensure quality application of, and implementation of, management guidelines.
- 10.1 Research on dispersal and recolonisation capacities-
- 10.2 Response to edge effects
- 10.3 Fire modelling

The Actions above are listed in order of priority for implementation recognising that some actions need to be undertaken concurrently.

The Proposed Forest Management Plan for the Central Highlands (NRE, 1996) implements Action 5, and will be reflected in the Central Highlands Regional Forest Agreement, and specifies measures that will implement Actions 2 and 7.

Estimated Cost of Recovery:

Error! Not a valid link.

Biodiversity Benefits:

Successful management for the long-term conservation of Leadbeater's Possum offers clear benefits to a wide range of other hollow-dependent fauna inhabiting Leadbeater's Possum habitat, in particular the montane ash forests of Victoria. This group of animals has been identified as those most at threat as a result of some past and present management activities. In addition, adoption of actions outlined in this Plan will ensure the protection of **all** montane ash old-growth and older-aged forests in the Central Highlands of Victoria.

Table 2: Relationships between the objectives, criteria and actions in the recovery plan.

Overall Objective: To downlist Leadbeater's Possum from endangered to vulnerable within 10 years based on the IUCN (1994) criteria of population trend and size, extent of occurrence and probability of extinction.

S	pecific Objectives	C	riteria	A	ctions
1.	Identify and implement protection of optimum and potentially optimum habitat including the establishment of a permanent reserve system.	− 1.	Identify and enter onto GIS all optimum and potentially optimum habitat by 1997.	1. —2.	Monitor and review the recovery program via the Leadbeater's Possum Management Team (LMT). Identify and map Leadbeater's Possum Management Units (LMUs).
				-3.	Complete habitat resource assessment
				-4.	Zone all areas of forest within known range of Leadbeater's Possum according to habitat suitability.
2.	Apply strategies that address the development and continued availability habitat in each Leadbeater's Possum Management Unit (LMU).	+2.	Establish a permanent reserve system in 10 Leadbeater's Possum Management Units (LMU) by June 1997 and the remaining LMU's by June 1998.	<u> </u>	Establish a reserve system across the range of the species based on habitat suitability.
3.	Implement population monitoring of Leadbeater's Possum.	<u>-3</u> .	Develop and implement a monitoring program of Leadbeater's Possum and the effectiveness of the reserve system.	—6.	Implement population monitoring
4.	Develop management guidelines for Leadbeater's Possum throughout its range.	-4.	Existence of management guidelines that address the conservation of Leadbeater's Possum throughout its range.	7.	Apply guidelines during logging coupe planning and harvesting and adopt modified or alternative silvicultural systems
				-8.	1 Assess development proposals which could affect Leadbeater's Possum in areas outside State Forest
				⊢8.	2 Determine management objectives for the populations of Leadbeater's Possum in the Yellingbo State Nature Reserve and snow gum forests at Lake Mountain and Mt. Baw Baw
5.	Implement training for all relevant field and planning staff.	-5.	Implement training for all relevant field and planning staff and monitor implementation of management guidelines.	<u>-9</u> .	Implement training programs to ensure quality application of, and implementation of, management guidelines.
6.	Undertake research on biology and ecology.	<u>-6</u> .	Establish research projects by 1997.		0.1 Research on dispersal and recolonisation capacities0.2 Response to edge effects0.3 Fire modelling

1. INTRODUCTION

Description

Leadbeater's Possum (*Gymnobelideus leadbeateri*) is a small omnivorous arboreal marsupial with a head and body length between 150 and 170 mm and a tail length between 145 and 180 mm. The animal weighs between 100 and 135 g in the spring and 110 and 166 g in the autumn. It is grey to greyish-brown above and paler below with a prominent dark mid-dorsal stripe. Leadbeater's Possum is distinguishable from the related Sugar Glider (*Petaurus breviceps*) by the absence of a gliding membrane and a club-shaped tail, broader near the tip than at the base (Smith 1980).

Distribution and Abundance

Until 1961, Leadbeater's Possum was known from only five specimens which had been collected prior to 1910. Four of these had originally been assumed to have come from the Bass River region in south-western Gippsland. As most of the forest and scrub in this area had been cleared for agriculture by early in the twentieth century, the possum was presumed extinct. However, in 1931 a fifth specimen, which had been previously overlooked, was found to have been collected in 1909 at Sunnyside, Mt Wills, approximately 250 km north-east of the Bass River locality (Brazenor 1932). It was also determined by Brazenor that one of the specimens which had been assumed to have come from the Bass River had in fact come from the edge of the Koo-Wee-Rup swamp, near the township of Tynong, more than 30 km north. Recently, a further specimen was discovered that had been sent to the National Museum of Victoria in the early 1960s from a museum in Beechworth, northern Victoria (Lindenmayer and Dixon 1992). This specimen was thought to be between 50 and 100 years old at the time of transfer, but the site of collection could not be determined. The localities of these specimens indicated that the possum had a wider distribution than previously thought and naturalists conducted a number of searches in these localities (Brazenor 1931, 1946; Fleav 1933, 1947). These searches were unsuccessful and in 1960 Leadbeater's Possum was listed as 'probably extinct' by the International Union for the Conservation of Nature (Calaby 1960). However, one year later the possum was re-discovered at Tommy's Bend, near Marysville in the Central Highlands of Victoria (Wilkinson 1961). This discovery, the first for this region, resulted in many exploratory surveys in montane ash forests and there was a sudden and increasing number of sightings within the Central Highlands.

Since its re-discovery in 1961, Leadbeater's Possum has been recorded at approximately 300 localities. However, some of these sites have since been disturbed by fire and logging and all have been subject to successional changes so many may no longer contain suitable habitat. More than half of the site localities have been recorded during the last decade (Atlas of Victorian Wildlife Database, Flora and Fauna Branch, Department of Natural Resources and Environment). This may reflect increased survey activity and improved detection methods. Records since the species' rediscovery indicate that Leadbeater's Possum is mainly confined to montane ash forests, dominated by *Eucalyptus regnans, E. delegatensis* or *E. nitens*, in the Central Highlands of Victoria (Figure 1). It appears that the possum is not uniformly distributed throughout this area, but occurs in patches of suitable habitat positively influenced by past wildfires and selective timber harvesting operations. Extensive field data collection and subsequent analyses have indicated that Leadbeater's Possum is most likely to be detected on sites which support numerous trees with hollows and a dense understorey of *Acacia* spp. trees (Lindenmayer *et al.* 1991b). No asymptote was identified in these relationships and the probability of

occurrence of Leadbeater's Possum increases with the availability of both these habitat attributes. In addition, on sites where the species occurs, populations of animals are likely to be most abundant in forests on flat terrain and characterised by few shrubs, numerous hollow-bearing stems and a dense understorey of *Acacia* spp. trees (Lindenmayer *et al.* 1991b). Notably, subsequent field work has validated these relationships and the statistical models perform well when subject to rigorous testing (Lindenmayer *et al.* 1994).

