Technical Report

Leadbeater's Possum Advisory Group

23 January 2014

Contents

1.   Purpose and introduction

The purpose of this document is to describe in further detail the process used to develop recommendations and to provide the supporting technical information that informed the Leadbeater's Possum Advisory Group deliberations. It should be read in conjunction with the Recommendations Report.

The Leadbeater's Possum Advisory Group (the Advisory Group) was established in June 2013 at the request of the Minister for Environment and Climate Change, Ryan Smith, and the Minister for Agriculture and Food Security, Peter Walsh. The Advisory Group was tasked with developing recommendations to support the recovery of Leadbeater's Possum while maintaining a sustainable timber industry. The Advisory Group was co-convened by Zoos Victoria and the Victorian Association for Forest Industries, and included representatives from VicForests, Parks Victoria and the Leadbeater's Possum Recovery Team.

The Advisory Group's recommendations to government are set out in the Recommendations Report. The Recommendations Report also summarises the issues relating to Leadbeater's Possum and the timber industry, and provides an overview of the Advisory Group's approach.

The Advisory Group was based on a partnership approach, and it consulted with a range of experts, scientists, targeted stakeholders, and the wider community to develop an understanding of the range of possible actions that have potential to support the recovery of the Leadbeater's Possum while maintaining a sustainable timber industry.

Consistent with the Terms of Reference, the approach of the Advisory Group focused on:

- actions to manage the near-term risks of decline of the species; and
- medium and longer-term actions focused on ensuring the persistence of the species and its co-existence with a sustainable timber industry.

The Advisory Group focused its efforts on identifying actions that would provide the most positive outcomes for Leadbeater's Possum to support the recovery of the species while minimising costs to the timber industry. While not necessarily equating cost minimisation with sustainability, this approach provided a clear framework for making positive recommendations to support the recovery of the species while considering impacts on the timber industry.

Actions identified from existing research, publications and documents and through the stakeholder engagement process were evaluated against their estimated benefit to the possum and the estimated impact they imposed on the timber industry. Through the applications of ecological and economic modelling, a package of actions for consideration by government was recommended, as outlined in the Recommendations Report.

This Technical Report outlines the information considered in the development of the recommendations. In particular, it outlines the background information, stakeholder engagement process, the methodologies used and key findings.

Background information on the Leadbeater's Possum, the timber industry and the regulatory frameworks in place to manage both are included in Chapter 2. This information was collated to enable an agreed understanding of the current situation.

The approach taken and the findings of the investigations are detailed in Chapter 3. This starts with the stakeholder engagement and consultation process, including a summary of the actions suggested by stakeholders for consideration through this process. A summary of the approach and findings of the qualitative and quantitative assessments used in considering the range of identified actions is then presented. These key findings informed the Advisory Group's recommendations.

Chapter 4 then provides further detail on the recommended package of actions, including a rationale and definitions for each recommended action (to further clarify the intent of each recommendation).

A glossary is provided to assist in the understanding of terms used during this process.

2. Background information

2.1 Leadbeater's Possum

2.1.1 Status, distribution and habitat

Leadbeater's Possum *Gymnobelideus leadbeateri* – one of Victoria's faunal emblems – is a small possum that occurs only in Victoria. It is listed as 'threatened' under the Victorian *Flora and Fauna Guarantee Act 1988* (FFG Act) and as 'endangered' under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Habitat loss (primarily through bushfires and to a lesser extent timber harvesting) is considered to be the main cause of the decline in the conservation status of Leadbeater's Possum.

Leadbeater's Possum is restricted to an area of approximately 70 x 80 km in the Central Highlands to the northeast of Melbourne and a small, lowland area east of Melbourne in the Yellingbo Nature Conservation Reserve (Figure 1). It was first recorded from lowland areas around Westernport Bay and from Mt Wills in north-eastern Victoria, with just five records recorded between 1867 and 1909. It was not seen for another 50 years and, due to clearing in areas where it was originally recorded, it was thought to have gone extinct. However, in 1961 it was rediscovered in the Central Highlands (Harley 2004).

This species is now known to occur in three distinct habitat types: ash forests (Mountain Ash *Eucalyptus regnans*, Alpine Ash *E. delegatensis* and Shining Gum *E. nitens*), sub-alpine woodland (Snow Gum *E. pauciflora*) and lowland floodplain forest (dominated by Mountain Swamp Gum *E. camphora* in the Yellingbo Nature Conservation Reserve) (Lindenmayer *et al.* 1989; Harley 2004). There are approximately 204,400 hectares of potential ash or Snow Gum woodland habitat within the range of Leadbeater's Possum, the majority of which is ash forest (96 per cent), with only 4 per cent Snow Gum woodland. The lowland floodplain forest habitat used by Leadbeater's Possum at Yellingbo covers just 50 hectares (Harley *et al.* 2005).

In total, 69 per cent of the area of potential habitat (i.e. ash forests or Snow Gum woodlands) within the range of Leadbeater's Possum in the Central Highlands is located in formal national parks and conservation reserves, Special Protection Zones in State forest (including the Leadbeater's Possum Reserve, 30,500 hectares of high quality habitat; Figure 1) or areas excluded from harvesting due to biodiversity and regulatory reasons. Other areas of high quality Leadbeater's Possum habitat are excluded due to VicForests' operational constraints and prescriptions (e.g. Leadbeater's Possum habitat zones).

Hollow-bearing trees, which provide den sites, are a critical habitat feature for Leadbeater's Possum. Hollows can occur in large, live trees or in large, dead trees, such as those killed during bushfires (Smith and Lindenmayer 1988; Lindenmayer *et al.* 1991a). In ash forests, hollow formation starts at about 120 years. However, hollows suitable for Leadbeater's Possum do not typically form until trees reach around 190 – 220 years of age (Smith and Lindenmayer 1988; Lindenmayer *et al.* 1991b). The species requires hollows with large internal dimensions, in the order of 30 cm in diameter, in which to build their nests. Leadbeater's Possums are more likely to occur in areas with higher densities of hollow-bearing trees, such as areas with more than two or three hollow-bearing trees per hectare (Smith and Lindenmayer 1988, 1992; Lindenmayer *et al.* 1990, 1991b).

Other important habitat features include smooth-barked eucalypts, which provide long strips of bark that are used for building nests and provide opportunities to forage for insects (Harley 2004). Unlike some other small possums that can glide between trees, Leadbeater's Possums depend on connecting vegetation to move through their home range. Areas of suitable habitat typically have a dense understorey that provides movement pathways (Smith and Lindenmayer 1992; Harley 2004). In ash forest, the understorey often comprises wattles, which also provide food in the form of carbohydrate-rich plant and insect secretions, such as sap, manna and honeydew (Smith 1984a).

Leadbeater's Possum is a communal species living in small colonies of typically two or three individuals, although larger colonies have sometimes been recorded in the past (up to 12 individuals). Colonies are territorial, defending areas of 1-3 hectares (Smith 1980, 1984b; Harley 2005).
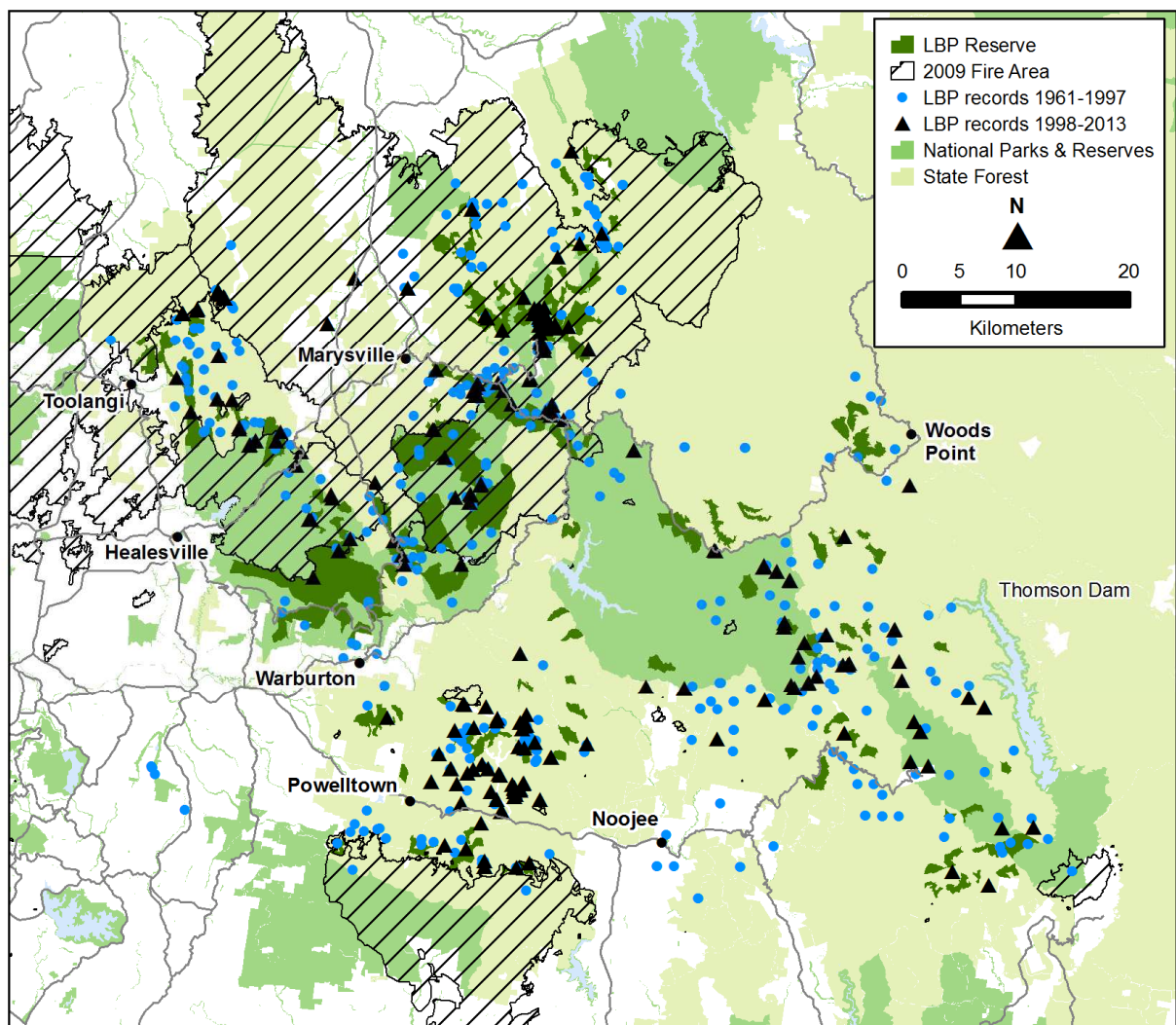

Figure 1. Known records of Leadbeater's Possum (based on records in the Victorian Biodiversity Atlas). Records from the last 15 years are shown by black triangles with older records in blue. The area burnt during the 2009 fires is indicated by the cross hatching and the Leadbeater's Possum Reserve is shown in dark green.

2.1.2 Issues for the Leadbeater's Possum

2.1.2.1 Impact of fire

Fire is an integral component of ash forests and has an important influence on the occurrence, extent and viability of the Leadbeater's Possum and its habitat (Lindenmayer and Possingham 1995). The impact of bushfires can vary greatly depending on the frequency, intensity, location and extent of the fire. Over the last century, bushfires have occurred in the Central Highlands on average once every 10 years, with the fires in 1939 and 2009 the most intense and extensive (Lindenmayer and Possingham 1995; McCarthy and Lindenmayer 2000; Lumsden *et al.* 2013). Frequent, extensive, high-intensity bushfires are a major threat to the survival of Leadbeater's Possum, resulting in mortality, destruction of food resources, alteration of forest structure and loss of hollow-bearing trees, with dead hollow-bearing trees at particular risk (Lindenmayer and Possingham 1995). As the species is confined to a relatively small area, a single large fire can impact on a significant proportion of the population. Future climate changes are predicted to lead to an increase in the frequency of such fires, increasing the risk to Leadbeater's Possum (DSE 2012a; Mackey *et al.* 2002).

Severe, high-intensity fires kill Mountain Ash trees, resulting in regeneration of single-aged stands (Ashton 1976). In these situations, hollows are only found in fire-killed trees (stags) until the regenerating forest matures and new hollows develop. While fire in old-growth forest may create stags with hollows, fire in younger regrowth forest (including 1939 regrowth and more recent regrowth) has been suggested to be less likely to produce suitable hollows because the damaged or killed stems are mostly too small to form the large hollows needed by Leadbeater's Possum (Lindenmayer and Possingham 1995; Lindenmayer 2009), although further investigations over coming years are required to test this suggestion. Patchy or lower-intensity fires can result in multi-aged ash forests (Ashton 1976) within which hollow-bearing trees are retained or can develop (McCarthy and Lindenmayer 1998; Lindenmayer *et al.* 1999).

Wattles are usually killed by bushfires, which eliminates a major food source of Leadbeater's Possum. However, over the medium-term (within approximately 20 years of the fire) wattle regenerating after fire provides an important source of food and movement pathways. As wattles age and decline (e.g. more than 50 years after fire) (Adams and Attiwill 1984), opening up of the understorey leads to a lack of vegetation connectivity, which can limit possum movement patterns (Lindenmayer and Possingham 1995).

If the interval between intense bushfires is short (less than the 20 to 30 years that is needed in order for trees to begin producing seed), ash forests may be eliminated and replaced by other species, such as wattles (Ashton 1981).

2.1.2.2 Impact of timber harvesting

Approximately 63,000 hectares of ash forest within the range of Leadbeater's Possum (31 per cent of potential habitat) is projected to be harvested and then actively regenerated over the length of harvesting rotation (around 80 years). Harvesting currently occurs primarily in 1939 regrowth, although stands resulting from fires between 1900 and 1936 are also harvested. Clearfelling, in which all trees suitable for harvesting (apart from those to be retained for wildlife habitat) are removed, is the standard method of harvesting applied in the ash forests of the Central Highlands. After harvesting, the remaining debris (i.e. bark, tree crowns, branches) is burnt, which creates a receptive seedbed that promotes regeneration of a new stand of eucalypts. Clearfelling creates even-aged stands in the areas that are harvested, since all the trees and other plants that re-

establish begin growing at the same time (DSE 2007). Areas of retained forest within and adjacent to the harvested area result in a mosaic of multi-aged forest at a landscape scale.

In addition to the loss of hollow-bearing trees through fire, timber harvesting operations can impact on hollow-bearing trees (reviewed in Lindenmayer 2009). With the exception of trees retained as habitat trees (including those originating from pre-1900), other hollow-bearing trees or those in the early stages of hollow formation are removed during harvesting. A harvest rotation of 80 years results in younger trees being harvested before they reach an age where they will develop hollows. Where large, old trees are retained in areas undergoing harvesting, they often have limited longevity with accelerated rates of collapse due to exposure and the impact of the high-intensity regeneration burns that are typically applied in harvested areas (Lindenmayer *et al.* 1990; Gibbons and Lindenmayer 1996). Areas of retained habitat in the surrounding area leads to multi-aged forest that can contribute to suitable habitat for Leadbeater's Possum.

Old-growth ash stands contain the highest densities of hollow-bearing trees (Lindenmayer *et al.* 1991c; Lindenmayer *et al.* 2000). All old growth ash stands have been protected from harvesting in the Central Highlands for over 20 years. The combination of landscape-wide fires and 30 years of salvage harvesting after the 1939 fires, has led to very little old growth ash forest remaining in the Central Highlands. It is estimated that old growth ash forest currently comprises less than two per cent of the Mountain Ash forest in the Central Highlands (Lindenmayer *et al.* 2012).

In addition to the extensive reserve system, high quality habitat in proposed harvesting areas is protected through Leadbeater's Possum habitat zones and other prescriptions (e.g. streamside buffers). However, there are currently no measures specifically focused on the protection of colonies. Leadbeater's Possum can and do reside in areas with fewer hollow-bearing trees than the number required to qualify for protection as Leadbeater's Possum habitat zones (i.e. Zone 1A or Zone 1B; Lumsden *et al.* 2013) and so may be impacted by harvesting in these areas without other forms of protection measures.

In ash forest, Leadbeater's Possum occurs at highest densities in multi-aged forest containing several age classes of eucalypts, including live and dead hollow-bearing trees, together with a dense understorey of wattle (Lindenmayer *et al.* 1990, 1991b; Smith and Lindenmayer 1992). Although forest regenerating after harvesting can provide habitat for Leadbeater's Possum, the small number of hollow-bearing trees typically present in these stands makes them generally unsuitable for the species, although retained habitat in the adjacent area may enable a colony to make use of regenerating habitat while using nearby retained habitat for nesting.