Of considerable interest are a number of recent records within snow gum *E. pauciflora* woodland at Lake Mountain in the Victorian Alps (Jelinek *et al.* 1995). Leadbeater's Possum has been observed previously in snow gum woodland at Lake Mountain and the Mt Baw Baw area, however, the recent records involved daytime observations of animals sheltering in 2-3m high snow gum stumps with obvious hollows. These observations suggest the possibility of the species establishing territories totally within snow gum woodlands and not just being nocturnal visitors from adjacent montane ash forests as was previously thought. Other records exist in the forests of eastern Victoria, but all are unconfirmed except for a small resident colony in a lowland *E. camphora* and *E. ovata* dominated swamp forest at Cockatoo Creek, in Yellingbo State Nature Reserve (Smales 1994, Thomas 1989). The habitat at that site contrasts markedly with that of the montane forests of the Central Highlands. However, it may be similar to the habitat from which the Tynong specimen had been collected in the Koo-Wee-Rup swamp, long since drained and cleared.

Habitat

The most important components of Leadbeater's Possum habitat are nest-tree abundance, vegetation structure and food availability. Large old hollow trees (either dead or alive) for nesting and shelter are essential for the survival of Leadbeater's Possum. Leadbeater's Possum prefer short, fat trees with numerous holes and a large quantity of dense surrounding vegetation (Lindenmayer *et al.*, 1991a). Leadbeater's Possum harvests a dispersed food supply, and because the species lacks a gliding membrane animals must rely on running and jumping to move from tree to tree. This requirement is best met in structurally dense regrowth or understorey vegetation (Smith 1982). The major components of Leadbeater's Possum diet are obtained from smooth-barked eucalypts and some species of wattle (Smith 1984; Lindenmayer *et al.*, 1991b).

Life History

Leadbeater's Possum is a communally-nesting species and colonies of up to 12 animals actively defend territories of approximately 2-3 ha (Lindenmayer and Possingham 1994). Colonies have a matriarchal social structure and usually consist of a monogamously-mated breeding pair, young offspring that have not dispersed and unrelated non-breeding adult males (Smith 1984). Leadbeater's Possum may breed twice annually, although the autumn/winter season is less productive than the spring/summer season (Smith 1980; 1984). The species is polyoestrous, and if the first litter is lost a second one may be produced in the same breeding season (Smith 1980). A maximum of two young are produced in a litter (Smith 1980). Success in breeding appears to be largely related to food supply and under conditions of excess resource availability the species has a

Figure 1: Range of Leadbeater's Possum

relatively high innate capacity for increase (Smith 1984). Female offspring disperse at an earlier age (10 months) than males (15 months) and suffer a high mortality due to their exclusion from established colonies (Smith 1984).

Reasons for listing.

Leadbeater's Possum is the only member of the genus *Gymnobelideus* and wild populations are confined to Victoria. This means that the survival of the species in the wild is totally dependent on conservation measures undertaken in Victoria.

Leadbeater's Possum now appears to be mainly confined to the montane ash forests of the Central Highlands of Victoria. Records from last century and early this century come from a larger area of the State, but not from interstate, with one record from the north-east of the State and four from south-western Gippsland. These indicate a probable range reduction within Victoria. The known range of the species expanded rapidly following rediscovery in 1961, and this trend, although slower in recent times, has continued. This is probably due to increasing search efforts and improved detection methods.

The current and predicted abundance of Leadbeater's Possum, within its known range, is based on the results of analyses using multiple regression models (Smith and Lindenmayer 1992). These models and others, that address a predicted reduction in the availability of nest trees (Lindenmayer et al., 1990), indicate a massive decline of Leadbeater's Possum between the present and the year 2020, followed by a population bottleneck lasting until the year 2075. This predicted "bottleneck" means that for a period of 55 years, from the year 2020 to 2075, habitat suitable for Leadbeater's Possum, and by implication population size, will be at its lowest.

Smith *et al.* (1985), and Smith and Lindenmayer (1988) pointed out that existing nesttrees in 1939 regrowth forests or recently-logged regrowth forests are being reduced by logging or natural decay more rapidly than replacement hollows are developing. Thus, the suitability of regrowth forest for Leadbeater's Possum is declining and it is in these regrowth forests where the highest densities of Leadbeater's Possum may be currently found. Further, regrowth forests constitute approximately 82% of forests within the known range of the species (CNR Forest Information Section, 1994). Smith and Lindenmayer (1988) asserted that, since Leadbeater's Possum does not prefer living mature trees as nest sites until they exceed 2 m dbh (approximately 200 years old), the loss of dead hollow-bearing trees due to natural fall would render much existing regrowth forest unsuitable during the next 140 years . Smith *et al.* (1985) estimated a reduction in population size of 92% based on their data from a small area of ash forest in the Cambarville region of the Central Highlands. However, these authors noted this was likely to be an over estimate due to the presence of scattered mature living trees in some regrowth forests.

Optimum habitat of Leadbeater's Possum is a young regenerating or mixed-aged ash forest that contains both wattles and an ample supply of old hollow trees (Lindenmayer *et al.*, 1991b). This optimum habitat is most likely to occur in Mountain Ash forest and is induced primarily by patterns of successional change and stand development that may be induced by fire or selective timber harvesting operations. Regrowth from the 1939 wildfires, combined with fire-killed remnants of mature forest, has provided abundant

feeding and nesting habitat during the past 30 years. However, the recruitment and continuing occurrence of large old hollow trees is dependent on the absence of intense fire and clear felling operations for periods greater than 200 years (Lindenmayer *et al.*, 1991c).

Older-aged⁴ and mixed-aged forest containing hollow-bearing trees also support populations of Leadbeater's Possum, although not in the same high densities that may be found in suitable regrowth forests. However, their role in the medium-term (50 - 105 years) will be critical for the conservation of the species because these forests are not subject to a rapid decline in habitat suitability as predicted in current high value habitat regrowth forests. Mixed-aged forest with hollow-bearing trees and a low occurrence of wattles and older-aged forest are defined as potentially optimum habitat because of their potential to become optimum in the short term (< 50 years), as a result of natural or deliberate disturbance.

A Population Viability Analysis (PVA), using VORTEX software, has shown that, for a 100 year projection, simulated populations of 200 animals or more remained demographically stable and experienced a less-than-10% decline in predicted genetic variability (Lindenmayer *et al.* 1993). With a mean density of one animal per 3 ha of old growth forest (Lindenmayer 1989) populations of Leadbeater's Possum could survive in areas of mature forest as small as 600 ha, such as those currently in the Yarra Ranges National Park that are not subject to timber harvesting. This approach will not adequately conserve Leadbeater's Possum throughout the species range. However, the relatively simplified nature of population modelling and the suite of assumptions which underpin VORTEX mean that the probability of extinction of populations of this size may be greater than determined in this study. As a result, it is possible that only populations of > 200 animals may persist in the long-term where suitable habitat can be conserved or established, and subsequently maintained without a reduction in carrying capacity.