The suitability of regenerating forests for Leadbeater's Possum is reduced by thinning operations. Thinning involves the removal of smaller merchantable trees to increase the growth rate and/or health of retained trees and to obtain timber from trees that would otherwise die before final harvest (DSE 2007). Thinning operations also significantly increase the growth of the retained trees thereby enabling increased volumes of high quality logs to be harvested from a reduced area. Regenerating stands are mostly thinned at 18-30 years. Thinning opens forest stands and disturbs understorey vegetation through the passage of machinery, resulting in the loss of mid-storey connectivity that is required by Leadbeater's Possum in order to move through its habitat.

Salvage harvesting operations can be conducted to recover timber following events that result in significant tree mortality or damage, such as bushfires (DSE 2007). In the Central Highlands, salvage

harvesting took place after bushfires in 1926, 1932, 1939, 1983 and 2009. The most extensive salvage operations occurred after the 1939 wildfires, with forests intensively salvaged until the late 1950s. Salvage harvesting removes dead and damaged trees, resulting in large areas of mostly single-aged forest, with only small areas of older or mixed-age ash-eucalypt forest remaining (DNRE 1998; Lindenmayer *et al.* 2008).

2.1.2.3 Decline in habitat quality

There has been significant losses of hollow-bearing trees in past decades. Long-term monitoring over the last 30 years in the Central Highlands has shown that approximately 3.5 per cent of dead trees collapsed per year during that period and approximately 1.5 per cent of large, live hollow-bearing trees died per year (these figures are higher in burnt areas) (Lindenmayer *et al.* 2012). This loss of hollow-bearing trees is predicted to continue into the future, with most of the remaining dead trees from the 1939 fires predicted to collapse in the next few decades. There is currently negligible development of new hollow-bearing trees, as the majority of younger age-classes of live trees that now dominate the forest (1939 regrowth) are yet to form hollows. The combination of the loss of existing hollow-bearing trees and a lack of formation of new hollow-bearing trees is predicted to lead to a severe shortage of these trees in the next 30-70 years (Lindenmayer *et al.* 1990; Lindenmayer *et al.* 2012).

Well-connected vegetation is integral to Leadbeater's Possum habitat suitability. In addition to the loss of habitat connectivity resulting from severe bushfires, and to a lesser extent timber harvesting and natural wattle decline, lack of connectivity can arise from road and track construction, maintenance and widening.

Climate projections for Victoria include more extreme weather days with temperatures over 35° Celsius, higher mean annual temperatures and reduced annual rainfall. These projections suggest an increased risk of bushfires, heatwaves and drought (DSE 2012a). Leadbeater's Possum occurs in areas characterised by cold, wet climates with relatively low summer temperatures and high summer rainfall (Lindenmayer *et al.* 1991d; Harley 2004; Lumsden *et al.* 2013). A hotter and drier climate may reduce the area of suitable habitat available for Leadbeater's Possum. Hollow-bearing trees died at a higher rate between 2006 and 2009, which corresponded to a period of low rainfall, compared to outside this period (Lindenmayer *et al.* 2012). This may have been a response to moisture stress. Increased frequency of drought could further exacerbate the loss of hollow-bearing trees in the future.

2.1.2.4 Population fragmentation

Fire, timber harvesting, hollow-bearing tree loss and wattle decline can result in the creation of areas of unsuitable habitat, leading to isolation of colonies and further fragmentation of the population, resulting in reduced genetic diversity at a landscape scale. Genetic differentiation has been detected in Leadbeater's Possum populations from the north of the species' range (e.g. in the Marysville/Lake Mountain area) compared to those in the south (e.g. near Powelltown), suggesting recent disruptions to the gene flow between these areas. Habitat fragmentation, timber harvesting and bushfires are likely to have contributed to these disruptions to gene flow (Hansen *et al.* 2009), with extensive bushfires likely to be the key factor. The extensive bushfires in February 2009 have further isolated populations. For example, the subpopulation in the Toolangi area, which is surrounded by areas burnt in 2009, may be currently isolated from subpopulations to the south (Figure 2). The location and scale of fire and timber harvesting in relation to Leadbeater's Possum

populations, as well as the spread of the population, determines the level of fragmentation to populations.

2.1.3 The current situation

The 2009 bushfires had a significant impact on the Leadbeater's Possum population and its habitat. In total, 34 per cent of the potential ash forest and Snow Gum woodland habitat (68,000 hectares) within the range of Leadbeater's Possum in the Central Highlands was burnt in February 2009 (this includes all fire severities). Overall, 45 per cent of the Leadbeater's Possum Reserve was burnt.

Post-fire, virtually no Leadbeater's Possums have been detected at burnt sites, irrespective of the fire intensity, including where the understorey was burnt but the canopy remained intact (Lindenmayer *et al.* 2013a; Lumsden *et al.* 2013). More than 95 per cent of known individual Leadbeater's Possums occurring in Snow Gum woodland at Lake Mountain, where the fire intensity was severe, were killed in the 2009 fire (D. Harley, Zoos Victoria, pers. comm.).

Surveys in unburnt refuges within the overall area burnt in 2009 revealed Leadbeater's Possums in 16 per cent of sites, all in or close to gullies (Lumsden *et al.* 2013). If the likely small numbers of individuals in these fire refuges can persist until the surrounding regenerating habitat becomes suitable, recolonisation of this regenerating habitat could occur from within the fire-affected area as well as from outside. This will be important for the recolonisation and persistence of Leadbeater's Possum throughout the northern half of its range. However, the extent of such recolonisation may be limited by the small number of refuges and the risk of extinction of these small, isolated populations before the adjacent habitat regenerates sufficiently (Lumsden *et al.* 2013).

During recent broad-scale surveys at 180 sites across the Central Highlands investigating the current distribution and population strongholds, Leadbeater's Possum was detected at 16 per cent of all sites surveyed (Lumsden *et al.* 2013). All records were from unburnt sites, with no Leadbeater's Possum recorded at the 30 sites sampled within areas burnt in the 2009 bushfire. Considering just the unburnt sites (150 sites), Leadbeater's Possum were recorded at 19 per cent of sites (Lumsden *et al.* 2013). Models based on these surveys predicted that the current distribution of the species is centred on unburnt habitat, mostly in the southern parts of the Central Highlands from the Baw Baw area in the east to Warburton in the west, and the unburnt sections of the Toolangi area (Figure 2). Not all areas of potential habitat (i.e. ash forests or Snow Gum woodlands) are likely to be currently suitable and occupied by Leadbeater's Possum due to a lack of critical habitat features (e.g. the necessary density of hollow-bearing trees or wattle understorey). Sites most likely to be occupied are lush, long-unburnt vegetation in gullies that are located in areas with relatively low summer temperatures and high summer rainfall (Lumsden *et al.* 2013).

It is difficult to determine precisely the current number of Leadbeater's Possums. However, estimates based on recent surveys throughout the Central Highlands suggest there may be between 1,578 and 4,384 colonies at present (based on the number of adult breeding females). These estimates factored in variability in recording rate, ability to detect the species where it occurs and the area able to be effectively sampled during the surveys. There is uncertainty around colony sizes; however, assuming colony sizes are currently typically 2-3 individuals, this would equate to approximately 3,945 to 10,960 individuals (using 2.5 individuals as an average). Further information on how these figures were estimated is provided in Appendix 2 of the Recommendations Report.

2.1.4 What is the future for the Leadbeater's Possum?

To investigate the current trend in population numbers, the Arthur Rylah Institute (ARI) from the Department of Environment and Primary Industries (DEPI) developed a Population Viability Analysis that modelled past patterns and predicted future changes in numbers of Leadbeater's Possum (Lumsden *et al.* 2013). This modelling revealed significant fluctuations in population numbers over time due to past fires, especially the extensive fires in 1939 and 2009. The model suggests that the population would have crashed after the 1939 fires and then recovered as the habitat became suitable (Figure 3). The model showed another severe reduction in the population due to the 2009 bushfires. This decline is predicted to continue as habitat deteriorates further due to the collapse of dead nest trees. The model predicts that the population of Leadbeater's Possum will fall to very low levels during the next 70 years, with future bushfires within the species' range further exacerbating this situation.
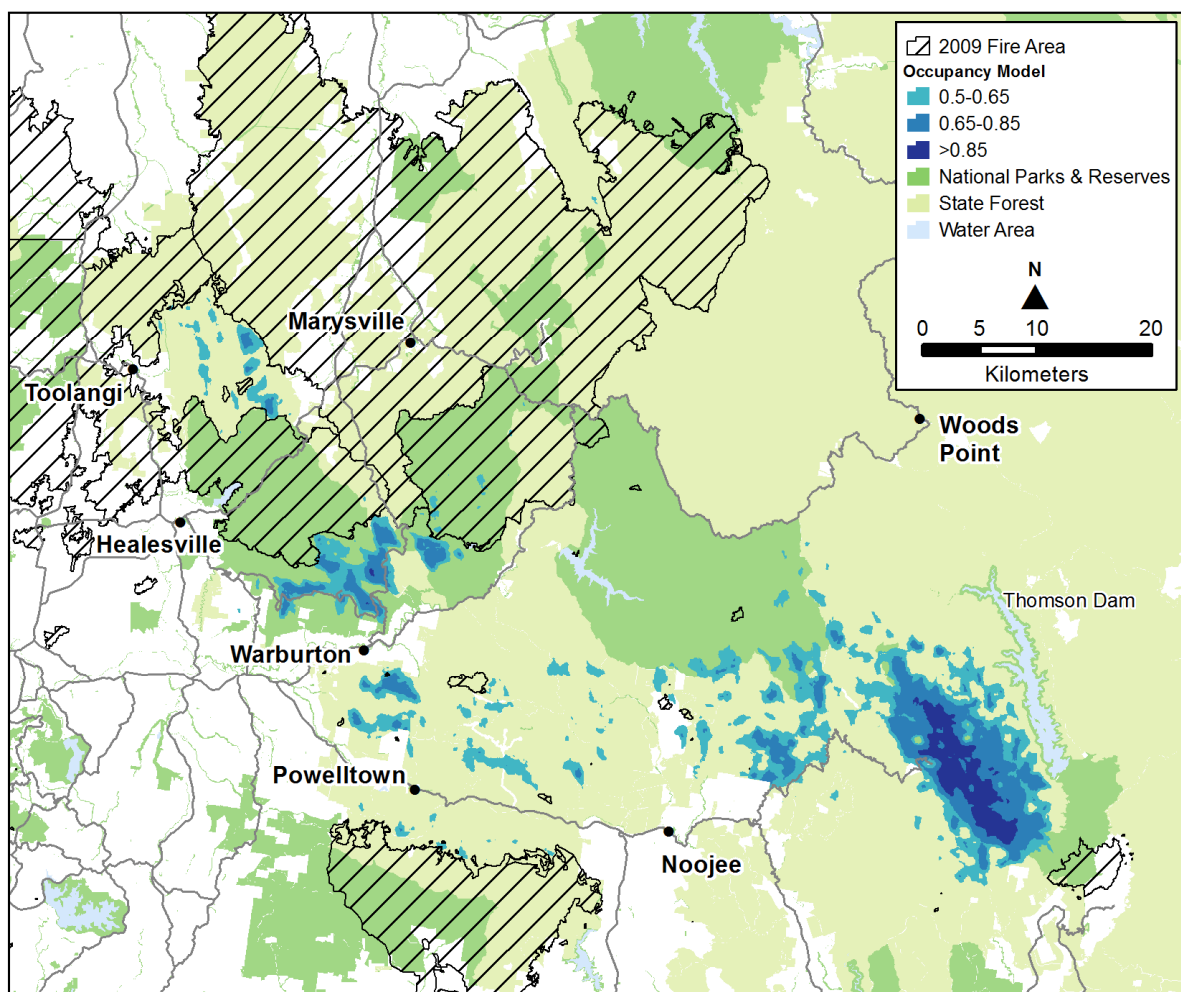
Figure 2. Areas most likely to be currently occupied by Leadbeater's Possum as predicted by occupancy modelling post 2009 fires. The dark blue area shows where there is a greater than 85% likelihood (i.e. >0.85 probability) that the species is currently present, with greater than 65% and 50% shown in paler shades of blue (Lumsden *et al*. 2013). The area burnt during the February 2009 bushfires is shown with cross-hatching.

To quantify the risk of extinction, the probability that the number of adult females within the Leadbeater's Possum Reserve would fall below 500 individuals within a 200 year time frame was calculated (Lumsden *et al.* 2013). Typically, once populations drop below these levels they are more susceptible to extinction. All modelled scenarios (using different amounts of habitat loss and size of bushfires in the future) resulted in a high probability that the population within the Leadbeater's Possum Reserve would fall below this size, although there are a range of assumptions used in these calculations and a wide range in the predicted population numbers (Figure 3). The PVA was then extended to include national parks and conservation reserves, and concluded that the parks system in conjunction with the Leadbeater's Possum Reserve was insufficient to ensure the long term survival of the species.

Although the above findings do not include the contribution made by habitat protection measures in State forests (e.g. other Special Protection Zones, prescriptions in timber harvesting areas or code exclusions) and further work is needed in this area, Lumsden *et al.* (2013) suggests that additional management actions needed to be considered to reduce the extinction risk of Leadbeater's Possum.
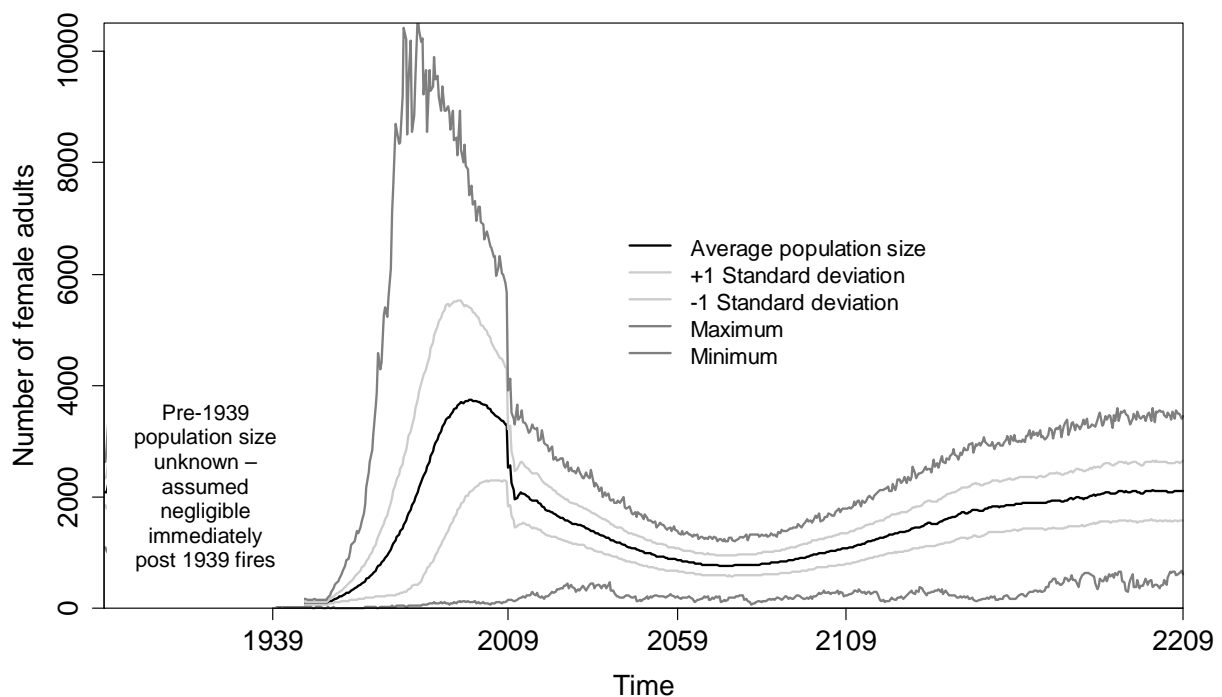
Figure 3. The number of adult females within the Leadbeater's Possum Reserve modelled over time under a scenarios of no future fires or increased rate of loss of hollow-bearing trees (Lumsden *et al*. 2013). Future fires and habitat loss result in further declines. The population numbers prior to 1939 is unknown.

While population estimates indicate that there may currently be more individuals than previously thought, the predicted trend for the species is still a notable decline in population size over the next 70 years. Despite this, it is considered that the estimated population size is large enough to provide opportunities for recovery of the species during this period, assuming that required actions can be implemented soon enough and that threats can be adequately managed.

2.2 Current legislative, policy and regulatory arrangements

The following State and Commonwealth legislative, policy and regulatory arrangements are relevant for the management of Leadbeater's Possum across public land in Victoria, including national parks, State forests and other reserves. This section focuses on the key arrangements of particular relevance to Leadbeater's Possum, which:

- seek to provide for biodiversity protection and threatened species management; and/or
- regulate timber harvesting activities.

These arrangements are further supported by a range of integrated and adaptive land management frameworks that provide a landscape-wide approach to the conservation and management of Leadbeater's Possum, which deliver a range of further social, environmental, economic and cultural heritage outcomes from these areas.

2.2.1 Leadbeater's Possum Action Statement and Recovery Plan

2.2.1.1 Flora and Fauna Guarantee Act 1988

The Victorian *Flora and Fauna Guarantee Act 1998* (FFG Act) provides a legal and administrative structure to enable and promote the conservation of Victoria's native flora and fauna. It provides for a suite of procedures which can be used for the conservation, management or control of flora and fauna and the management of potentially threatening processes. Key procedures include the listing of threatened species and communities and processes threatening Victoria's flora and fauna, the development of Action Statements, controls over the taking, trading and keeping of native species, and the use of Interim Conservation orders for the urgent protection of areas facing immediate threats.

The FFG Act requires the development of an Action Statement as soon as possible after the listing of a species as threatened under the Act. Action Statements are high-level management plans that set out the distribution and habitat requirements, conservation objectives, key challenges and current and intended management actions for the conservation of a listed threatened species. They are designed to apply for three to five years, after which time they are to be reviewed and updated (although some are in place for longer than this period, including the Leadbeater's Possum Action Statement). Measures specified in Action Statements are generally not legally binding. However, conditions and requirements in Action Statements relevant to timber harvesting activities are binding in relation to timber harvesting operations in State forests, as compliance with their terms is a mandatory requirement of the *Code of Practice for Timber Production (2007).*

The Leadbeater's Possum is listed as threatened under the FFG Act, and the Leadbeater's Possum Action Statement was published in 1995 (DSE 2003). This Action Statement:

- identified the need to establish a permanent reserve system in which all timber harvesting activities are prohibited;
- identified the need to implement detailed prescriptions for the protection of high-quality Leadbeater's Possum habitat for areas outside of the reserve system (especially in timber production areas);
- recommended the trial of, with the view to adopting, alternative silvicultural systems; and
- recommended continued research and monitoring activities.

2.2.1.2 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the Australian Government's key piece of environmental legislation, focuses on the protection of matters of national environmental significance. The objectives of the EPBC Act include:

• protecting the environment, especially those aspects of the environment that are matters of national environmental significance (which includes listed threatened species and communities);
• conserving Australian biodiversity; and
• promoting ecologically sustainable development through the conservation and ecologically sustainable use of natural resources.

The Leadbeater's Possum is listed as endangered under the EPBC Act.

Under the EPBC Act:

• actions that will or are likely to have a significant impact on matters of national environmental significance are prohibited without approval; and
• for listed threatened species and ecological communities it is an offence to take an action that will or is likely to have a significant impact on a listed threatened species or community without approval.

Activities that take place under State forest management arrangements that have been accredited by the Commonwealth Government under a bilaterally negotiated Regional Forest Agreement do not require approval of the Commonwealth Government under the EPBC Act. Instead, the State-accredited arrangements (comprising its suite of legislation, policies, codes, plans, management practices, and processes for timber harvesting) provide the agreed basis for environmental regulation of the activity. A Regional Forest Agreement for Central Highlands State forests was signed in 1998.

Recovery Plans

Recovery Plans set out the management and research actions necessary to stop the decline of, and support the recovery of, listed threatened species. Measures specified in Recovery Plans provide guidance on whether actions may have a significant impact on a listed species.

A Recovery Plan was prepared for Leadbeater's Possum in 1997 (Macfarlane *et al.* 1997), which is consistent with the 1995 Leadbeater's Possum Action Statement.

Leadbeater's Possum Recovery Team

The Leadbeater's Possum Recovery Team was formed in 1995 with the objective of preparing and coordinating the implementation of the Recovery Plan under the EPBC Act. The Recovery Team commenced operation in 1995, focusing on projects being undertaken by groups and agencies in accordance with the Leadbeater's Possum Action Statement and the Recovery Plan. In 2010 the Recovery Team refocussed on the plight of the species after the 2009 bushfires in the Central Highlands. The Recovery Team consists of members from State Agencies, community representatives and researchers.

2.2.2 Land management arrangements for conservation of Leadbeater's Possum

Leadbeater's Possum is mainly confined to the ash forests and Snow Gum woodlands of Victoria's Central Highlands, which occur primarily on public land situated in national parks, State forests and a range of smaller flora, fauna or nature conservation reserves. These areas are managed using adaptive management frameworks, which allow adjustment of management practices as new information is obtained. Specific areas within these forests have been set aside for the conservation and protection of the Leadbeater's Possum.

As proposed in the Action Statement, a 30,500 hectare Leadbeater's Possum reserve system was established in the Central Highlands in 2008 based on patches of high quality Leadbeater's Possum habitat (Figure 1). Areas of old growth ash forest were primarily selected, as these were likely to provide suitable habitat into the future. The reserve system comprises areas in both national parks (58 per cent) and State forest Special Protection Zones (42 per cent) (Smith and Morey 2001).

The reserve system was implemented through the Central Highlands Forest Management Plan (DNRE 1998) (CHFMP) zoning scheme changes. Timber harvesting is not permitted in the reserve. The 2009 bushfires burnt approximately 45 per cent of the Leadbeater's Possum reserve (DEPI unpublished data).

2.2.3 Arrangements for Victoria's national parks

Victoria's parks and reserves system is managed in accordance with the Guidelines for Protected Area Management Categories (IUCN 1994), which describes the basic concepts and defines six protected area (Park) categories and their management objectives. These categories and management objectives have been adopted by the Commonwealth Government and all State and Territory Governments in Australia, and Parks Victoria apply these categories and objectives in managing Victoria's parks and conservation reserves.

National parks are managed by Parks Victoria under the Victorian *National Parks Act 1975*. The objectives of the Act are the preservation and protection of the natural environment and indigenous flora and fauna, as well as natural, cultural and other features. The objectives also include scientific studies relating to conservation of the natural environment and responsible land management in national parks, and promoting and encouraging the use and enjoyment of national parks by the public. The Act aims to preserve and protect the parks in their natural condition; use of the parks for enjoyment and recreation is provided where this is consistent with the objects of the Act. Parks Victoria has a Management Services Agreement with DEPI describing the agreed management arrangements.

Approximately 50 per cent of Victoria's public land (3,982,000 hectares) is in parks and conservation reserves, which Parks Victoria manages primarily for their environmental and ecosystem service values as well as their significant cultural, recreational and tourism values. National parks are important for the long-term conservation and protection of Leadbeater's Possum, with 34 per cent of potential habitat within the species' range currently found in national parks or other reserves managed by Parks Victoria (see Table 1).

Conservation and protection of indigenous flora and fauna such as Leadbeater's Possum is achieved in national parks through adaptive and evidence-based management, which recognises that park environments are constantly changing. Mechanisms used include 15-year park management plans, which articulate the vision, goals, measures and long term strategies for parks, and adopt a

landscape-wide, multi-scale approach to their management. This is considered fundamental for achieving optimal outcomes for species such as Leadbeater's Possum, which only occurs in small patches of suitable habitat in parks. They also include a conservation action plan that specifies the desired condition of natural assets in a park, acceptable level of threat to these assets, and practices used for managing these threats. These can be adjusted to changing circumstances and new information in order to ensure optimal conservation and protection of species, including Leadbeater's Possum.

There are management plans for two of the key national parks relevant to Leadbeater's Possum: the Yarra Ranges National Park Management Plan (Parks Victoria 2002) and the Baw Baw National Park Management Plan (Parks Victoria 2005). The Baw Baw National Park also falls within the Greater Alpine Management Plan area, for which a management plan is currently in preparation. A detailed conservation action plan for the Central Highlands parks is scheduled to commence in 2014/15.

2.2.4   Arrangements for Victoria's State forests

State forests, established under the Victorian *Forests Act 1958*, are managed for a range of values including timber harvesting, water supply, biodiversity conservation, cultural heritage, recreation, mining, apiary and other economic uses.

Various State and Commonwealth policy, legislative and regulatory arrangements apply to biodiversity conservation and timber harvesting operations in State forests. Key aspects of these are outlined below.

2.2.4.1 National Forest Policy Statement 1992

The *National Forest Policy Statement 1992* (Australian Government 1995) sets out the shared vision of the governments of Australia (the Australian Government and all mainland state and territory governments) for ecologically sustainable development of Australia's forests. The three key requirements for this are: maintaining the ecological processes within forests; maintaining the biological diversity of forests; and optimising the benefits to the community from all uses of forests within ecological constraints. The policy statement includes shared goals, objectives and policies for achieving this. Bilaterally-negotiated Regional Forest Agreements are a key tool for implementing the policy statement.

2.2.4.2 Regional Forest Agreements

The State of Victoria and the Commonwealth of Australia entered into five Regional Forest Agreements (RFAs) between February 1997 and March 2000. These 20-year agreements establish the framework for the conservation and sustainable management of State forests within each of the five Victorian RFA regions. The agreements seek to balance and protect the full range of values of forests for current and future generations. The main objectives of the Victorian RFAs are to:

- identify 'Comprehensive, Adequate and Representative' (CAR) reserve systems and provide for the conservation of these areas;
- provide for ecologically sustainable management and use of forests; and
- provide for long-term stability of forests and forest industries.

The RFAs formally accredit Victoria's State forest management arrangements, including relevant *Forest Management Plans*, the FFG Act and the processes established by the *Code of Forest Practices for Timber Production (2007)*. RFAs are recognised under the EPBC Act. Timber harvesting operations

undertaken within the requirements of an RFA are exempt from the environmental approval requirements which might otherwise apply under the EPBC Act. Instead the obligations and arrangements accredited by the RFA apply. The Central Highlands Regional Forest Agreement was concluded in March 1998 and is due for renegotiation in 2018.

2.2.4.3 Forest Management Plans

Forest Management Plans (FMPs) are required under the Victorian *Forests Act 1958*. They are also a requirement of Regional Forest Agreements and the Code of Forest Practice. FMPs, the forest management zoning schemes established under FMPs, and prescriptions contained in FMPs for the conservation and protection of biodiversity (including their process for review) form an important part of Victoria's accredited forest management arrangements.

The Central Highlands Forest Management Plan was completed in May 1998 (CHFMP). The plan was to apply until 2008 or until other circumstances warranted a major review. It has not yet been reviewed and is considered to still be in place. A zoning review of the Central Highlands is currently underway.

The CHFMP provides for the balanced use and care of the Central Highlands State forests and provides a framework in which the area's timber industry can continue to confidently invest while providing protection for the natural and cultural values of the forest. It achieves this by establishing a system of forest management zones that sets priorities and permitted uses for different parts of the forest.

- Special Protection Zones (SPZ) are managed for the conservation of natural and cultural values and exclude timber harvesting.
- Special Management Zones (SMZ) are managed to maintain specific values while catering for timber production under certain conditions.
- The General Management Zone (GMZ) caters for a range of uses, with timber production a high priority.

It also provides a series of management guidelines, prescriptions and actions for the management of all aspects of Central Highlands State forests. The CHFMP also provides guidance for and circumstances in which the zoning scheme, guidelines and prescriptions can be amended to adapt to changing circumstances and new information. Management prescriptions for Leadbeater's Possum habitat zones are outlined in the CHFMP and seek to give effect to the 1995 Leadbeater's Possum Action Statement.

Additional habitat for Leadbeater's Possum is protected in other areas of State forests through prescriptions in the CHFMP. Areas of ash forest in harvestable State forest outside of Special Protection Zones must be assessed on a case by case basis prior to timber harvesting in order to determine whether they contain areas meeting the definition of Leadbeater's Possum habitat zones. The Leadbeater's Possum habitat zones include:

- Zone 1A habitat – contains more than 12 living, old, hollow-bearing trees in patches greater than 3 hectares in size. These areas of old and multi-aged forest are expected to be important for the long-term conservation of the species. The CHFMP requires that Zone 1A habitat is permanently excluded from timber harvesting regardless of whether Leadbeater's Possum have been recorded at the location.

- Zone 1B habitat – currently contains high quality habitat (more than 12 hollow-bearing trees per 3 hectares, over a 10 hectare area), but most of the existing hollow-bearing trees are dead and are likely to collapse in the near future. In Zone 1B there is also a requirement for a dense layer of wattle understorey. The CHFMP requires that Zone 1B habitat is excluded from timber harvesting until either of the Zone 1B habitat attributes (the presence of dead mature or senescing trees, or wattle understorey) no longer exist, at which time the area can return to General Management Zone and is available for timber harvesting.

2.2.4.4 Sustainable Forests (Timber) Act 2004

The Victorian *Sustainable Forests (Timber) Act 2004* is the primary legislation for managing commercial timber harvesting in Victorian State forests. The Act was recently amended by *Sustainable Forests (Timber) Amendment Act 2013.* The main purposes of the Act are to provide a framework for sustainable forest management and sustainable timber harvesting in State forests, to provide for the granting of long-term access to timber resources in State forests, and to foster investment in, and returns from, timber resources in State forests.

It provides for allocating timber resources in State forests subject to a range of conditions. A new Allocation Order 2013 was issued to VicForests on 1 October 2013. From this date, property in timber resources in State forests in the east of Victoria, excluding those in Special Protection Zones, vests in VicForests. The conditions upon which the Allocation Order was made include requirements that VicForests comply with the *Code of Practice for Timber Production (2007),* the *Code of Practice for Bushfire Management on Public Land 2012,* and the *Management Procedures for Timber Harvesting, Roading and Regeneration in Victoria's State Forests 2009.* It also includes a range of planning, reporting and compliance obligations; limits on the total areas (in hectares) available for harvesting based on a five year rolling average; and a requirement that VicForests may not offer timber supply contracts for longer than 20 years (unless otherwise approved by the Minister for Agriculture and Food Security).

2.2.4.5 Conservation, Forests and Lands Act 1987

The objective of the Victorian *Conservation, Forests and Lands Act* 1987 (CFL Act) is to enable the Minister for Environment and Climate Change to be an effective conserver of the State's lands, water, flora and fauna, and to make provision for the productive, educational and recreational use of these in ways which are environmentally sound, socially just and economically efficient. It provides for codes of practice to be made, which specify standards and procedures for carrying out any of the objectives or purposes of a relevant law.

2.2.4.6 Code of Practice for Timber Production (2007)

The *Code of Practice for Timber Production (2007)* (the Code) was made under the CFL Act and provides broad direction for the planning and undertaking of timber harvesting activities. It provides a series of mandatory actions and other guidance on best practice for timber harvesting in Victoria. The Code requires that VicForests' Timber Release Plans be consistent with Forest Management Plans. The Code also requires that forest management planning and all forestry operations must comply with measures specified in relevant Action Statements.

Compliance with the Code of Practice and the planning, practices and performance of VicForests are audited each year through the Forest Audit Program. This program is overseen by DEPI and undertaken independently by an Environment Protection Agency-accredited auditor. Audit results are published on the DEPI website.

2.2.5   Fire management in State forests and national parks

DEPI has overall responsibility for fire management on all public land, including State forests and national parks. In this role, DEPI is committed to reducing the impact of major bushfires and other extreme events on people, infrastructure and the environment. DEPI works with a range of partner agencies to achieve this objective, including Parks Victoria, VicForests, Fire Services Commissioner, Melbourne Water and the Country Fire Authority.

These agencies manage Victoria's environmental assets and systems through effective environmental policy, investment and regulation. DEPI also works with other land managers and the community on programs such as education and risk-based fire planning, planned burn, bushfire response and fire recovery activities.

2.2.5.1 Forests Act 1958

DEPI's fire management responsibilities are outlined in the *Forests Act 1958,* which requires DEPI to carry out "proper and sufficient work for the prevention and suppression of fire in every state forest, national park and all protected public land". These sit alongside DEPI's statutory responsibilities as a land manager under the FFG Act and the EPBC Act.

2.2.5.2 Code of Practice for Bushfire Management on Public Land (2012)

DEPI undertakes fire management activities in line with the *Code of Practice for Bushfire Management on Public Land,* which lists two objectives for bushfire management on public land:

- to minimise the impact of major bushfires on human life, communities, essential and community infrastructure, industries, the economy and the environment. Human life will be afforded priority over all other considerations.
- to maintain or improve the resilience of natural ecosystems and their ability to deliver services such as biodiversity, water, carbon storage and forest products.

2.3   The Victorian timber industry

2.3.1   Broader timber industry context

Of the 7.9 million hectares of Crown land in Victoria, approximately 3,138,000 hectares (40 per cent) are in State forest (DEPI 2013a). State forests are multi-purpose areas that aim to balance uses and values, including sustainable timber production, water production, tourism, recreation, carbon sequestration and biodiversity conservation. Based on sustainable yield modelling, in 2011/12 VicForests harvested around 4,300 hectares of forest, representing less than 0.06 per cent of the 7.9 million hectares of Crown land, or 0.13 per cent of State forest (based on all vegetation types). Of the 547,000 hectares of ash forest in Victoria, 241,000 hectares (44 per cent) is available for timber harvesting (Sustainable Forest Act Allocation Order 2013).