A more recent and detailed PVA, undertaken by Lindenmayer and Possingham (1994), was commissioned by NRE and ANCA as part of developing strategies for the conservation of the species. The PVA simulated the dynamics of metapopulations of Leadbeater's Possum in three forest blocks where timber harvesting is permitted and one closed water catchment. This study combined extensive information on the life history attributes of Leadbeater's Possum, the habitat requirements of the species, the spatial distribution of suitable habitat patches, changes in the temporal suitability of forest habitats, and data on the frequency and impact of disturbances such as logging operations and wildfire. Spatial data on the distribution of different types of habitat patches were derived from detailed forest inventory information that has been captured in a Geographic Information System (GIS) developed by NRE. The analysis predicted the likelihood of Leadbeater's Possum becoming extinct within the next 150 years in two of the three forest blocks studied due to the limited areas of existing older-growth montane ash forest. A higher probability of persistence was predicted in the other forest block and the water catchment which were characterised by larger patches of old- growth forest. The three blocks and the water catchment studied represent a wide range of older-aged forest occurrence, including the extremes. On the basis of this work, the authors strongly recommended that a key forest wildlife management objective must be to grow areas of existing regrowth forest through to ecological maturity or old-growth status (i.e. > 250 years).

⁴ Older-aged forests are defined as comprising trees established prior to approximately 1900.

Wildfires were predicted to have a major negative effect on the persistence of populations of Leadbeater's Possum, particularly in areas supporting limited areas of old-growth forest (Lindenmayer and Possingham 1994). It is important to note that wildfire has been instrumental in the habitat development process, but the scale and intensity of wildfires since European settlement, most notably the 1939 wildfires, has resulted in approximately 82% of ash type forests in the Central Highlands being regrowth with few live hollow-bearing trees. Consequently, these regrowth forests require more than 150 years of growth before fire can effectively create the necessary floristics and structural diversity critical for Leadbeater's Possum habitat. Therefore more frequent, extensive, high intensity wildfires are a major threat to the survival of Leadbeater's Possum. Current efforts to prevent uncontrolled wildfire occurring in the montane ash forests of the Central Highlands should continue.

Lindenmayer and Possingham (1994) included a number of other recommendations in their report based on the PVA analysis and other research. These included the need to address the conservation of Leadbeater's Possum in each forest block and the three major water catchments within the distribution of the species; in each forest block logging should be excluded from 600-1000 ha of ash-type eucalypt forest; such areas should not be salvage logged or confined to steep and rocky or riparian areas; in each forest block there should be an array of reserved areas of between 50 and 100 ha in size and a GIS-based analysis should be used to identify the optimum reserve system within each forest block. These recommendations are generally reflected in current management strategies for the conservation of the species.

Existing conservation measures

Under the *Flora and Fauna Guarantee Act 1988*, Action Statement number 62 was published (Macfarlane *et al.* 1995). This Recovery Plan has been prepared to meet the requirements of the *Commonwealth Endangered Species Protection Act 1992*. Broad guidelines and principles to achieve a balance in Victoria between timber production and environmental protection have been developed in the Code of Forest Practices for Timber Production (Department of Natural Resources and Environment 1996). A requirement of this "Code" is the production of Forest Management Plans (FMPs) which include detailed prescriptions for the conservation of native forest fauna. Implementation of the forest management components of the Action Statement will be by the Forest Management Plan - Central Highlands, which will be reflected in the Central Highlands Regional Forest Agreement. The proposed plan was published for comment in December 1996 and has established a comprehensive system of retained habitat for Leadbeater's Possum.

The land use of the forests within the known distribution of Leadbeater's Possum includes forest where timber harvesting is permitted (69%), and parks and reserves (31%) (Land Conservation Council 1994). A further 27% of State forest is excluded from timber harvesting by prescription. The majority of the reserved forest is contained within the recently legislated Yarra Ranges National Park, which is strategically placed at the core of the species' distribution. The Park encloses three large water catchments, comprising the most extensive areas of old-growth and mixed-age forest in this region and represents a critical medium and long-term resource of hollow-bearing trees.

In closed water catchments, parks and reserves, Leadbeater's Possum habitat is not subjected to the degree of change by deliberate management as in State Forest. However, in State forest (forest where timber harvesting is permitted) the current system of harvesting and regenerating ash forests is clearfelling. In areas harvested, this involves the removal of all merchantable trees at one felling, followed by seedbed preparation by either burning or mechanical disturbance, and artificial sowing or planting. Large old dead and live trees are left standing on the coupe unless they: (a) present an unacceptable safety hazard, or (b) are chosen for seed collection. It is considered that the current clearfelling practice has the potential to meet the majority of the key silvicultural requirements that have been delineated by past research (Campbell *et al.* 1984). From an operational view-point, the method is comparatively simple, safe and easily supervised. However, for the conservation of hollow-dependent forest fauna, including Leadbeater's Possum, the current practice has two major problems. Firstly, retained trees within the coupe are subject to a high intensity regeneration fire and then to varying degrees of exposure. For these reasons it cannot be guaranteed that these trees will remain standing through the following rotation. Secondly, the current system is planned to operate on a nominal 80 year rotation, which leaves minimal allowance for any trees on logging coupes to grow to ecological maturity and thus develop hollows for future use. Trees in retained areas will thus provide the major source of new hollows.

In 1991, the then Victorian Department of Conservation and Environment released Draft Management Strategies for the Conservation of Leadbeater's Possum, *Gymnobelideus leadbeateri*, in Victoria (Macfarlane and Seebeck 1991). The aim of the Strategies was to ensure the long-term conservation of Leadbeater's Possum over the known range of the species. Conservation management is based on a combination of habitat protection and habitat development. Implementation began immediately, although the Strategies were intended to be adaptive and reviewed and revised as new information on the biology and ecology of the species became available (Macfarlane and Seebeck 1991). The Strategies classified all State forest into three management zones based on the growth stage of ash forest and the density of hollow-bearing trees. The objective of this zoning system was to protect both optimum and potentially optimum habitat.

The Management Strategies recognised that a geographic information system (GIS) is essential to map the management zones and assess the impact of the Strategies on timber harvesting. Consequently, aerial photograph interpretation (API) is being used to map attributes such as forest type, growth stages and all individual emergent live and dead hollow-bearing trees. The data are scanned and entered onto GIS. The GIS is then used to generate a map of zones excluded from timber harvesting and to measure the impact of habitat protection and habitat development on the availability of forest for timber harvesting. The mapping of hollow-bearing trees, growth stages and forest types by API is complete for forest, covering 75% of the distribution of Leadbeater's Possum (Smith and Macfarlane 1994). The production of maps showing management zones has assisted field staff to implement habitat protection and assisted in general forest planning. Using GIS for the storage and analysis of habitat resource information, such as the distribution of hollow-bearing trees, has also provided the flexibility to be adaptive in applying management strategies for Leadbeater's Possum. For example, data on the distribution of hollow-bearing trees, captured on GIS, can be used to review the zoning system by modelling alternative strategies.