DEPI is the environmental regulator and land manager of all State forest and is responsible for regulating commercial activities related to areas available for harvesting. VicForests is a State-owned business responsible for the majority of commercial harvest and the sale of timber from public land in Victoria.

The wood products produced from VicForests' operations supply a broad range of industries across eastern Victoria and metropolitan Melbourne. In 2012, the Victorian native timber industry directly employed around 2,284 people in tree growing, services to forestry (harvest, haulage and silviculture) and primary processing businesses (saw milling, paper production) (Schirmer *et al*. 2013 forthcoming). Timber harvesting in both native and plantation forests also support indirect employment. Across Victoria, there are almost 14,500 people employed in secondary processing businesses (e.g. window frames, joinery), which rely on Victorian plantation and native forest timber, as well as timber imported into Victoria) (Schirmer *et al*. 2013 forthcoming). However, it is difficult to precisely estimate the contribution made by the native timber industry to this figure.

VicForests operates within the approximately 2.5 million hectares of State forest in eastern Victoria. In 2011/12, the Victorian native timber industry harvested around 1.5 million cubic metres of logs with a gross value of more than $120 million. This represented more than 30 per cent of the Australian native timber industry by volume and value (ABARES 2013). This harvesting produced more than 490,000 cubic metres of sawlogs and approximately 1.05 million cubic metres of pulplogs. Timber harvesting in public native forests in Victoria has significantly decreased over past decades, in line with reductions in the area of forest available for timber production. The 2011/12 Victorian native timber harvest is lower than at any point this century, representing a significant decline from the more than 2.4 million cubic metres of logs harvested in 2001/02, with reduction in resource availability a key driver for this.

Timber from native forests in Victoria is predominantly processed and consumed domestically. The number of businesses involved in the Victorian native timber industry has also significantly declined in response to a declining resource and industry rationalisation. In 1997 there were approximately 100 native timber sawmills operating across Victoria, compared to less than the 40 that are currently operating (Timber Industry Strategy 2009). Sawmills provide wood to the local timber manufacturing and housing and construction industries.

2.3.2 Central Highlands timber industry

2.3.2.1 Area available for harvesting

VicForests produces timber from a variety of forest types across eastern Victoria. These forest types are grouped into two broad categories: mixed species forests and ash forests. These groupings reflect the type of timber that is produced, the area in which these forests are located, and the type of growth cycle.

Ash forests include three key species, Mountain Ash, Alpine Ash and Shining Gum, which make up approximately 60 per cent of the total timber produced by VicForests (VicForests 2013a). Ash forests are generally faster growing and of a higher timber quality than mixed species forests.

Ash forests are found from Kinglake in the west to Swifts Creek in the east, and north to Corryong. The most productive of these ash forests are located in the Central Highlands, which overlaps with the range of Leadbeater's Possum. This area includes some of the most productive and valuable timber producing forests in Australia. Approximately 600,000 cubic metres (70 per cent) of VicForests' annual ash timber supply is sourced from within the range of the Leadbeater's Possum (VicForests unpublished data). As a result, it is critical that harvesting is undertaken in a manner that complements the management of the Leadbeater's Possum.

Within the Central Highlands there are over 200,000 hectares of potential habitat for Leadbeater's Possum (Table 1). Potential habitat is defined as all ash forests or Snow Gum woodlands within the range of the species. Thirty-four per cent of potential habitat within the species range is reserved within national parks and conservation reserves. A further 14 per cent of the potential habitat is protected within SPZs, while an additional 21 per cent is excluded from harvesting due to biodiversity, regulatory and operational reasons. The remaining 31 per cent (62,600 hectares) is available for timber harvesting (Table 1). Not all of this area is suitable for harvesting within the next 20-30 years (i.e. areas burnt in recent fires or recently harvested) and hence the area that is likely to be actually harvested will be less than this area. It is estimated that 24,000 hectares of ash forest within the range of Leadbeater's Possum is likely to be harvested during this time (VicForests unpublished data).

The harvest levels over the last decade from the ash forests in the Central, Central Gippsland and Dandenong Forest Management Areas (an area larger than the Leadbeater's Possum distribution) is shown in Figure 4. The spike in 2009/10 includes salvage harvesting that occurred after the 2009 bushfires.

Table 1. **The area of potential habitat reserved and available for timber harvesting within the range of Leadbeater's Possum in the Central Highlands.**

Type	Area in hectares	Per cent of range
Area of potential habitat within the range of Leadbeater's Possum in the Central Highlands (all ash forests and Snow Gum woodlands)	204,400	100
National parks and formal reserves	69,200	34
Special Protection Zones – reserves in State forest managed for a range of environmental reasons, including Leadbeater's Possum	29,300	14
State forest available for timber harvesting but excluded from harvesting due to biodiversity, regulatory, operational and prescriptive reasons	43,300*	21
State forest potentially available for timber harvesting	62,600	31

* Exclusions due to operational and prescriptive reasons are estimates only.
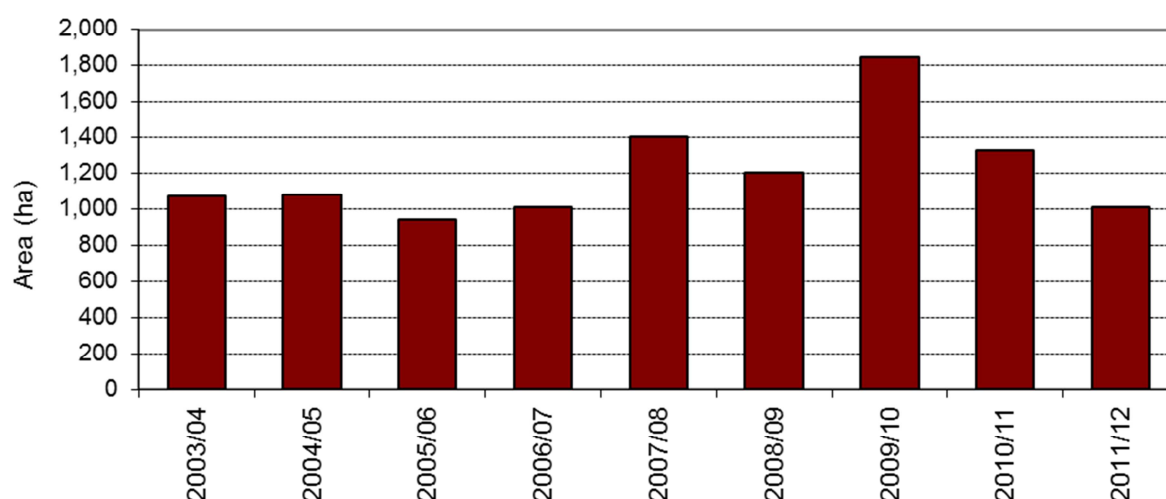
Figure 4. The area of ash harvested in the Central, Central Gippsland and Dandenong Forest Management Areas each year. Note that these figures include some areas outside the range of Leadbeater's Possum (VicForests unpublished data).

2.3.2.2 Employment figures

There are 12 timber mills, processors, contractors, and harvest and haulage businesses that process timber from ash forests within the range of the Leadbeater's Possum, which are estimated to directly support 1222 jobs (excluding jobs in secondary processing).

2.3.3   Timber harvesting planning and management

2.3.3.1 Legal and planning framework

There is a comprehensive legal and planning framework that guides VicForests' harvest levels. The Minister for Agriculture and Food Security provides VicForests with an Allocation Order, which describes the area of State forest that is available for timber harvesting. The Allocation Order sets an

upper area limit for how much harvesting may occur in any five year period. VicForests is not required to harvest at the upper limit described by the Allocation Order.

Key components of the legal and planning framework include:

- **The Resource Outlook**: Determines how much harvesting will occur based on analysis of the forest, including modelling sustainable harvest levels from the available forest. The Resource Outlook provides the proposed harvest level, the volume of timber which this harvesting will produce, and how much of this harvest VicForests proposes to sell over the next 20 years. The Resource Outlook is updated every year to take into account major impacts to the forests (such as from large bushfires), which can change the sustainable harvest level in the short and medium term.
- **Timber Release Plans:** Identifies specific areas of forest for harvest in the coming two to three years. Timber Release Plans are developed to enable VicForests to engage with a range of stakeholders (including DEPI, Parks Victoria, local government and the community) regarding their proposals, to ensure that any issues relating to the proposed harvest areas (coupes) are identified and appropriately managed.
- VicForests' **Operations Plan:** Determines the actual coupes which are proposed to be harvested over the next 18 months. The level of harvesting undertaken aligns with the harvest levels described within the VicForests' Resource Outlook. The coupes on the operations plan are a sub-set of the coupes on the Timber Release Plan. These coupes have been selected to best meet industry, community and environmental values. VicForests' Operations Plans are available on the VicForests' web site.

VicForests' 2013 Resource Outlook outlines a transition to lower harvest levels in ash forests in the future. This reduction is a direct result of the impact of the large scale bushfires in 2009 on areas of forest available for timber production. It also considers the effect of the fires on habitat for a range of species, including the Leadbeater's Possum, by reducing the level of harvesting within the distribution of Leadbeater's Possum by 25 per cent starting from 2017, to between 500 – 1000 hectares per year (VicForests unpublished data).

Annual harvest levels are the sum of the area actually harvested in any given year. The annual harvest levels are the true measure of VicForests' harvest. These include a sub-set of the coupes on the Operations Plan.

2.3.3.2 Forest planning and operations
The Central Highlands Forest Management Plan outlines a range of conservation objectives relating to Leadbeater's Possum that are to be met through two key management actions: a permanent reserve system from which timber harvesting is excluded, and the implementation of prescriptions in State forest outside this reserve when high quality Leadbeater's Possum habitat is identified. An important consideration in forest planning and management in the Central Highlands is that the current proportion of maturing and old growth forest is low, and this has led to a reduction in habitat for hollow-dependent species, such as the Leadbeater's Possum.

The planning of all timber harvesting operations takes into account a range of environmental, cultural and operational factors. These lead to some areas that are available for timber production but where harvesting does not occur, in addition to the existing reserve system. All patches of old

growth forest are exempt from timber harvesting. In addition, isolated trees that are considered to be older than 1900 are not harvested and are left standing on the coupe.

Important components of forest planning and operations include:

- **Forest Coupe Plans:** Prepared by VicForests for all approved operations prior to commencement. These are the specific operational documents under which a harvesting contractor must operate. They outline all management actions identified within the Timber Release Plans.
- **Gross Coupe Area**: Refers to the general area in which harvesting will occur – prepared by VicForests. May include forest that will be excluded from harvesting due to regulatory, operational or other reasons such as stream reserves, threatened species habitat or historic sites.
- **Operational exclusions**: State forest available for timber harvesting but excluded from harvesting due to biodiversity, regulatory and operational reasons (e.g. steep slopes, cultural sites of significance, site-based prescriptions).
- **Net Harvest Area:** The actual area of the forest harvested (i.e. the remaining area once all of the excluded areas are removed from the Gross Coupe Area). The net harvest area is generally between 50 – 70 per cent of the Gross Coupe Area. In other words, 30 – 50 per cent of the forest within a coupe is generally retained for habitat and other values.

Prior to any harvesting operations, VicForests' staff survey areas proposed for harvest to identify a range of environmental values. Areas of harvestable State forest outside of Special Protection Zones are assessed on a case by case basis to determine if they contain Leadbeater's Possum habitat as defined by Zone 1A or Zone 1B habitat (described in Section 3.2).

The current Timber Release Plan identifies potential Leadbeater's Possum habitat zones in approximately 15 per cent of the ash coupes planned in the Central Highlands (VicForests unpublished data).

2.3.3.3 Certification and scrutiny

VicForests operates under a Sustainable Forest Management System which includes a wide range of instructions and controls to make sure the business meets the requirements of the regulatory framework. The Sustainable Forest Management System includes internal and external auditing of all VicForests' activities to ensure compliance with the Code of Practice for Timber Production, Management Plans, Action Statements and VicForests' own requirements.

VicForests' Sustainable Forest Management System is externally certified by the Australian Forestry Standard, aligned to the global Programme for the Endorsement of Forest Certification, the world's largest forest certification scheme.

VicForests is regularly scrutinised, with extensive internal, external and regulatory audits taking place each year. In addition to the Australian Forestry Standard re-certification audit that occurs every three years, VicForests is also subject to Australian Forestry Standard surveillance audits every six months. Regulatory Forest Audit Program audits, managed by DEPI, are also performed each year, as well as VicForests' own internal auditing.

Regular auditing ensures procedures and staff are up-to-date with all regulatory requirements and it encourages innovation and fresh approaches to ongoing system improvements and practices.

3   Approach and findings

3.1   Advisory Group approach and scope

3.1.1   Approach

To inform the development of its recommendations, the Advisory Group sought to understand the range of potential actions that could be undertaken to support recovery of Leadbeater's Possum while maintaining a sustainable timber industry. To compile an initial list of possible actions for consideration, existing documentation and recent research was examined and there was engagement with a wide variety of stakeholders to seek their ideas and views (Section 3.2).

A three staged process of qualitative and quantitative analysis of the suggested actions was then undertaken to help determine those best able to deliver on the Terms of Reference (Section 3.3). This process made use of expert knowledge and various modelling tools to develop an understanding of the scale of the costs and benefits expected to result from identified actions. The results of this analysis informed the shaping of a package that the Advisory Group considers supports recovery of Leadbeater's Possum while maintaining a sustainable timber industry (Section 4).

An overview of the Advisory Group's process is outlined in its Decision-making Framework in Appendix 5 of the Recommendations Report.

3.1.2   Geographic area under consideration

The area under consideration by the Advisory Group is the Central Highlands ash forests and Snow Gum woodlands to the northeast of Melbourne, which encompasses all of the current known range of the species (with the exception of the lowland forests in the Yellingbo area) (Figure 1). There are separate processes developing recommendations for the conservation of the Yellingbo population (VEAC 2013), and while mindful of the work being undertaken in Yellingbo, the Advisory Group has not included this area in its recommendations.

The defined range of the species within the Central Highlands is based on known records (Figure 1; Harley 2004) and habitat requirements of Leadbeater's Possum. It is delineated by potentially suitable habitat in the Central Highlands Regional Forest Agreement area, excluding the ash forests in the Dandenongs and in the western Kinglake area. The species has not been recorded in these areas and it is assumed that it is absent from these locations. The Leadbeater's Possum range is a subset of Central, Dandenong and Central Gippsland Forest Management Agreements areas.