Unfortunately, mapping by API is not able to identify forest with dead hollow-bearing trees that do not protrude above the regrowth canopy. Consequently many areas of currently optimum habitat are not mapped by this method and alternative methods such as ground and helicopter survey are also necessary to check for habitat in proposed logging coupes before harvesting. It is not feasible for these methods to rapidly cover the same extent of forest as can be achieved by API and quantitative measures of the overall distribution and amount of high quality habitat are not available. However, while areas

containing numerous dead hollow-bearing trees below the canopy currently contain high densities of Leadbeater's Possum, these areas are predicted to be the first to decline in habitat quality (within the next 30 years), due to decay and collapse of hollow-bearing trees.

The Land Conservation Council (1994) in its recommendations to Government made the following specific recommendations with regard to the conservation of Leadbeater's Possum:

- Suitable habitat should be maintained across the distribution of Leadbeater's possum in the Central Highlands to provide for the long-term survival of the species.
- Where they have been identified as providing important habitat for hollow-dependent species, older-aged ash forests (essentially comprising trees established prior to 1900), mixed-aged ash forests in which the older-aged trees predominate and individual, living older-aged ash eucalypt trees should be conserved.
- A proportion of the regrowth ash forest in the Central Highlands should similarly be set aside.
- Salvage logging following fire or other damaging agency should take place according to established procedures that protect the habitat of Leadbeater's possum.
- Management prescriptions, which may include specific silvicultural practices, should be developed for timber production forests in order to conserve existing habitat as a complement to the reserve system and to enhance and increase suitable habitat for hollow-dependent fauna, particularly Leadbeater's possum.
- Subject to other requirements for nature conservation, such as to provide for the protection of other specific plants and animals, the remaining regrowth ash forests should be available for timber production.

2. RECOVERY OBJECTIVES

Overall Objective

To downlist Leadbeater's Possum from endangered to vulnerable within 10 years based on the IUCN (1994) criteria of population trend and size, extent of occurrence, probability of extinction, and the management of habitat towards a target of no more than a 1% probability of extinction over 250 years throughout the forest within its current range.⁵

Specific Objectives

- 1. Identify and implement protection of optimum and potentially optimum habitat⁶ throughout the known range of the species, including the establishment of a permanent reserve system. All references in this recovery plan to a permanent reserve system refer to a comprehensive, adequate and representative (CAR) reserve system established consistent with the JANIS⁷ criteria.
- 2. Apply strategies that address the development and continued availability of adequate high quality habitat in each Leadbeater's Possum Management Unit (LMU) for the future.
- 3. Implement population monitoring of Leadbeater's Possum throughout its range and assess the effectiveness of the reserve system for the species conservation, using rigorous experimental design.
- 4. Develop management guidelines for Leadbeater's Possum throughout its range. In particular develop and apply modified and alternative silvicultural systems that result in the continuing presence of high quality habitat, while providing for commercial timber production.
- 5. Implement training for all relevant field and planning staff involved with Leadbeater's Possum management and timber production within its range in relation to ecology, habitat assessment and progress towards implementation of Leadbeater's Possum management guidelines and this Recovery Plan.
- 6. Undertake research on the biology and ecology of the species with particular emphasis on the risk of wildfire reducing strategic populations, the dispersal and recolonisation capacities of the species and response to edge effects.

⁵It is recognised that it is not currently possible to accurately measure this criterion, but the current risk of extinction of the species has been determined in this fashion, which in turn, has had substantial influence in the development of conservation strategies for the species. The same process, improved over time, will provide a relative measure of positive or negative success towards the stated target.

⁶ Optimum habitat of Leadbeater's Possum is young regenerating or uneven-aged ash forest that contains both wattles and an ample supply of old hollow trees.

⁷ JANIS 1996. The proposed nationally agreed criteria for the establishment of a comprehensive, adequate and representative reserve system for forests in Australia. Joint ANZECC/MCFFA National Forest Policy Statement Implementation Subcommittee; Canberra.

Recovery Criteria

The identification number of each criterion (below) corresponds to the identification number of the Specific Objectives (above).

- 1. Identify all optimum and potentially optimum habitat within the known range of the species by 1997 and have this data scanned and entered onto NRE's Geographic Information System (GIS).
- 2. Establish a permanent reserve system in 10 Leadbeater's Possum Management Units (LMU) by June 1997 and the remaining LMU's by June 1998. The reserve system will include strategic areas of both existing optimum and potentially optimum habitat with a target of at least 600 ha of ash forest in each designated LMU.
- 3. Develop and implement a monitoring program based on rigorous experimental design to assess population status of Leadbeater's Possum throughout its range and the effectiveness of the reserve system for the conservation of the species.
- 4. Existence of management guidelines that address the conservation of Leadbeater's Possum throughout its range. Including the application of modified or alternative silvicultural prescriptions to protect and promote the availability of hollow-bearing trees, specifically in the Special Management Zone (SMZ) implemented through the Central Highlands Forest Management Plan.
- 5. Implement training for all relevant field and planning staff, and monitor and report annually on progress towards implementation of Leadbeater's Possum management guidelines as contained in the Central Highlands Forest Management Plan.
- 6. Establish research projects by 1997 addressing the dispersal and recolonisation capacities of the species, modelling of fire as it relates to the risks of reducing populations of Leadbeater's Possum and response to edge effects.

Recovery Actions

Management for the conservation of Leadbeater's Possum will continue to be based on a combination of habitat protection and habitat development. The key strategies involved in this approach are the establishment of a permanent reserve system, protection of optimal and potentially optimal habitat outside the permanent reserve; detailed prescriptions for areas where other management actions are planned (especially in designated timber production areas); the adoption of alternative silvicultural systems; and continued research and monitoring activities. This approach requires a variety of management actions which may be undertaken in combination, or singularly, and will necessarily vary from area to area within the known distribution of the species. Such variation will depend on the natural and management history of areas as well as determined land use, future commitments and associated planning. Management actions will also need to be planned for specific time frames. For example, habitat protection actions will be designed to benefit the species in the medium term (in 50 - 105 years), while habitat development actions will be designed to benefit the species in the longer-term (> 150 years). Both approaches require implementation in the short-term.

Implicit in the adoption of management actions contained in this document and their subsequent implementation is the recognition that they are dynamic and subject to

continuing review. New information on the biology, ecology and distribution of the species, combined with knowledge about the practicalities and logistics of application, will drive and direct the species management. In short, the management of Leadbeater's Possum in Victoria will continue to take an adaptive approach.

(Note: Costs are expressed as \$000s per year, at 1996 values. Year 1 = 1996, Year 5 = 2000)

The following actions are listed in order of their implementation priority recognising that some actions need to be undertaken concurrently:

ACTION 1: Leadbeater's Possum Management (Recovery) Team

1.1 The Leadbeater's Possum Management Team (LMT) includes representation from academia, the community, Australian Nature Conservation Agency (ANCA) and staff from the relevant NRE areas and policy divisions. It reports on actions being implemented and provides a forum for discussing problems and recommending modification. The LMT provides an annual written report to the Leadbeater's Possum Steering Committee (LPSC), which will include an evaluation of progress towards achieving objectives of this Recovery Plan.

Costs	Year 1	Year 2	Year 3	Year 4	Year 5
NRE	1.0	1.0	1.0	1.0	1.0
DEST	1.0	1.0	1.0	1.0	1.0
Total Cost	2	2	2	2	2

ACTION 2: Planning and management units

2.1 Management actions outlined in this Plan are designed to cover all ash-type forest within the known distribution of the species. For the management of Leadbeater's Possum public forests within the Central Highlands have been divided into geographic units based on the extent and spatial distribution of ashtype forest (Figure 1; Table 3). These are referred to as Leadbeater's Possum Management Units (LMUs). Each LMU generally contains between 6,000 and 10,000 ha of ash-type forest; the LMUs are composed of one or more forest management blocks containing contiguous patches of ash-type forest. Planning for intended management actions will consider the conservation status and intended actions in adjacent LMUs. Twenty-one LMUs have been delineated, covering the known distribution of Leadbeater's Possum in the Central Highlands. The target for the conservation of Leadbeater's Possum is to maintain viable populations of the species in all LMUs.

Costs	Year 1	Year 2	Year 3	Year 4	Year 5
NRE	7				
DEST					
Total Cost	7				

LMU no.	Forest block name	Total area	Area of ash	Proportion of
		(ha)	(ha)	ash assessed
1	Yea River Kalatha	24809	3950	100%
2	Murrindindi Yellowdindi Mohican East Mohican West	30151	6260	100%
	Narbethong Robbies			
3	Torbreck River Manago Stockmans Gumtop	23591	7460	95%
4	Little River Rubicon	30073	8640	100%
5	Upper Taggerty	11955	5710	100%
6	Royston Snobs Torbreck Taponga	27346	9320	76%
7	Upper Bunyip Pioneer Tarago Lavery Labertouche	32282	7310	45%
8	Bennie Ada	10536	7940	100%
9	Mississippi Little Yarra Tarrango	34892	6250	100%
10	Watts	17888	11420	100%
10	O'Shannassy	13304	11420	100%
12	Steavenson Acheron Triangle	19962	8250	100%
13	Yuonga	33890	6110	100%
14	Upper Yarra	33781	14940	0%
15	Brimbonga Loch	25325	8350	100%
16	Toorongo Rowleys	22212	7830	66%
17	Frenchmans Big River Oaks	16420	4270	0%
18	Goulburn Easton Red Jacket Deerhound Mt Matlock	52021	7740	0%
19	Bells Cascade Baw Baw	27834	8800	100%
20	Thomson Tanjil	14711	9160	46%
21	Lady Western Tyers Eastern Tyers	11993	5410	95%
Total	*	514976	166780	75%
Mean		24523	7940	

Table 3: Leadbeater's Possum Management Units (LMUs)

Forest block not yet mapped

ACTION: 3 Habitat resource assessment

3.1 Habitat resource assessment is being undertaken to determine the extent and distribution of current optimum and potentially optimum habitat for Leadbeater's Possum (as defined in this document). The methodology uses aerial photo interpretation to map a vegetation mosaic of the dominant canopy species and age-class or growth-form and the location of individual old ash trees (where they occur outside patches of old ash-type forest) and emergent stags. Mapping is done at a scale of 1:25000, in a manner suitable for incorporation into NRE's Geographic Information System (GIS). The habitat resource assessment is complete for 75% of the ash forest throughout the range of Leadbeater's Possum (Table 3). In addition, proposed logging coupes as set out in 3 year wood utilisation plans are checked by either helicopter survey or ground survey, or both for areas of Zone 1B habitat that cannot be identified by air photo interpretation.

Costs	Year 1	Year 2	Year 3	Year 4	Year 5
NRE	25	25	25	7	
DEST	50	50	26	7	
Total Cost	75	75	51	14	

ACTION 4: Management zoning

4.1 The management zoning system for Leadbeater's Possum in State forest has been revised to reflect the relative long-term stability of some good habitat with live old trees (Zone 1A) and the impermanence of habitat where most existing nest-trees are dead and likely to collapse in the near future (Zone 1B). The management zones are defined as follows:-

Zone 1A: Leadbeater's Possum (and other wildlife) conservation as the major priority.

- mature ash forest (> 120 years old) and mixed-aged ash forest where the oldest age class is mature (> 120 years old)
- regrowth ash forests with \geq 12 live hollow-bearing trees per 3 ha.
- the minimum area for assessment and establishment of Zone 1A type forest shall be 3 hectares.

Zone 1B: Leadbeater's Possum conservation and timber production as joint priorities.

- regrowth ash forest with ≥ 12 live or dead hollow-bearing trees per 3 ha. combined with a basal area $> 5m^2$ of *Acacia dealbata*, *A. obliquinervia* or *A. frigescens*.
- the minimum area for assessment and establishment of Zone 1B type forest shall be 10 hectares.

Zones 1A and 1B, regardless of minimum size criteria, have the highest priority in the reserve selection process detailed in Action 5. Areas of Zone 1B, identified and mapped as priority for inclusion in the reserve system, will be protected from timber harvesting. If these areas become unsuitable or offer little potential as habitat for Leadbeater's Possum through successional or other change, (which is likely for Zone 1B during the next 50 years), they will become available for timber harvesting. Conversely, areas that develop the essential components for Zone 1 classification through time, or circumstance will attain Zone 1 status. Zone 1A forest will not be included in sustainable yield calculations whilst Zone 1B will be included. The role of Zone 1B, including the minimum area of assessment, will be reviewed following completed habitat resource assessment, reserve establishment and subsequent population viability analysis (PVA), to determine its effectiveness in contributing to the major conservation objectives.

Zone 2: Timber production as the major priority, but including the conservation of existing components of habitat.

- regrowth ash forest of varying ages
- areas with features of Zone 1A, but< 3 ha. in size and Zone 1B, but< 10 ha. in size .

This zone will consist of remaining forest, where the prescriptions outlined in Action 7 will be applied to protect existing habitat components for their on-site value and to enhance the value of adjacent habitat.

4.2 GIS based analysis will continue to be used to identify the Leadbeater's Possum management zones, generate maps, examine management options and assess impact on other forest values and uses. A model has been developed to identify and map Zone 1A forest using data collected for the habitat resource assessment (Action 3). The model is based on the numbers and spacing of hollow-bearing trees. The model needs to be extended to identify areas of Zone 1B forest. Zone 1B habitat includes under canopy stags and wattle which cannot be identified by air photo interpretation, therefore, only some areas of Zone 1B will be identified using the model proposed. The areas of Zone 1B identified will assist in the development of wood utilisation plans and the targeting of ground surveys.