Broadly, the following Ecological Vegetation Classes (vegetation types) are relevant to the area under consideration:

- Wet Forest;
- Montane Wet Forest;
- Montane Damp Forest;
- Cool Temperate Rainforest;
- Sub-alpine Woodland; and
- Montane Riparian Thicket

To inform the analysis, this classification was refined using a combination of Statewide Forest Resource Inventory (SFRI) data (primarily available just for State forests) and an alternative dataset

based on a non-tenure specific description of structural vegetation in Victoria (SVEG100) for parks and reserves. The species selected as potential habitat from these layers included:

- Alpine Ash *E. delegatensis*;
- Mountain Ash *E. regnans*;
- Shining Gum *E. nitens*;
- Snow Gum *E. pauciflora*; and
- Myrtle Beech *Nothofagus cunninghamii.*

A final spatial (GIS) layer was produced showing all potential areas of habitat within the range of Leadbeater's Possum (Figure 5), which was used to define the geographic area under consideration.
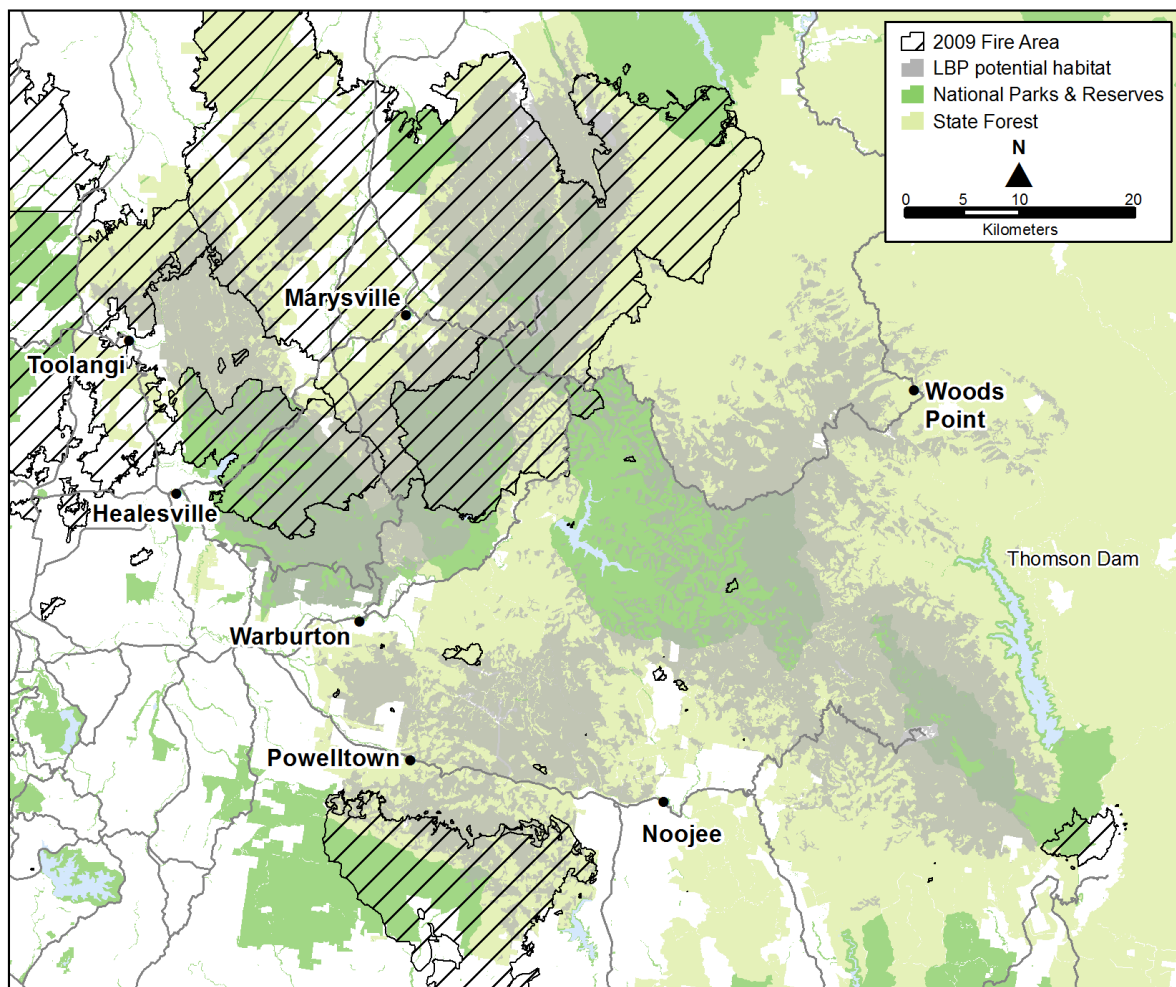
Figure 5. The area of potential habitat for Leadbeater's Possum within the Central Highlands, based on areas of ash forest and Snow Gum woodland which defines the area under consideration (grey shading). The area burnt in the 2009 bushfires is shown by the cross hatching.

3.2   Stakeholder engagement process

3.2.1   Overview of the stakeholder engagement process

Consultation with a targeted range of experts, scientists and stakeholders including the wider community, contributed to an understanding of the range of possible actions to support recovery of the Leadbeater's Possum. Along with actions identified from existing documents (e.g. the existing Action Statement and Recovery Plan for Leadbeater's Possum), suggested actions from the stakeholder engagement process played an important role in the development and refinement of the list of possible actions that was considered.

Three avenues of stakeholder engagement were utilised:

- targeted stakeholder workshops;
- written submissions; and
- on-line forum.

In addition, the opinion of a range of experts was sought as recommendations were developed. This supported refinement of the recommendations.

3.2.2   Targeted stakeholder workshops

Four half-day stakeholder forums were held in Melbourne over 30 September and 1 October, with stakeholders grouped into one of four categories according to their major interest or specialisation: science, environment, industry and community. A total of 145 organisations and individuals were personally invited to the workshops. Of these, 56 attended one of the four workshops (Appendix 1). Each workshop was chaired by DEPI Chief Scientist, Dr Graham Mitchell and facilitated by *pollinate,* an independent research consultancy. Members of the Advisory Group and staff from DEPI attended the workshops.

Each workshop commenced with presentations from experts on Leadbeater's Possum, including Dr Dan Harley (Zoos Victoria), Professor David Lindenmayer (the Australian National University) and Dr Lindy Lumsden (Arthur Rylah Institute, DEPI). These presentations were pre-recorded as videos and placed on the Advisory Group's webpage hosted on the DEPI website (http://www.depi.vic.gov.au/environment-and-wildlife/wildlife/leadbeaters-possum). This ensured that the same information provided at the workshops was available to members of the public to assist with the preparation of written submissions. Collectively, these presentations provided a current evidence base for the status of Leadbeater's Possum and the challenges to its recovery.

Workshop participants were asked to respond to the following points:

- list any actions that you recommend should be undertaken to support the recovery of the Leadbeater's Possum while maintaining a sustainable timber industry;
- identify your top three actions that will most benefit the Leadbeater's Possum;
- identify your top three actions that will most benefit the Leadbeater's Possum and ALSO have minimal cost (both to implement and on society/industry); and
- any other comments you would like the Advisory Group to consider.

Key high level discussion points arising from the four workshops are summarised below. A record taken at each of the workshops of suggested actions from participants is provided in Appendix 1.

3.2.2.1 Science workshop

Most attendees of the science workshop were research scientists based at universities, government agencies, institutes or private consultancies, with ecological, zoological, forest science or fire science expertise. Key discussion points identified from the actions suggested at the science workshop include:

- whether the aims and terms of reference of the Advisory Group could be fulfilled (i.e. whether recovery of Leadbeater's Possum <u>and</u> a sustainable timber industry is feasible under current government policy);
- innovation and new forest habitat management approaches, including greater intervention in terms of lengthening rotation, habitat development through thinning, captive breeding and testing of nest boxes;
- pros and cons of interventions such as captive breeding and nest boxes were discussed, although there was no consensus on the likelihood of success of different options;
- the difference between minimizing the risk of extinction versus recovery of the species was raised as an important issue of distinction;
- impacts of climate change and fire were noted as threatening processes that the Advisory Group should consider when drafting recommendations; and
- general agreement that evidence-based decision-making and collaboration across sectors are important for moving forward.

3.2.2.2 Environment workshop

Attendees at the environment workshop were from various national, state and regional (Central Highlands) environmental organisations. Key discussion points identified from the actions suggested at the environment workshop include:

- concerns that the Advisory Group's Terms of Reference were too narrow and lacked clarity, and the need to define key terms, such as a "sustainable timber industry";
- strong support for accepting the recommendations in Professor David Lindenmayer's prescriptions report in full and creating a Great Forest National Park (Lindenmayer *et al.* 2013b: *New restoration forest management prescriptions to conserve Leadbeater's Possum and rebuild the cover of ecologically mature forest in the Central Highlands of Victoria*), with expectations of reform of the timber industry;
- strong desire for greater political will by the Victorian Government to tackle broader biodiversity challenges in a timely manner;
- the need for more and better surveys and data collection at the landscape management level down to a focus on individual trees and a concurrent review of acceptable standards for forestry operations; and
- questions about the clarity and accuracy of industry statistics, particularly the employment figures.

3.2.2.3 Industry workshop

Attendees at the industry workshop included representatives of various timber industry organisations, owners and employees of a number of harvest and haulage companies operating in the Central Highlands region, and representatives from forest users. Key discussion points identified from the actions suggested at the industry workshop include:

- a concern that the efforts of industry on biodiversity and fire management are not widely recognised, including current efforts to protect threatened species;
- general agreement that more could be done: it was noted that there could be further on-ground conservation measures with increased flexibility and new/different forest management approaches (e.g. variable retention harvesting);
- questions about the importance of the current range of Leadbeater's Possum and the possibility of expanding the range of the species via translocation to other forest areas within Victoria;
- strong concern about the implications of implementing in full the Lindenmayer *et al*. (2013b) prescriptions including the proposed Great Forest National Park. It was suggested this would eliminate the local native timber industry; and
- opportunities for innovation and interventions, such as nest boxes.

3.2.2.4 Community workshop

Attendees at the community workshop included representatives of various local government authorities, regional commerce organisations and businesses and regional environmental organisations. There was a strong diversity of organisations and perspectives within this workshop. Key discussion points identified from the actions suggested at the community workshop include:

- the ability of the Advisory Group to deliver on its Terms of Reference, particularly given the competing aims and current policy commitments;
- issues about governance, trust and broader land management structures;
- transparency and access to information, including industry statistics;
- strong support for the Lindenmayer *et al*. (2013b) prescriptions in their entirety, while others were quite concerned about their potential impact on industry; and
- a sense of fatigue in relation to conflicting information and the ongoing debate, and an eagerness for resolution.

3.2.3   Written submissions

The community was invited via the Advisory Group's webpage on the DEPI website to provide written submissions. Respondents were asked to address the same questions asked of participants at each stakeholder workshop.

A total of 41 submissions were received, 13 of which were from participants who also attended the stakeholder workshops. In most submissions, respondents simply listed their suggested 'top three actions'. Some submissions also provided detail to support the issues raised. The majority of the issues raised in the written submissions were also raised in the stakeholder forums. As such, they are generally reflected in the lists of suggested actions in Appendix 1. The majority of written submissions mentioned some, or all, of the suite of prescriptions outlined in Lindenmayer *et al*. (2013b).

High-level themes raised by stakeholders in written submissions are outlined below.

- The need to secure habitat for Leadbeater's Possum now and into the future, and to ensure this habitat has connectivity and a distribution of age classes. The strongest call was for the creation of a Great Forest National Park, in line with the Lindenmayer *et al*. (2013b) prescriptions. Of the 41 submissions, 28 (70%) recommended this course of action.

- A call for the end of clearfall timber harvesting. (Note that submissions did not equate the establishment of the Great Forest National Park as equivalent to ceasing native timber harvest.) There is an opinion that timber harvesting should be migrated to plantations.
- Protection of Leadbeater's Possum colonies was a strong theme throughout the submissions. In line with the position adopted by the leading scientist on the species, Professor David Lindenmayer, many submissions adopted either all his recommendations or variations on those recommendations.
- Address forestry prescriptions to secure environmental benefits – particularly the protection of old growth forest and the need to ensure the recruitment of the next generation of old growth.
- Lack of information and transparency – a call for an end to the (perceived) subsidisation of VicForests, clarity on the sustainability of native timber harvest and the economic impacts/benefits of native timber harvest. Many submissions indicated a lack of trust and called for full disclosure on the state of the possum and the industry.
- Call for better information on the location and extent of the Leadbeater's Possum and for this to be linked better to the planning of allowable harvesting.
- Fire management including an acknowledgement of the impact of fire and recommendations to address the management of fire and its impacts on the species.
- Solutions such as nest boxes, captive breeding, artificial hollow development and translocation.
- The importance of the timber industry and concern regarding potential impacts on resource availability. There was recognition of the areas already conserved for Leadbeater's Possums and biodiversity in national parks and conservation reserves.
- The Advisory Group's Terms of Reference and process was too restrictive, with some challenging the need to retain the native timber industry.

3.2.4 On-line forum

Members of the community were invited by the Advisory Group via its webpages to share ideas and ask questions through an on-line forum hosted on the DEPI website. The on-line forum used IdeaScale, which enables users to post questions and vote on the ideas/questions of other participants. The on-line forum was conducted over 10 days and promoted through Zoos Victoria, VAFI and DEPI social media and the DEPI website. A total of 17 posts were made to the on-line forum; in most cases these were in the form of comments rather than questions.

3.2.5 Expert opinion

The views on the effectiveness of possible actions in terms of benefits to Leadbeater's Possum and impacts on the estimates of volume and costs to the timber industry were sought from a range of internal (cross-agency) and external sources.

In terms of expected benefits to Leadbeater's Possum the following experts were consulted:

- a working group convened by the Advisory Group, comprised of subject matter experts from various government agencies;
- the Australian National University (ANU) Leadbeater's Possum research team lead by Prof. David Lindenmayer; and
- the Leadbeater's Possum Recovery Team.

In terms of expected impacts on the timber industry the following experts were consulted:

- a working group convened by the Advisory Group, comprised of subject matter experts from various government agencies;
- commissioned timber industry economists; and
- external forest consultants.

This expert opinion played an important role in assisting the Advisory Group in developing and refining possible packages of actions to recommend to the government.

3.3 Development and evaluation of options

Based on the outcomes of the stakeholder engagement process described above, and with reference to existing documents, a comprehensive list of potential actions was developed that could assist in supporting the recovery of the Leadbeater's Possum.

The list of potential actions was then assessed through a three stage process:

Stage 1 A qualitative assessment, verified by independent third-party experts, to evaluate all the actions in terms of their estimated benefit to the possum and estimated cost to the timber industry (Section 3.3.2). This assessment allowed the Advisory Group to eliminate from consideration actions that were considered to have limited benefit to the possum or an unacceptably high cost to the industry. The remaining actions were then assessed further in Stage 2.

Stage 2 A quantitative assessment, using ecological and economic modelling techniques, to assess actions for their estimated relative benefit to the possum and cost to the timber industry (Section 3.3.3). Based on this assessment, the Advisory Group developed a range of alternative packages of actions with varying benefits to the possum and costs to the timber industry.

Stage 3 The ecological and economic modelling techniques assisted with testing the alternative packages (Section 3.3.4) and informed the development of the recommended package of actions (Section 4).

This process is outlined in more detail in the Decision-making Framework (Appendix 5 in the Final Recommendations report).

3.3.1 Developing a comprehensive list of potential actions

A comprehensive list of potential actions to support the recovery of Leadbeater's Possum was developed by reviewing existing documents and seeking further input from other sources, including:

- Action Statement 62: Leadbeater's Possum, 1995;
- draft revised Leadbeater's Possum Action Statement, 2010;
- Leadbeater's Possum Recovery Plan, 1997;
- DEPI Actions for Biodiversity Conservation Database;
- *New Restoration Forest Management Prescriptions to Conserve Leadbeater's Possum and Rebuild the Cover of Ecologically Mature Forest in the Central Highlands of Victoria* (Lindenmayer *et al.* 2013b);
- VicForests Operating Procedures;
- actions proposed by ARI/DEPI; and
- actions proposed by the Recovery Team.

The list of potential actions was then augmented with actions suggested by participants in the four stakeholder workshops and through the written submissions (Section 3.2). All actions suggested by stakeholders were considered by the Advisory Group:

- those actions that were within the Terms of Reference and not already included were added to the list of potential actions;

- those actions deemed to be outside the Terms of Reference were treated as comments and were broadly used to inform the Advisory Group in its deliberations;
- some actions suggested by stakeholders were considered as possible mitigation measures rather than on-ground action;
- actions were merged if they addressed similar issues; and
- some actions were sub-divided based on the extent or scale to which the action could be undertaken.

The potential actions were then grouped into seven categories, each with associated sub-categories, based on the focus of the actions (Table 2).

Table 2. The categories of actions considered, with their rationale for supporting the recovery of Leadbeater's Possum

Category of action	Rationale
1. Streamlining accelerated delivery of emergency interventions post disturbance	The aim of this group of actions is to provide assistance to individuals and colonies that have been directly impacted by disturbance or habitat decline to such an extent that the individual or colony is unlikely to survive without direct intervention.
1.1 Active colony management	Includes actions that involve actively assisting colonies that have been adversely affected by disturbance or habitat loss and will not survive without active management.
1.2 Active habitat management	Includes actions that involve immediately improving existing habitat to minimise the effects of disturbance or habitat decline.
2. Improve protection of existing colonies and habitat	The aim of this group of actions is to ensure the remaining colonies and currently suitable habitat are maintained to maximise capacity for the species to recover. It recognises that recent fire events and ongoing habitat decline due to previous fire events and management practices has led to a reduced population of Leadbeater's Possums. The remaining wild population is therefore critical to the recovery of the species. Similarly this recognises that the habitat requirements of the Leadbeater's Possum are very specific and suitable habitat is becoming increasingly rare. As the development of suitable habitat takes a very long time, the preservation of existing suitable habitat is important for the ongoing persistence of Leadbeater's Possum.
2.1 Protection of existing colonies	Includes actions that identify the location of colonies and protects these from impacts that can be directly controlled or to implement programs that minimise risk of unplanned impacts on these colonies.
2.2 Protection of existing suitable habitat	Includes actions that protect existing suitable habitat from disturbance and decline, including identifying and defining the characteristics of existing habitat, and actions that exclude (or minimise risk of) activities that can reduce the quality and/or abundance of that habitat.
2.3 Active species management	Includes actions that can enhance the capacity of the species to increase in population size and disperse into suitable habitat.

Category of action	Rationale
3. Improving future habitat availability and quality	The aim of this group of actions is to provide for an expanded area of forest in the future that is suitable habitat for Leadbeater's Possum. This recognises that a critical element of Leadbeater's Possum habitat requirements is the presence of sufficient densities of suitable hollow-bearing trees and that the natural formation of such trees is a slow process. Therefore strategies that accelerate the development of required forest structures or enable protection of the forest so that it may develop to such an age that required habitat is formed naturally will assist in improving future habitat.
3.1 Improve forest structure/function	Includes actions that promote a multi-age forest structure across the landscape that contains the elements required to produce suitable habitat for Leadbeater's Possum. This includes development of suitable densities of hollow-bearing trees and a vegetation structure that allows for movement through the understorey.
3.2 Increase future old growth	Includes actions that enable stands to grow to ecological maturity through protection from disturbance such as fire and timber harvesting.
4. Improving transparency of Leadbeater's Possum management	The aim of this group of actions is to ensure there is confidence that proposed actions are being undertaken in an effective manner. Transparency can be improved through improved availability of information, improved monitoring and regular reporting and greater communications regarding quality assurance processes including auditing.
4.1 Improve information recording and access	Includes actions that consolidate, clarify and communicate baseline information regarding Leadbeater's Possum and its habitat. It recognises that there are many groups and institutions that have recorded information regarding the Leadbeater's Possum, yet the consolidation of this information in a central, accessible location has been inconsistent.
4.2 Implementation monitoring and reporting	All actions included within any revised management plan for Leadbeater's Possum should be accompanied by an appropriate and funded monitoring program to evaluate the implementation of those actions. It is recognised that there are a number of bodies responsible for overseeing delivery of management actions. However, explicit responsibilities should be clarified to ensure that actions are undertaken.
4.3 Improve quality assurance and accountability	Includes actions relating to overseeing and auditing action delivery as well as improved communication of these programs to build confidence in the quality assurance process.

Category of action	Rationale
5. Improving knowledge regarding Leadbeater's Possum populations, ecology, habitat and habitat resilience	The aim of this group of actions is to ensure that management actions are driven by scientific information and that potential for improved outcomes can be measured.
5.1 Research	Includes investigation of knowledge gaps relating to the Leadbeater's Possum. Research is to be targeted at areas which directly support recovery actions.
6. Improve engagement with the community	The aim of this group of actions is to involve the community in managing Victoria's State owned forests since they are managed for all Victorians.
6.1 Stakeholder engagement	Engagement with the community regarding issues of high interest, such as Leadbeater's Possum and its management, improves understanding of issues and provides for greater contribution into decision making and outcome delivery.

To clarify the role of each action in supporting outcomes for Leadbeater's Possum, the list of potential actions was divided into three categories:

- on-ground actions (actions that will directly benefit Leadbeater's Possum);
- enabling actions (actions that would generally be core business for DEPI and other organisations that provide the mechanisms for implementing the actions); and
- supporting actions (actions that would provide additional information to more effectively implement the on-ground actions, including research, surveys and community engagement).

3.3.2 Stage 1 – Qualitative assessment of actions

3.3.2.1 Development of performance measures – benefits to Leadbeater's Possum

Five performance measures were developed to qualitatively assess the likely impact of each potential action on Leadbeater's Possum's recovery and persistence in the wild (Table 3). On-ground actions were assessed against all performance measures, while enabling and supporting actions were assessed against how important they were to supporting the implementation of on-ground actions.

Table 3. Performance measures for assessing benefits to Leadbeater's Possum of the potential on-ground actions.

Performance Measure	Rating		
	High	**Medium**	**Low**
Risk of extinction of Leadbeater's Possums	Action will have a significant impact on reducing the risk of extinction over the next 100 years and/or will have a significant impact on reducing the rate of decline in the near future.	Action will have a moderate impact on reducing the risk of extinction over the next 100 years and/or will have a moderate impact on reducing the rate of decline in the near future.	Action will have a small impact on reducing the risk of extinction over the next 100 years and/or will have a small impact on reducing the rate of decline in the near future.
Impact on the number of individuals	Action will effect a large proportion of the total population and will have a significant, positive impact on those individuals.	Action will affect a small proportion of the total population but will have a significant, positive impact on those individuals; or will affect a large proportion of the total population but have only a small impact on those individuals.	Action will affect only a small proportion of the total population and will only have a small impact on those individuals.
Quality of habitat	Action will markedly improve the quality of habitat or will markedly reduce the risk of loss of quality habitat.	Action will moderately improve the quality of habitat or will moderately reduce the risk of loss of quality habitat.	Action will have small impact on improving the quality of habitat or only small impact on reducing the risk of loss of quality habitat.
Extent of habitat	Action will markedly improve the extent of habitat or markedly reduce the risk of loss of habitat across large areas.	Action will moderately improve the extent of habitat or will moderately reduce the risk of loss of habitat across some areas.	Action will have small impact on improving the extent of habitat or only small impact on reducing the risk of loss of habitat.
Distribution of habitat to spread the risk	Intervention will be implemented across the species range, or will assist the species to be more resilient across its range.	Intervention will be implemented across part of the range.	Intervention will be localised and applicable to only small areas, or clustered within one area.

Each potential action was assessed separately against each performance measure. The rating of each of the performance measures were then assessed collectively to determine each action's overall benefit to Leadbeater's Possum. Actions were ranked as high, medium or low, based on an agreed 'average' of their rating against the performance measures (e.g. if rated low for most performance measures but medium for one of the performance measures, the estimated 'average' would be low).

Additional supporting criteria were also evaluated for each potential action (Table 4).

Table 4. Supporting criteria used to assess actions.

Supporting criteria	Rating		
	High	**Medium**	**Low**
The probability that the action can be effectively implemented.	Proven technique for which there is a high level of certainty that, if implemented at the appropriate scale, it will be effective.	Existing technique that may need some refinement to improve certainty of its effectiveness.	Unproven technique with a high level of uncertainty as to whether it will be effective.
Ease of implementing action.	Can be undertaken under existing policies and procedures. (May also consider: project lead established, funding available, can be planned and completed within first 2 years.)	Can be undertaken under existing policies but procedures will require modification. (May also consider: project lead suggested but not confirmed, funding possible, can be planned and completed within 2-5 years.)	Policy or legislative changes would be required for option to be implemented. (May also consider: funding uncertain or not available, no project lead, will take more than 5 years to plan and complete.)
Time frame for implementing action.	Action can be implemented immediately (<2 years).	Action will take some planning and time before possible to implement (e.g. 2-5 years).	Implementation would not be possible for some time (e.g. 5+ years).
Time frame over which the benefits will be realised.	Benefits will start accruing immediately once action is implemented.	Benefits will accrue in the medium term (e.g. 2-15 years).	Benefits will not be realised for some time (e.g. 15+ years).
Implications for fire management.	Fits within current fire management planning and implementation processes.	Current fire management planning and implementation processes could be modified to accommodate actions.	Outside current fire management planning and implementation processes.

Supporting criteria	Rating		
	High	**Medium**	**Low**
Adequacy of knowledge to assess effectiveness of action.	Existing knowledge is sufficient to confidently assess the potential effectiveness of the action.	There is some existing knowledge, allowing a moderate level of confidence in the assessment of the potential effectiveness of the action.	Insufficient existing knowledge resulting in a low confidence in the assessment of the potential effectiveness of the action.
Adequacy of current knowledge required to effectively implement action.	Knowledge sufficient to implement action.	Additional knowledge required to effectively implement action.	Little knowledge available on how and where to implement action.

3.3.2.2 Development of performance measures – impact on the timber industry

In Stage 1, the impact of on-ground actions on the timber industry were assessed using preliminary estimates for two indicators:

- the likely reduction in volume of timber produced (as a readily understandable proxy for the overall impact on the industry); and
- the likely order of magnitude of the impact on the cost of supply of each action.

The cost estimates for the timber industry included both direct and opportunity costs, where direct costs are those costs that can be completely attributed to the production of ash sawlog and pulplog (harvest, haulage and operational costs) and opportunity costs result from loss of foregone revenue. The process for developing the preliminary estimates of impact on the timber industry was:

- for each on-ground action VicForests provided an estimated reduction in the volume of ash sawlog and pulplog that could be produced;
- the analysis considered whether the timber could be supplied from elsewhere to replace this, and estimated direct and opportunity costs;
- direct costs included extra harvest and transport costs of alternative supply, and any increased operational costs for VicForests for the remaining supply;
- opportunity cost was estimated as revenue, less harvest and haulage costs, for any timber volumes that would no longer be supplied from within Victoria;
- the costs did not include compensation or flow on effects past VicForests' supply at the mill gate; and
- cost estimates were developed for each on-ground action independently (noting that the areas potentially affected by many of the actions are likely to overlap and so, if multiple actions are implemented, the costs will not necessarily be additive).

Costs were calculated as annualised costs over a twenty year period. This period was chosen as a reasonable term to assess likely outcomes past the duration of VicForests' current contracts without requiring forecasts of costing parameters too far into the future. The costs were not discounted (as

they were average annual estimates and discounting would not affect the relativities between actions).

Limitations of the preliminary costing method used in Stage 1 include:

- some of the on-ground actions had broad descriptions so estimating their impacts required an interpretation of how the action would be defined and applied;
- the analysis was undertaken at a highly aggregated level. Impacts were averaged and many spatial elements that may impact on cost were not taken into account; and
- no rigorous verification of the methodology for calculating volume and cost estimates was undertaken in Stage 1.

Costs were divided into four impact categories in order to produce usable information for the Stage 1 assessment, while recognising the limitations in the data. These were:

- Less than $1 million per annum;
- $1-$10 million per annum;
- $10-$20 million per annum; and
- $20-$30 million per annum.

As the indicators of volume and costs were strongly correlated, each action was given a ranking based on its likely impact on timber volumes (Table 5).

Table 5. Preliminary estimations of reduction in annual volume of ash sawlogs. Note that these reductions would be in addition to the 25 per cent reduction in ash harvest volumes commencing in 2017 which are in response to the 2009 bushfires (announced by VicForests in August 2013).

Ranking for impact on timber industry	Preliminary estimation of reduction in annual volume of ash sawlogs produced
Low	Less than 1%
Medium	1-10%
High	10-50%
Very high - extreme	50-100%

Note that these indicators did not consider broader impacts such as regional impacts and jobs. As part of developing its final recommendations, the Advisory Group also considered the results of modelling undertaken for DEPI Forest Industry Policy to understand the potential impacts on regional jobs from various timber volume reduction scenarios.

3.3.2.3 Evaluation of on-ground actions against performance measures

The list of on-ground actions was assessed against each performance measure and supporting criteria. This work was undertaken by an Actions Working Group (AWG), which was chaired by one of the Advisory Group co-conveners and included some representatives from the Leadbeater's Possum Recovery Team, the Arthur Rylah Institute, Zoos Victoria, Parks Victoria, VicForests and DEPI. The AWG reviewed and assessed the on-ground actions over three full-day workshops. The evaluation by the AWG of the expected benefit to Leadbeater's Possum of each on-ground action,

using the assessments of each of the performance measures and supporting criteria, is presented in Table 6.

The AWG assessment was cross-checked with similar assessments carried out by independent experts (see Section 3.3.2.5).

The timber industry performance measures were estimated by DEPI in collaboration with VicForests using the approach described in Section 3.3.2.2. These estimations were not verified externally for Stage 1.

Table 6. The evaluation of potential on-ground actions against the performance measures and supporting criteria for benefits to Leadbeater's Possum and for the impact on the timber industry. Impact on timber industry includes both direct and opportunity costs. The categories of actions outlined in Table 2 are shown here with grey shading. See Tables 3, 4 and 5 for explanations of performance measures and supporting criteria. Timeframe for implementation: high = short timeframe. Timeframe for benefits: high = short timeframe. Implications for fire management: high = within existing processes.

Potential actions	Benefits to Leadbeater's Possum						Supporting criteria							Impact on timber industry
	Impact on risk of extinction	Impact on number of individuals	Improving quality of habitat	Increasing extent of habitat	Spreading the risk	Overall benefit	Probability of effective implement-ation	Ease of implement-ation	Timeframe for implement-ation	Timeframe for benefits	Implications for fire management	Adequacy of knowledge to assess effectiveness	Adequacy of knowledge to implement	
1. Streamline accelerated delivery of emergency interventions post disturbance														
No on-ground actions – see enabling actions														
2. Improve protection of existing colonies and habitat														
2.1 Protection of existing colonies														
Action 1. Protect all known colonies of Leadbeater's Possum with a buffer, based on records within the past 15 years (i.e. since 1998):														
a) Buffer all known records by 100m radius	low	low	low	low	med	**low**	high	high	high	high	high	high	med	med
b) Buffer all known records by 200m radius	low-med	med	low	low	med	**low-med**	high	med	high	high	high	high	med	med
c) Buffer all known records by 500m radius	med	med	med	med	med	**med**	high	low	med	high	high	high	med	med
d) Buffer all known records by 1km radius	high	med-high	med	high	high	**high**	high	low	low	high	high	high	med	high
e) Buffer with site specific plan protecting the most appropriate 4 ha around the record.	low-med	med	low	low	med	**low-med**	high	med	high	high	high	high	med	med
Action 2. Undertake active fire management activities (including fuel management in adjacent forests or fire break creation) to protect identified colonies from fire.	High	High	High	High	high	**high**	low-med	med-high	med-high	high	med	med	low-med	n/a
Action 3. Undertake predator control in areas where colonies are vulnerable to introduced predators (most relevant to Snow Gum habitats).	low	low	low	n/a	low	**low**	low	medium	high	high	high	high	low	n/a
Action 4. Supplement (hollows or food, if needed) to enable colonies surviving in 2009 fire refuges to persist until surrounding habitat becomes suitable.	low	low-med	low	low	low-med	**low**	low-med	high	high	med	High	med	med-low	n/a
Action 5. Exclude logging from fire refuge areas (from the 2009 fires and subsequent fires) - i.e. areas where both the understorey and canopy remained unburnt, surrounded by burnt area, irrespective of whether it meets Zone 1 habitat or known colonies present. Areas to be greater than 10 ha or 20 ha in size with an upper size limit to be determined.	low-med	low-med	low-med	low-med	med	**low-med**	high	med-high	high	high-med	med	med	med-high	no estimate
Action 6. Exclude logging from unburnt refuges (as defined in Action 5) and buffer them.	med	low-med	med	low-med	med	**med**	high	med-high	high	high-med	med	med	med-high	no estimate
Action 7. Exclude fire refuges (as defined in Action 5) from planned burning and protect where possible during wildfire.	low-med	low-med	low-med	low-med	med	**low-med**	high	med-high	high	high-med	med	med	med-high	n/a

Potential actions	Benefits to Leadbeater's Possum						Supporting criteria							Impact on timber industry
	Impact on risk of extinction	Impact on number of individuals	Improving quality of habitat	Increasing extent of habitat	Spreading the risk	Overall benefit	Probability of effective implement-ation	Ease of implement-ation	Timeframe for implement-ation	Timeframe for benefits	Implications for fire management	Adequacy of knowledge to assess effectiveness	Adequacy of knowledge to implement	
2.2 Protection of existing suitable habitat														
Action 8. Revise management prescriptions to protect currently suitable habitat from harvesting activities and other forest management activities (i.e. roads) including a revision of the existing Leadbeater's Possum habitat zone definitions, and associated survey standards:														
a) Maintain Zone 1A as > 12 trees/ 3 ha, but redefine trees as any hollow-bearing tree (HBT) > 1.5 m diameter at breast height (DBH)	negative	negative	negative	negative	negative	**negative**[1]	high	high	high	low	high	high	high	no estimate
b) Maintain Zone 1A as > 12 trees/ 3 ha, but redefine trees as any HBT > 1.0 m DBH (dead or live)	low-med	low-med	low-med	low-med	low-med	**low-med**	medium-high	high	high	high	high	medium	high	no estimate
c) Maintain Zone 1A as > 12 trees/ 3 ha, but redefine trees as any tree > 80 cm DBH HBT live or dead	med	med	med	med	med	**med**	high	med	med	low-med	high	med	med	no estimate
d) Redefine Zone 1A as > 8 trees/ 3 ha, while retaining current tree age definition	med	med	med	med	med	**med**	high	med	High	high	high	med	med	no estimate
e) Redefine Zone 1A as > 8 trees/ 3 ha, and redefine trees as any HBT > 1.0 m DBH (dead or live)	med	med	med	med	med	**med**	medium-high	medium	high	high	high	medium	high	no estimate
f) Redefine Zone 1A as > 8 trees/ 3 ha, and redefine trees as any HBT > 80 cm DBH	med - high	med - high	med - high	med - high	med - high	**med - high**	high	med	med	med	high	med	med	no estimate
g) Redefine Zone 1A as > 6 trees/ 3 ha, while retaining current tree age definition	high	high	high	high	high	**high**	high	med	med	med	high	med	med	no estimate
Action 9. Buffer all Zone 1A habitat by 100 m, to improve protection from disturbance, especially during timber harvesting.	low-med	low-med	med	med	med	**med**	high	med-high	High	high	High	med	med	high
Action 10. Buffer all areas of old growth ash forest to improve protection from disturbance, especially during timber harvesting.	low	low	low-med	Low-med	low	**low**	high	high	high	high	high	med	med-high	no estimate
Action 11. Based on current improved knowledge of where colonies and habitat occur, incorporate into SPZs the most important areas:														
a) Within the existing cap of SPZs	low	low	low-med	low-med	low-med	**low-med**	med	high	high	high	high	medium	medium	no estimate
b) Increasing the area reserved above the cap														
b1) Move areas from GMZ to SPZ where ARI occupancy model > 0.65	low-med	low-med	med	med	med	**med**	med	med-low	high	high	high	med	med	med
b2) Move areas from GMZ to SPZ where ARI occupancy model > 0.50	med-high	med-high	med-high	med-high	med-high	**med-high**	med	low	high	high	high	med	med	high
b3) Move areas from GMZ to SPZ where ARI occupancy model > 0.30	high	high	high	high	high	**high**	med	low	high	high	high	med	med	very high - extreme
Action 12. Buffer areas in occupancy model represented by ARI 0.65-0.90 probability, by 50m.	low	low	low	low	low	**low**	med	med	high	high	high	low	med	med
Action 13. New formal reserve system based on the proposal for a Great Forest National Park in the Central Highlands.	med-high	high	med-high	high	high	**high**	med-high	low	high	high	high	med-high	high	very high - extreme

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[1] A rating of 'negative' was given where it was considered that the action would result in a worse position for Leadbeater's Possum compared to the current situation.