As new data are collected for the habitat resource assessment (Action 3) the management zone model will need to be run to identify Leadbeater's Possum management zones in the new areas. Figure 2 shows a diagram of the model proposed.

Costs	Year 1	Year 2	Year 3	Year 4	Year 5
NRE	7	7	7	7	7
DEST					
Total Cost	7	7	7	7	7



FIGURE 2: MODEL FOR MAPPING LEADBEATER'S POSSUM MANAGEMENT ZONES

ACTION 5: Reserve establishment

5.1 NRE will establish a permanent reserve system in each LMU based on the extent and spatial distribution of Zone 1 classified forest, combined with strategic areas of regrowth forest (Zone 2). All references in this recovery plan to a permanent reserve system refer to a comprehensive, adequate and representative (CAR) reserve system established consistent with the JANIS criteria. The intention of the permanent reserve will be to identify, and maintain in the long-term, sufficient areas in the forest that will sustain viable populations of Leadbeater's Possum. The exact boundaries of the permanent reserve may change with time, as the characteristics of patches of forest change (see Action 4.1). Provisions for flexibility are established in Chapter 9 of the proposed Forest Management Plan for the Central Highlands (NRE, 1996) to allow the management to adapt the system in the light of new information or circumstances.

The permanent reserve will exist in two forms; large, aggregated patches of ashtype eucalypt forest (>50 ha) and smaller (3-50 ha) patches of Zone 1A habitat that are dispersed throughout the forest. This permanent reserve system, mapped at 1:25 000, will be excluded from timber harvesting operations. Several large patches of ash-type eucalypt forest are required in each LMU to minimise the chances that all of the reserve system will be destroyed in a wildfire. Large patches will be 50 to 100 hectares in size to minimise the impact of threatening processes and be linked by wildlife corridors, streamside reserves, buffer strips and areas of State forest not suitable or available for timber harvesting. The total area of large patches in each LMU will be a target of at least 600 hectares of ash forest, but will vary depending on the extent and spatial distribution of potential and existing habitat, both within and adjacent to each LMU. Small dispersed patches will generally not contribute to this target.

Data collected for the habitat resource assessment (Action 3) will be used to further develop a model using GIS to identify options for the reserve system. Figure 3 shows a model proposed and tested on one LMU. The test LMU covered Little Yarra, Tarrango and Mississippi Forest Blocks and contained 6,250 hectares of ash forest.

The proposed model (Figure 3) uses data from the habitat resource assessment (Action 3) to create a ranking of forest for inclusion into the reserve for Leadbeater's Possum based on forest type, the age-class of ash forest, the density of live and dead hollow-bearing trees and slope. Table 4 shows the habitat attributes and classes used to create the ranking. Figure 4 shows the results of the ranking for the test LMU.

The ranking is used in the model to select patches of forest as options for inclusion into the reserve system. Initially, all areas of habitat rank 1 are selected. Patches of the selected habitat rank within 50 meters of each other are modelled as a single patch-group. Patch-groups of the selected habitat rank (or better) that contain 50 hectares or more of ash forest are added to the reserve options. The process is iterative and for the remaining areas of forest the next best rank is added to the rankings already selected then tested to see if they contain at least 50 hectares of ash-type forest. This process continues until there are at least 12 patches in the reserve options.

The final process to select patches for the reserve system will consider the location and configuration of patches, other forest values and uses and issues of practical implementation. Figures 5 is an example of one of many possible solutions from the reserve selection model for the test LMU.

5.2 The reserve system will be implemented through the Central Highlands Forest Management Plan and reflected in the Regional Forest Agreement. Options for a permanent reserve system will be identified using the reserve establishment model. Maps of the reserve system will be produced at 1:25 000. The reserve boundaries will be delineated considering other values, without compromising the reserve system's effectiveness for conserving Leadbeater's Possum.

Costs	Year 1	Year 2	Year 3	Year 4	Year 5
NRE	17	17	17		
DEST	27	16	16	11	
Total Cost	44	33	33	11	

Figure 3: The model proposed to identify options for a reserve system for Leadbeater's Possum.





ATTRIBUTE	CLASS
Presence of ash forest	Ash-type forest
	Non-ash forest
Age-class of ash forest	Old forest
	Mature forest
	Regrowth forest older than 1939
	1939 regrowth
	1940 to 1990 regrowth
Density of live old trees	\geq 4 per hectare
	2 to < 4 per hectare
	1 to 2 per hectare
	< 1 per hectare
Density of live and dead old trees	\geq 4 per hectare
	2 to $<$ 4 per hectare
	1 to 2 per hectare
	< 1 per hectare
Slope class	< 25 degrees or unknown
	\geq 25 degrees
Other forest values	Special protection zone (SPZ) or conservation zone in
	the forest management plan
	Not special protection zone or conservation zone

Table 4: The attributes used to rank forest for inclusion into a reserve for Leadbeater's Possum

Figure 4: Ranking of forest for inclusion into a reserve for Leadbeater's Possum

Figure 5: Draft example showing a possible solution from the reserve selection model.

ACTION 6: Population Monitoring

6.1 Implement monitoring of Leadbeater's Possum populations throughout its range, using rigorous experimental design to assess its conservation status and to assess the effectiveness of the reserve system for Leadbeater's Possum conservation.

Costs	Year 1	Year 2	Year 3	Year 4	Year 5
NRE					
DEST	105	85	85	85	85
Total Cost	105	85	85	85	85

ACTION 7: Logging coupe planning and harvesting

Various techniques can be used to maintain and develop Leadbeater's Possum habitat and work towards simultaneous Leadbeater's Possum conservation and timber production.

- 7.1 **Assessment:** Assessment of proposed logging coupes and roading to validate zoning classification will continue to be undertaken using resource information held on GIS and elsewhere in NRE, aerial photographs, helicopter reconnaissance and ground inspection.
- 7.2 Buffer Strips: Consideration will be given to retaining buffer strips of unlogged forest to avoid creating large areas of continuously logged forest (e.g. > 40 ha coupe conglomerates). These will be most applicable where streamside or other reserves do not form coupe boundaries. These buffer strips will be allowed to grow to ecological maturity (at least 250 years old) and thereby provide hollow trees for Leadbeater's Possum and other hollow-dependent wildlife. The width of buffers should ensure that the health of trees within them is maintained, and allow for continual replacement of hollow trees in the future. The desired width will vary with aspect, position on slope or ridge, and climatic factors. Where possible logging operations should be staggered so that a retained buffer strip is not simultaneously exposed on both sides.
- 7.3 **Coupe Shape:** The practice of logging variably sized and shaped coupes, interspersed with areas of undisturbed forest, ensures a scattering of different age classes and hence habitat niches throughout the forest. The desired shape of logging coupes to aid Leadbeater's Possum conservation may vary depending on the physical characteristics of vegetation both within and adjacent to the coupe. Coupe shape may change to accommodate the protection of Zone 1A and Zone 1B areas.
- 7.4 Protection of Hollow Trees: Protective measures to aid the continued survival of nest-trees on logging coupes will be used, including the use of fire retardants and the bulldozing of fire breaks around such trees. Special attention will be given to the protection of currently living nest-trees regardless of zoning classification. Even if these trees die after subsequent fire or exposure they will still provide potential nesting sites for Leadbeater's Possum during the following rotation. Hollow-bearing trees will not be felled for seed collection purposes. Consideration will be given to the protection of groups of >10 retained trees from regeneration burning to minimise windthrow effects.
- 7.5 **Salvage Logging:** Special plans for salvage logging, required under the Code of Forest Practices for Timber Production (1996), should consider both the number and spatial distribution of hollow-bearing trees and zoned accordingly, especially in areas of Zone 1B. Zone 1A forest will not be salvage logged.