Potential actions	Benefits to Leadbeater's Possum						Supporting criteria							Impact on timber industry
	Impact on risk of extinction	Impact on number of individuals	Improving quality of habitat	Increasing extent of habitat	Spreading the risk	Overall benefit	Probability of effective implementation	Ease of implementation	Timeframe for implementation	Timeframe for benefits	Implications for fire management	Adequacy of knowledge to assess effectiveness	Adequacy of knowledge to implement	
Action 14. Implement revised regeneration burn practices to minimise risk to habitat elements.	low-med	low	med	med	high	**med**	med	high	high	high	high	high	med	no estimate
Action 15. Exclude thinning in GMZ from areas within 200 m of all known colonies.	low	low-med	low-med	low	low	**low-med**	med	high	high	high	high	high	med	no estimate
Action 16. Exclude thinning in GMZ from areas within 200 m of areas reserved specifically for Leadbeater's Possum (Zone 1A&B or Leadbeater's Possum reserve).	low	low-med	low-med	low	low	**low-med**	med	high	high	high	high	high	med	no estimate
Action 17. Expand riparian buffers:														
a) Increase riparian buffers to 20m either side of all permanent and temporary streams	low	low	low	low	low	**low**	high	high	high	high	high	high	high	nil
b) Increase riparian buffers to 50m either side of all permanent and temporary streams	med-high	med-high	med-high	med-high	med-high	**med-high**	high	med	high	high	high	med-high	high	high
c) Increase riparian buffers to 100m	high	high	high	high	high	**high**	high	low	high	high	high	high	high	very high - extreme
d) Variable width riparian buffers based on the suitability of the habitat, with width to be between 20 and 100 m.	med-high	med-high	med-high	med-high	med-high	**med-high**	high	low	high	high	high	med-high	high	high
Action 18. Undertake active fire management activities (including but not limited to fuel management in adjacent forests or fire break creation and suppression activities) to protect identified suitable habitat from fire.	high	high	high	high	high	**high**	low-medium	High	med-high	high	medium	med-high	med	n/a
2.3 Active Species Management														
Action 19. Translocation of wild animals into suitable unoccupied habitat within the known range of the species, especially areas regenerating after the 2009 fires.	low	low-med	n/a	n/a	low	**low-med**	low	med	med	medium	high	low-med	low-med	n/a
Action 20. Captive breeding program to breed possums that can be released to increase the number, distribution and genetic diversity of the wild population.	low	low-med	n/a	n/a	low-med	**low**	low-med	high	med	medium	high	low-med	low-med	n/a
Action 21. Release animals (wild or captive bred) to potentially suitable habitat outside the known range.	low	low	n/a	n/a	low-med	**low**	low	med	med	high	high	med-high	low-med	n/a
Action 22. Capture animals from the wild and hold at zoo as an insurance population, with sufficient individuals to ensure genetic diversity.	low	low	n/a	n/a	low	**low**	low	med	med	low	high	med-high	low-med	n/a
3. Improving future habitat availability and quality														
3.1 Improve forest structure														
Action 23. Active management of suitable stands (typically old growth forest) to encourage the regeneration of understorey wattle at suitable density.	low	low	low-med	low	med	**low**	low	med-high	high	low	med	med	med	n/a
Action 24. Develop active fire management techniques that will encourage the development of suitable forest structure.	low	low	low	low	low	**low**	low	high	high	low	med	low	low	n/a

Potential actions	Benefits to Leadbeater's Possum						Supporting criteria							Impact on timber industry
	Impact on risk of extinction	Impact on number of individuals	Improving quality of habitat	Increasing extent of habitat	Spreading the risk	Overall benefit	Probability of effective implement-ation	Ease of implement-ation	Timeframe for implement-ation	Timeframe for benefits	Implications for fire management	Adequacy of knowledge to assess effectiveness	Adequacy of knowledge to implement	
Action 25. Actively promote *natural* accelerated development of hollows in areas with insufficient hollow bearing tree densities, using selective thinning or other silvicultural processes.	med	low-med	med	med	high	**med**	low-med	high	high-med	low	high	low	med	n/a
Action 26. *Artificially* accelerate the development of hollows.	med	med	med-high	med-high	med	**med**	low-med	high	high	high-low	high	low	med	n/a
Action 27. Implement retention harvesting systems so that post-harvest forest maintains high levels of structural heterogeneity:														no estimate
a) Retention harvesting on 30% of coupes	low	low	low-med	low-med	low-med	**low-med**	high	high	high	med	high	high	high	limited impact
b) Retention harvesting on 50% of coupes	low-med	low-med	med	med	med	**med**	high	med	high	high	high	high	high	med
c) Retention harvesting on all coupes	med	med	med-high	med-high	med-high	**med-high**	high	med	high	high	high	high	high	med
3.2 Increase future old growth														
Action 28. Identify future old growth areas such as those areas least likely to be affected by fire and other disturbance to be considered for active management to enable stands to grow on to ecological maturity. Set targets as part of a landscape planning system for the development of old growth ash forests across the landscape. Implement this system to meet specified targets:														
a) Expand reserves within each Leadbeater's Possum Management Unit (LMU) to 30% (any forest types)	low	low	low	low	low	**low**	high	med	high	low	med	med	med	low
b) Expand reserves within each LMU to 30% ash forest type to enable the development of old growth ash	med-high	med	med-high	med-high	med	**med-high**	high	low	high	low	med	high	med	very high - extreme
c) Expand reserves within each LMU to 50% (any forest type) to enable the development of old growth	low-med	low-med	low-med	low-med	low-med	**low-med**	high	low	med-high	low	med	med	med	med
d) Expand reserves within each LMU to 50% ash forest type to enable the development of old growth ash.	high	high	high	high	high	**high**	high	low	high	low	med	high	med	very high - extreme
Action 29. Buffer all mature live ash trees to improve protection from disturbance, especially timber harvesting:														
a) Buffer live mature trees by 100 m	med-high	med	med-high	med-high	high	**med-high**	high	High	high	med	high	high	med	no estimate
b) Buffer live mature trees by 800 m	high	med-high	high	high	med-high	**high**	high	low	low	high	high	med-high	med	no estimate
c) Buffer live senescent trees by 100 m	med	med	med	med	med	**med**	High	High	high	high- med	high	high	med	high
d) Buffer all live or dead hollow-bearing trees by 100 m	med-high	med	med-high	med-high	med	**med-high**	high	High	high	high	High	med	med	very high -extreme
e) Exclude any trees >1.5 m DBH from harvesting	low-med	low	low-med	low	low	**low-med**	high	high	high	high	high	high	high	high
f) Buffer any trees >1.5 m DBH from harvesting	med-high	med	med-high	med-high	med	**med-high**	high	high	high	med-high	high	med-high	med	no estimate
Action 30. Totally protect by law all hollow-bearing trees	low-med	low-med	low-med	low-med	low-med	**low-med**	high	low	low	high	high	med	med	no estimate

Potential actions	Benefits to Leadbeater's Possum						Supporting criteria							Impact on timber industry
	Impact on risk of extinction	Impact on number of individuals	Improving quality of habitat	Increasing extent of habitat	Spreading the risk	Overall benefit	Probability of effective implement-ation	Ease of implement-ation	Timeframe for implement-ation	Timeframe for benefits	Implications for fire management	Adequacy of knowledge to assess effectiveness	Adequacy of knowledge to implement	
3.3 Active habitat management														
Action 31. Install nest boxes to supplement declining natural hollow densities at occupied sites:														
a) In ash forest at varying densities and scales														
a1) low densities or just at restricted sites	low	low-med	low-med	low	low	**low**	low-med	med-high	high	med-high	med-high	med	med	n/a
a2) moderate density or spread	low-med	med	low-med	low	med	**low-med**	low	med-high	high	med-high	med-high	med	med	n/a
a3) high density and spread	med	med	med	low-med	med	**med**	low	med-high	high	med-high	med-high	med	low	n/a
b) In Snow Gum woodland at varying densities and scales														
b1) low densities or just at restricted sites	low	low-med	low	low	low	**low**	med-high	high	High	high	high	high	high	n/a
b2) moderate density or spread	low	med	low-med	low-med	low	**low-med**	med-high	high	High	high	high	high	high	n/a
b3) high density and spread	low-med	med	low-med	low-med	low-med	**low-med**	med-high	high	High	high	high	high	high	n/a
Action 32. Construct artificial stags using 3D printing technology	low	low	low	low	low	**low**	very low	high	med-low	med				n/a

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3.3.2.4 Evaluation of the enabling and supporting actions

The AWG also assessed the enabling and supporting actions. Unlike the on-ground actions, which were assessed against the performance measures and supporting criteria, enabling and supporting actions were assessed based on how useful they would be in effectively supporting implementation of the on-ground actions. This approach was used because the enabling and supporting actions do not, in themselves, have direct benefits for Leadbeater's Possum.

While carrying out their assessment, the AWG identified additional supporting and enabling actions to be added to the list of potential actions. The AWG noted that the list was not necessarily comprehensive and further work may be required to determine the key enabling and supporting actions required to facilitate the efficient and effective implementation of the on-ground actions.

3.3.2.4.1. Enabling Actions

The enabling actions (which are actions that would generally be core business for DEPI and other organisations that provide the mechanisms for implementing the actions) were prioritised by:

- assessing the current state of each enabling action in terms of progress towards it being a 'business as usual' practice;
- identifying any barriers to implementation (e.g. lack of standards, no reporting system, lack of compliance auditing etc.); and
- determining the relative priorities for removing barriers, based on an assessment of the importance of the enabling action or the risk of not implementing the action.

The enabling actions were evaluated by the AWG using a high, medium or low rating (Table 7).

Table 7. The assessment of the enabling actions with a rating of high to low, based on their importance in enabling implementation of the potential on-ground actions. The categories of actions outlined in Table 2 are shown here with grey shading. The numbering system for the actions continues from the on-ground actions so that each action has a unique identifier. The organisations that would be responsible for implementing the actions is provided in the final column. AG – Leadbeater's Possum Advisory Group; DEPI – Department of Environment and Primary Industries; PV – Parks Victoria; VF – VicForests; ZV – Zoos Victoria.

Potential enabling actions	Rationale	Rating	Responsible organisation
1.1 Active colony management			
Action 33. Develop approved fire recovery protocols that can be enacted without delay following fire (or other) disturbance events that effect known Leadbeater's Possum colonies.	This will assist in improving decisions about emergency responses and provide clear accountabilities (e.g. interventions such as supplementary feeding, predator control, translocation, bringing into captivity).	low-med	DEPI & ZV

Potential enabling actions	Rationale	Rating	Responsible organisation
2.1 Protection of existing colonies			
Action 34. Identify known colonies as critical assets in fire planning systems.	Feeding this information into Fire Operations Planning enables known colony areas to be considered during planned burning or fire suppression activities. Will be undertaken in conjunction with similar action under protecting habitat.	high	DEPI & PV
Action 35. Develop management prescriptions for the appropriate protection of identified colonies from harvesting activities and other forest management activities (i.e. roads).		med-high	DEPI & VF
2.2 Protection of existing suitable habitat			
Action 36. Identify known suitable habitat as critical assets in fire planning systems.	Feeding this information into Fire Operations Planning enables areas of high quality or strategically important habitat to be recognised, so that these areas do not get impacted during planned burning or fire suppression activities. Will be undertaken in conjunction with action based on colonies.	high	DEPI & PV
Action 37. Investigate the preferred size and shape of retained habitat between coupes to support colonies and facilitate dispersal.		n/a	VF & DEPI
Action 38. Investigate the preferred coupe placement to reduce habitat fragmentation.		n/a	VF & DEPI
3. Improving future habitat availability and quality			
Action 39. Review and formalise salvage logging prescription requirements within legal frameworks prior to next large fire.	There has been concern over the impact of salvage harvesting following large fires. A review of the prescriptions would improve transparency. Salvage harvesting is currently treated as if the trees were all alive and normal prescriptions apply.	high	VF & DEPI

Potential enabling actions	Rationale	Rating	Responsible organisation
4.1 Improve information recording and access			
Action 40. Actively seek out Leadbeater's Possum records from groups and institutions that are known to have undertaken survey work.	To ensure all known records are within DEPI databases and considered during all timber harvesting and fire planning.	high	DEPI
Action 41. Ensure that all records are published in the DEPI Victorian Biodiversity Atlas (VBA) in a timely manner.	To ensure all known records are available and considered during timber harvesting and fire planning.	high	DEPI
Action 42. Ensure effective and timely integration between the VBA and DEPI Corporate Spatial Data Library (CSDL).	To ensure accessibility of information and inform forest management and fire operational planning.	high	DEPI
Action 43. Ensure that all areas of currently suitable habitat identified through field surveys be mapped, consolidated and published. This includes suitable habitat identified through research, landscape surveys or during pre-harvest and other surveys undertaken by VicForests.	This will enable the information to be available for fire and timber harvesting planning. Based on all suitable habitat whether formally reserved or not.	high	VF & DEPI
Action 44. Ensure effective feedback loop between VicForests and DEPI and integration of VF information and data sets with DEPI data sets.	To ensure accessibility of information and inform forest management and fire operational planning.	high	VF & DEPI
Action 45. Where additional reserves are created their location and purpose is to be mapped, consolidated and published within the Forest Management Zoning scheme.	Core business if done within the current rezoning project and timelines. After finalisation of this project a process will need to be identified.	med-high	DEPI
Action 46. Following a significant change to the forest management zoning VicForests will revise and release an updated Timber Resource Outlook.	The Resource Outlook is revised each year. The Resource Outlook outlines how much timber is predicted to be produced from the area permitted for logging and the timeframe over which this occurs. (Note that the intent of the proposed action is likely to be more around the Allocation Order and Sustainable yield).	low	VF

Potential enabling actions	Rationale	Rating	Responsible organisation
4.2 Implementation monitoring and reporting			
Action 47. Confirm ongoing role and accountabilities of the Leadbeater's Possum Advisory Group and the Leadbeater's Possum Recovery Team regarding monitoring and reporting against actions.		high	AG, DEPI
Action 48. Define how, when and by who recovery actions will be monitored and reported for delivering this program.		high	DEPI
4.3 Improve quality assurance			
Action 49. Review to improve the operational auditing of compliance with respect to Leadbeater's Possum regulations and implement findings of this review.	This is currently undertaken by DEPI, however, it could be refined to improve confidence in the system.	high	DEPI
Action 50. Ensure that all management actions developed for Leadbeater's Possum are clearly articulated in a manner that can be unambiguously applied in the field.		med-high	DEPI & VF
Action 51. Ensure that all people involved in the implementation of Leadbeater's Possum habitat identification are adequately trained.		med	VF & DEPI
Action 52. Ensure that adequate resources are available to deliver the actions identified within any plan.		high	DEPI
Action 53. Revise Zone 1 habitat survey standards.		high	DEPI
4.4 Effective integration into regulatory frameworks			
Action 54. Consider options and timing for integration of actions into regulatory framework including through current Timber Industry Action Plan projects, future regulatory processes and/or interim contractual arrangements.		high	DEPI
Action 55. Ensure transparency and accessibility of regulatory framework and associated information.		high	DEPI

3.3.2.4.2. Supporting Actions

Supporting actions (which are actions that would provide additional information to more effectively implement the on-ground actions, including research, surveys and community engagement) were ranked by identifying their relative priority based on their expected benefits in terms of more effectively supporting implementation of the potential on-ground actions. All supporting actions were linked to one or more on-ground actions. The benefit of a supporting action was evaluated in terms of:

- the importance of the on-ground action/s that it supports (in terms of its benefit to Leadbeater's Possum) and the uncertainty around the benefits of those actions to the species;
- the level of uncertainty associated with achieving the benefits that the on-ground action is expected to provide, and the extent to which the uncertainty would be reduced if the supporting action was undertaken; and
- time taken to address the gap in knowledge, with actions that can provide information earlier considered a higher priority.