Prescriptions developed for normal logging operations will be adhered to in all areas where salvage logging is undertaken.

7.6 Adoption and refinement of alternative silvicultural systems NRE will continue to undertake operational trials of retained overwood silvicultural systems with a view to their adoption as an alternative to the current system of clearfelling in selected areas of ash forest within the Central Highlands. Such areas will be selected considering existing and potential habitat within each Leadbeater's Possum Management Unit (LMU).

Costs	Year 1	Year 2	Year 3	Year 4	Year 5
NRE	32	32	32	17	17
DEST					
Total Cost	32	32	32	17	17

ACTION 8: Habitat Management and Planning outside State Forest

- 8.1 Assessment of all areas within the known range of Leadbeater's Possum need to be carried out as part of any development proposals which could affect the species, including roading, recreation facilities, fire management.
- 8.2 Investigate the status and determine the necessary management objectives for the recently discovered populations of Leadbeater's Possum in the Yellingbo State Nature Reserve and snow gum forests at Lake Mountain and Mt. Baw Baw.

Costs	Year 1	Year 2	Year 3	Year 4	Year 5
NRE	5	5	5	5	5
DEST					
Total Cost	5	5	5	5	5

ACTION 9: Training

9.1 Implement training for all relevant field and planning staff involved with Leadbeater's Possum management and/or timber production within its range, in relation to understanding the ecology of Leadbeater's Possum, habitat assessment and recording, the recovery plan process, and progress towards implementation of Leadbeater's Possum management guidelines.

Costs	Year 1	Year 2	Year 3	Year 4	Year 5
NRE	3	3	3	3	3
DEST	3	3	3	3	3
Total Cost	6	6	6	6	6

ACTION 10: Research

NRE will continue research efforts to assist and improve management for the long-term conservation of Leadbeater's Possum. Those high priority projects necessary for the effective application of proposed and ongoing conservation strategies include:-

10.1 Determine the dispersal and recolonisation capacities of Leadbeater's Possum

10.1.1 Examine the results of genetic analysis to explore aspects of dispersal behaviour and population genetic variability in several wild sub-populations of Leadbeater's Possum.

Costs	Year 1	Year 2	Year 3	Year 4	Year 5
NRE					
DEST	5				
Total Cost	5				

10.1.2 Design, scope and implement a research project to determine the extent and limitations of dispersal and recolonisation capacities utilising artificial nest boxes as a trapping and recapture methodology. A major outcome of the project would be to determine the best spatial arrangement of reserved areas for the species.

Costs	Year 1	Year 2	Year 3	Year 4	Year 5
NRE	2	5	5	5	
DEST	2	20	20	20	
Total Cost	4	25	25	25	

10.2 Investigate the response of Leadbeater's Possum to edges of habitat.

Costs	Year 1	Year 2	Year 3	Year 4	Year 5
NRE	2	5	5	5	
DEST	2	30	30	30	
Total Cost	4	35	35	35	

10.3 Improve the precision of modelling fire in the ash forests of the Central Highlands, particularly as it relates to the risks of reducing populations of Leadbeater's Possum.

3. IMPLEMENTATION SCHEDULE

(missing)

ACKNOWLEDGEMENTS

Many people have contributed directly and indirectly to this Recovery Plan and we appreciate their commitment and quality of work. Environment Australia has provided funds for its compilation and for some of the collection and analysis of information it contains. We would like to particularly thank Brendan Edgar and Ann Jelinek for their input.

Dr David Lindenmayer and Dr Hugh Possingham deserve recognition for their recent Extinction Risk Assessment study which has suggested ways in which the management of Leadbeater's Possum could be improved. Peter Myroniuk from the Melbourne Zoo contributed to useful discussions relating to the role of the international captive population of Leadbeater's Possum towards the conservation of the species.

We recognise the need for management plans to have a sound scientific base. However, we also recognise the importance of management plans addressing the practical implementation of recommended management actions. Accordingly, we appreciate the considerable effort made by NRE's Forests Service, most notably Dave Holmes, Gerard O'Neill, Mike Leonard, Richard Gijsbers, Jon Drohan, Karl Rumba, Ross Potter, Mal McKinty, Alex Lau and David Flinn, towards positive discussion and resolution of the many difficult issues that are intrinsic to management for the conservation of Leadbeater's Possum.

The current and past members of the Leadbeater's Possum Management Team which includes, Brendan Edgar, Bruce Male, Ann Jelinek, David Lindenmayer, Hugh Possingham, Rob Wallis, Ross Penny, Mike Leonard, Karl Rumba, Mark Woodman, Rod Anderson, Brian Ward, John Morey, Peter Ford, Peter McHugh, Keith Maplestone, Bob Moodie, Gary Featherston, John Hopper and the authors of this Plan, have had many difficult, but always successful meetings. We would like to thank all the members of this Team and invited observers for their contributions.

Staff from NRE's Flora and Fauna Branch have been particularly helpful during general discussion and always willing to provide comment on conservation strategies and their presentation. These include Robert Begg, Richard Loyn, John Seebeck, Gary Backhouse and others. Nadia Marine and Petina Pert deserve special mention for their commitment and very attractive GIS maps.

REFERENCES

- ANZECC (1991) List of endangered vertebrate fauna in Australia. Australian National Parks & Wildlife Service: Canberra.
- Brazenor, C.W. (1931) Twelve days in north-east Victoria. Victorian Nat. 48: 165-7.
- Brazenor, C.W. (1932) A re-examination of *Gymnobelideus leadbeateri* McCoy. *Aust. Zool.* **7**: 106-9.
- Brazenor, C.W. (1946). Last chapter to come. Wild Life 8: 383-4.
- Calaby, J.H. (1960) Australia's threatened mammals. Oryx 5: 381-6.
- Campbell, R.G., Chesterfield, E.A., Craig, F.G., Fagg, P.C., Farrell P.W., Featherston, G.R., Flinn, D.W., Hopmans, P., Kellas, J.D., Leitch, C.J., Loyn, R.H., Macfarlane, M.A., Pederick, L.A., Squire, R.O., Stewart, H.T.L. and Suckling, G.C. (1984)
 Silvicultural and environmental aspects of harvesting some major commercial eucalypt forests in Victoria : A Review. Division of Education and Research, For. Comm.: Victoria.
- CNR (1995) *Threatened Fauna in Victoria 1995*. Department of Conservation and Natural Resources: Victoria.
- Fleay, D.H. (1933) A beautiful phalanger. Vict. Nat. 50: 35-40.
- Fleay, D.H. (1947) Gliders of the Gum Trees. Melbourne: Bread and Cheese Club.
- IUCN (1994) International Union for the Conservation of Nature Red List Categories. Species Survival Commission. Gland, Switzerland.
- Jelinek, A. Cameron, D., Belcher, C. and Turner, L. (1995) New perspectives on the ecology of Lake Mountain: the discovery of Leadbeater's Possum, *Gymnobelideus leadbeateri* McCoy in sub-alpine woodland. *Vict. Nat.* **112:** 112-15.
- Land Conservation Council (1994) *Final Recommendations. Melbourne Area. District 2 Review.* Land Conservation Council, Melbourne.
- Lindenmayer, D.B. (1989) The ecology and habitat requirements of Leadbeater's possum. PhD thesis, Australian National University: Canberra.
- Lindenmayer, D.B., Cunningham, R.B., Tanton, M.T. and Smith, A.P. (1990) The Conservation of Arboreal Marsupials in the Montane Ash Forests of the Central Highlands of Victoria, South-East Australia: II. The Loss of Trees with Hollows and its Implications for the Conservation of Leadbeater's Possum, *Gymnobelideus leadbeateri* McCoy (Marsupialia: Petauridae). *Biol. Conserv.* 54: 133-45.
- Lindenmayer, D.B., Cunningham, R.B., Tanton, M.T., Smith, A.P. and Nix, H.A. (1991a) Characteristics of hollow-bearing trees occupied by arboreal marsupials in the montane ash forests of the Central Highlands of Victoria, south-east Australia. *Forest Ecology and Management* **40**: 289-308.

- Lindenmayer, D.B., Cunningham, R.B., Tanton, M.T. and Smith, A.P. (1991b) The conservation of arboreal marsupials in the montane ash forests of the Central Highlands of Victoria, south-east Australia: III. The habitat requirements of Leadbeater's Possum *Gymnobelideus leadbeateri* and models of the diversity and abundance of arboreal marsupials. *Biol. Conserv.* 56: 295-315.
- Lindenmayer, D.B., Cunningham, R.B., Nix, H.A., Tanton, M.T. and Smith, A.P. (1991c) Predicting the abundance of hollow-bearing trees in montane forests of southeastern Australia. *Australian Journal of Ecology* 16: 91-8.
- Lindenmayer, D.B. and Dixon, J.M. (1992). An additional historical record of Leadbeater's Possum, *Gymnobelideus leadbeateri* McCoy, prior to the 1961 rediscovery of the species. *Vict. Nat.* **109:** 217-8.
- Lindenmayer, D.B., Lacy, R.C., Thomas, V.C. and Clark, T.W. (1993) Predictions of the impacts of changes in population size and environmental variability on Leadbeater's Possum, *Gymnobelideus leadbeateri* McCoy (Marsupialia : Petauridae) using Population Viability Analysis: an application of the computer program VORTEX. *Wildl. Res.* 20: 67-86.
- Lindenmayer, D.B., Cunningham, R.B. and Donnelly, C.F. (1994) The Conservation of Arboreal Marsupials in the Montane Ash Forests of the Central Highlands of Victoria, South-East Australia: VI. Tests of the performance of models of nest tree and habitat requirements of arboreal marsupials. *Biol. Conserv.* **70**: 143-47.
- Lindenmayer, D.B. and Possingham, H.P. (1994) *The risk of extinction: ranking management options for Leadbeater's Possum using population viability analysis.* Centre for Resource and Environmental Studies, the Australian National University: Canberra.
- Macfarlane, M.A. and Seebeck, J. H. (1991) Draft management strategies for the conservation of Leadbeater's Possum, *Gymnobelideus leadbeateri*, in Victoria. Arthur Rylah Institute Technical Report Series 111. Department of Conservation and Environment: Melbourne.
- Macfarlane, M., Lowe, K.W. and Smith, J. (1995) Flora and Fauna Guarantee Action Statement No. 62 Leadbeater's Possum *Gymnobelideus leadbeateri*, Flora and Fauna Branch, Department of Conservation and Natural Resources, East Melbourne.
- Natural Resources & Environment (1996) Proposed Forest Management Plan for the Central Highlands, December 1996. Department of Natural Resources & Environment, Victoria.
- Smales, I.J. (1994) The discovery of Leadbeater's Possum, Gymnobelideus leadbeateri McCoy, resident in a lowland swamp woodland. Vict. Nat. 111: 178-182.
- Smith, A.P. (1980) The diet and ecology of Leadbeater's Possum and the Sugar Glider. Ph.D. thesis, Zoology Department, Monash University: Clayton.
- Smith, A.P. (1982) Leadbeater's Possum and its management. pp. 129-45 in Groves, R.H. and Ride, W.D.L. (eds). Species at Risk: Research in Australia. Australian Academy of Science: Canberra.

- Smith, A.P. (1984) Diet of Leadbeater's Possum, *Gymnobelideus leadbeateri* (Marsupialia) *Aust. Wildl. Res.* **11**: 265-73.
- Smith, A.P., Lindenmayer, D. and Suckling, G.C. (1985) The ecology and management of Leadbeater's Possum. Research report to World Wildlife Fund Australia for Project 51. University of New England, Armidale.
- Smith, A.P. and Lindenmayer, D. (1988) Tree hollow requirements of Leadbeater's Possum and other possums and gliders in timber production ash forests of the Victorian Central Highlands. *Aust. Wildl. Res.* 15: 347-62.
- Smith, A.P. and Lindenmayer, D.B. (1992) Forest succession, timber production and conservation of Leadbeater's Possum (*Gymnobelideus leadbeateri* Marsupialia: Petauridae) For. Ecol. & Manage. 49: 311-32.
- Smith, J.D.B. and Macfarlane, M.A. (1994) Modelling Leadbeater's Possum habitat in the Central Highlands of using GIS. RT'94 Conference Proceedings: New Opportunities-Best Practice, Parkville, Victoria: The University of Melbourne.
- Thomas, V.C. (1989) The Ecology of Leadbeater's Possum (*Gymnobelideus leadbeateri* McCoy) at Cockatoo Swamp, Yellingbo State Nature Reserve. Honours Thesis, LaTrobe University, Bundoora, Vic.
- Victorian Government (1986) Timber Industry Strategy, Government Statement No. 9. VGPO: Melbourne.

Wilkinson, H.E. (1961) The rediscovery of Leadbeater's Possum. Vict. Nat. 78: 97-102.