The list of supporting actions with their evaluation by the AWG is provided in Table 8.

Table 8. The evaluation of the importance of the supporting actions for implementing on-ground actions.

Potential supporting actions	Overall importance for implementing on-ground actions
5.1 Improve knowledge of Leadbeater's Possum populations and their habitat	
Action 56. Targeted surveys to identify and map colonies and clusters of colonies within the known range of the species.	high
Action 57. Undertake a landscape wide survey program to identify areas of suitable habitat.	high
Action 58. In conjunction with species surveys assess habitat characteristics to improve the description of the range of habitats suitable for the possum across the distribution.	high
Action 59. Undertake a landscape wide, broadscale survey program to locate additional colonies and improve models of suitable habitat.	med-high
Action 60. Analyse data collected to continue to develop distribution and population models.	med-high
Action 61. Investigate potential to accelerate hollow creation.	med-high
Action 62. Continue the ANU long term monitoring program.	med-high
Action 63. Investigate potential to improve persistence within refuge areas.	med-high
Action 64. Continue variable retention harvesting study.	med-high
Action 65. Improve survey techniques and detection probability estimates.	med
Action 66. Improve understanding of species ecology.	med
Action 67. Improve understanding of habitat requirements.	med
Action 68. Determine dispersal and recolonisation capabilities.	med
Action 69. Conduct pre-logging surveys by independent biologists on all coupes to provide information on species and populations.	med

Potential supporting actions	Overall importance for implementing on-ground actions
Action 70. Investigate options for translocation, establishing protocols, procedures and trialing technique. Determine source population, impacts on that population, locate potential unoccupied release sites, and monitor for successful establishment.	med
Action 71. Investigate the most effective way to optimise for Leadbeater's Possum outcomes within an area cap using a bespoke reserve design that considers habitat (now and future); colonies; dispersal / connectivity; fire refugia.	med
Action 72. Improve understanding of habitat survival.	low-med
Action 73. Investigate potential to improve resilience within Snow Gum areas.	low-med
Action 74. Determine structure of Leadbeater's Possum populations.	low-med
Action 75. Targeted surveys of areas outside known range or habitat types to investigate if the species occurs in other areas.	low-med
Action 76. Investigate potential climate change impacts.	low
Action 77. Landscape disturbance patterns.	low
Action 78. Investigate a range of environmental economics of ash forests.	low
Action 79. Investigate population genetics.	low
Action 80. Research nest box designs to mimic natural hollows (and discourage non-target species).	low
Action 81. Investigate the impact of bees and other pests using of natural hollows.	low
Action 82. Investigate predators and predation impacts.	low
Action 83. Undertake surveys on private land.	low
6.1 Stakeholder Engagement	
Action 84. Implement ongoing community engagement.	high
Action 85. Involve community stakeholders in monitoring activities.	med
Action 86. Leadbeater's Possum education programs to improve understanding of management.	med
Action 87. Provide viewing opportunities at selected colonies to engage the community.	low

3.3.2.5 Independent verification of evaluation of actions in terms of Leadbeater's Possum benefits

In order to independently verify the AWG evaluation of actions, views on the effectiveness of potential actions were also sought from external sources. Four groups in particular were considered:

- participants in the stakeholder workshops – participants were asked to identify their top three actions and the views expressed through this process were noted when the actions were evaluated;
- feedback received through written submissions to the Advisory Group;
- external experts – the ANU Leadbeater's Possum research team lead by Professor David Lindenmayer (ANU research team); and
- the Leadbeater's Possum Recovery Team (Recovery Team).

The ANU research team and the Recovery Team were each provided with blank versions of Tables 6, 7 and 8 and asked to fill them in with their ratings, using the same performance measures and supporting criteria as the AWG.

The Recovery Team assessed the majority of the on-ground actions during a day-long workshop. While some of the Recovery Team had an opportunity to input into the Advisory Group process through participation in the AWG or the stakeholder workshops, other members were not represented in either and their input was provided through the Recovery Team assessment process.

Overall the ratings by the AWG, Recovery Team and the ANU research team were broadly similar, with consistent views on which actions were considered most important. There were, however, some more minor differences, based on either differing interpretations of the actions or different experiences of similar actions in the past.

In cases where the Recovery Team or ANU research team diverged from the AWG, these differences were provided to the Advisory Group for their consideration and assessment, and taken into account during the short-listing process.

3.3.2.6 Impact Assessment Tool

The overall ratings developed by the AWG were then plotted using an Impact Assessment Tool (Figure 6). This tool provided a simple visual approach to understanding the relative merits associated with different actions (in terms of indicative benefits to Leadbeater's Possum and impacts on industry). As illustrated in Figure 6, the tool provides an indicative assessment as follows

1. potential actions that were likely to result in significant benefits to Leadbeater's Possum with low impact on cost to industry were ideal;
2. potential actions that were likely to result in limited benefits to Leadbeater's Possum with low impact on cost to industry were worth considering;
3. potential actions that were likely to result in significant benefits to Leadbeater's Possum with high impact on cost to industry were considered; however, implementation may be a policy decision for the government; and
4. potential actions that were likely to result in a low benefit to Leadbeater's Possum but high impact on industry were considered unviable.

Actions were plotted using this Assessment Tool if they had a cost to industry that could be estimated (under the heading 'B' in Figure 7). It was not possible to estimate the cost of all actions, even where it was recognised that there would be an impact on industry. These actions (displayed on the right hand side of the graph under the heading 'C') were plotted for their estimated benefit to Leadbeater's Possum but without a cost to industry. Similarly, actions that would not impact on the timber industry (displayed on the left hand side under the heading 'A') were plotted just based on their benefit to the possum (Figure 7). This simple plot was used as a discussion starter for more detailed analysis in the later stages of analysis.
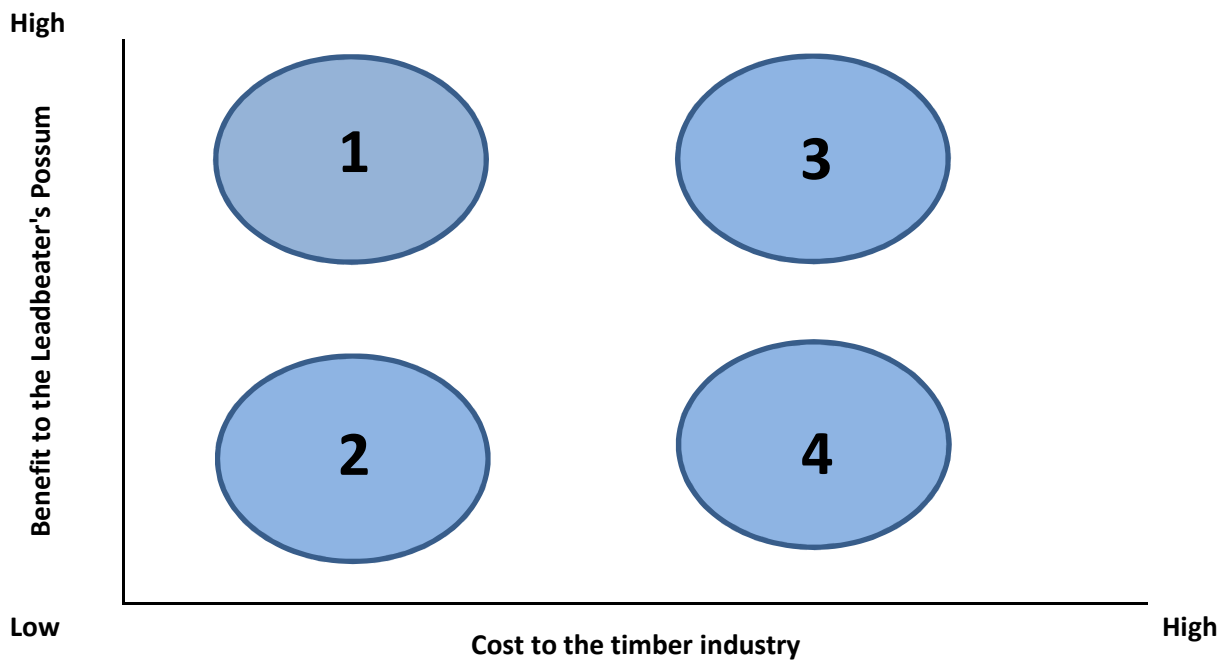
Figure 6. The Impact Assessment Tool

3.3.2.7 Outputs from Stage 1

Using the Impact Assessment Tool (Figure 7), the Advisory Group then selected a shortlist of actions, focusing on those considered to have the most benefits to Leadbeater's Possum with the lowest costs to industry. This was an indicative initial assessment based on expert opinion which was used to inform further discussion amongst the Advisory Group. The short-listed actions that proceeded to Stage 2 for further consideration are outlined in Table 9. Actions that were not further considered in Stage 2 generally fall into one of two groups – those considered to have very low benefits to Leadbeater's Possum or were unfeasible, or those that would have substantial impacts on the timber industry.

Figure 7. Impact Assessment Tool illustrating an initial indicative estimate of relative expected outcomes, based on expert opinion, from the on-ground actions for both Leadbeater's Possum and the timber industry. Actions with no direct cost to industry are shown on the left hand side (A). Actions for which there are cost implications for industry and these could be estimated are shown in the centre (B). Actions for which there are cost implications for industry but where these could not be estimated at this stage, due to the lack of spatial data, are shown in red on the right hand side (C). All actions have been assessed for their benefit to Leadbeater's Possum. Refer to Table 6 for explanation of each action, using the action number for reference.

Table 9. Actions shortlisted in the Stage 1 process to be included in Stage 2.

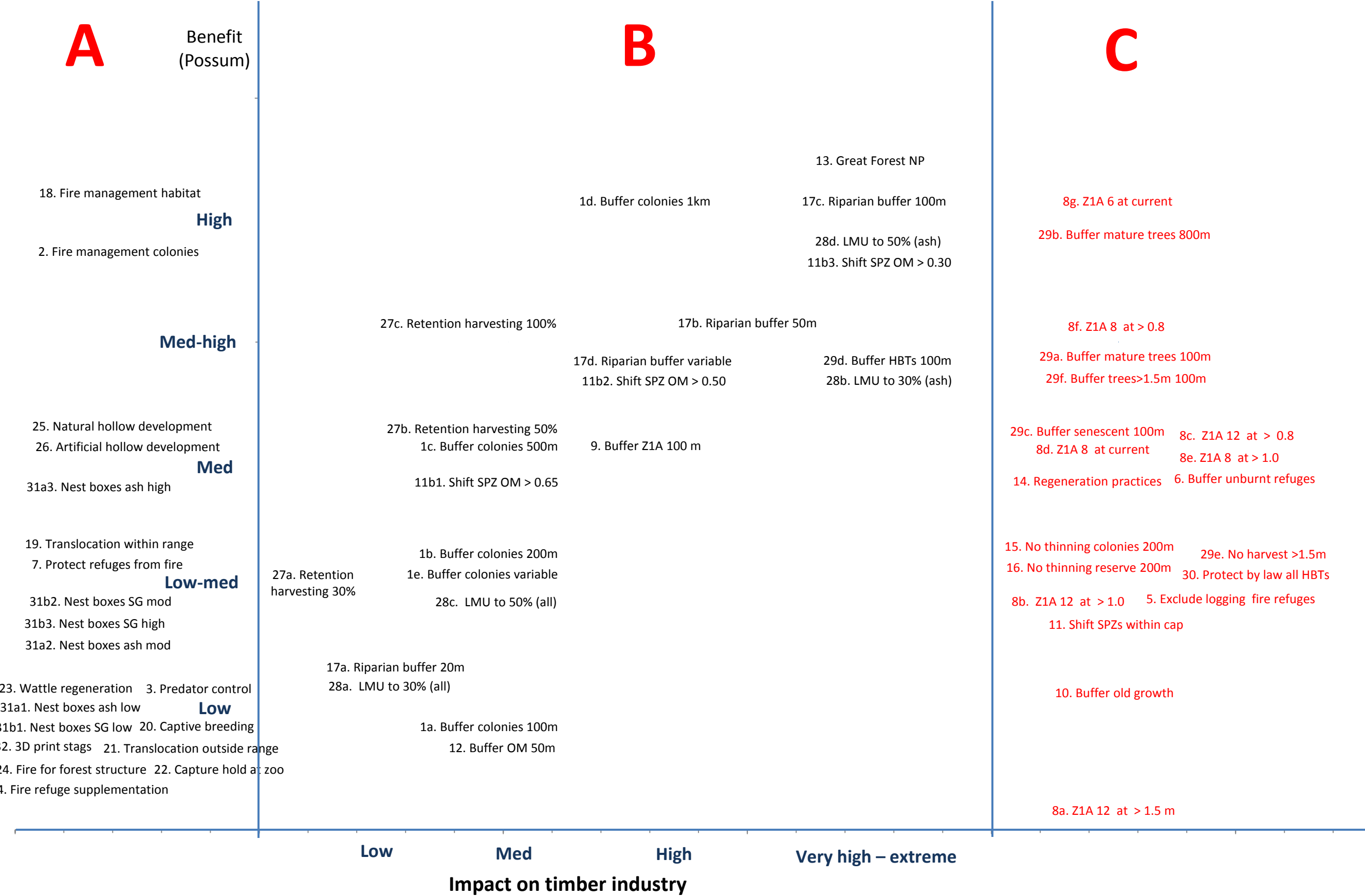| Action	Current management	Options for inclusion in Stage 2
Protect all identified Leadbeater's Possum colonies with a buffer. In Stage 1 assessment this was based just on the number of records within the last 15 years as no prediction of the number of future colonies was available at this stage; the impact of future records was incorporated in Stage 2. Exclude records in 2009 fire area with a fire severity of 1-3 (i.e. ash trees killed).	Colonies not currently protected.	Buffer of 100, 200 and 500 m radius.
Expand (or modify) the existing Leadbeater's Possum reserve to incorporate areas identified by the ARI occupancy modelling (Lumsden *et al.* 2013) as high probability of being occupied.	Significant portion of high probability habitat is already within reserves (e.g. 12,270 ha at the >0.5 probability level).	Reserve areas that are identified as having > 50%, >65% or > 85% probability of occurrence.
Implement retention harvesting systems within the range of Leadbeater's Possum.	Clear-felling is standard practice on nearly all ash harvesting coupes.	Assess retention harvesting on 30%, 50% or 100% of the ash area harvested.
Investigate/implement alternative regeneration practices that reduce the impact of high intensity regeneration burns on retained habitat.	High intensity burning is standard practice.	
Buffer all old growth ash forest from harvesting or thinning operations using DEPI's modelled old growth layer.	Old-growth ash forest is not currently harvested, but there is no buffer.	Buffer all patches of old growth ash forest by 100 m.
Revise management prescriptions and definition of Zone 1 habitat.	12 suitable hollow-bearing trees per 3 ha.	Assess 8, 10 and 12 trees per 3 ha with and without revised tree definition.
Include a target for future old growth within the range of Leadbeater's Possum.	Regrowth reserve areas broadly meet this objective on a landscape level. On a localised level this outcome varies.	Target for future old growth of at least 30% of all forest types, and for at least 30% of ash forests.
Undertake active fire management activities to protect identified colonies from fire.	Fire management does not specifically focus on Leadbeater's Possum.	

Action	Current management	Options for inclusion in Stage 2
Undertake active fire management activities to protect identified critical habitat from fire.	Fire management does not specifically focus on Leadbeater's Possum.	
Install nest boxes to supplement declining natural hollow densities at occupied sites.	Existing nest box projects in Snow Gum and some ash forests.	Small scale or large scale.
Translocation of wild (or captive bred) animals into suitable unoccupied habitat.	No current practice.	
Actively promote accelerated development of hollows, using selective thinning or other processes.	Damaging retained trees is actively discouraged.	
Exclude thinning from adjacent to areas reserved for Leadbeater's Possum.	Thinning adjacent to Leadbeater's Possum habitat is not restricted unless it meets habitat zone definitions.	Exclude thinning from areas within 100 m and 200 m of identified habitat.
Expand riparian buffers on all mapped streams using fixed or variable buffer widths.	Standard buffer is 20 m with larger variable buffers applied to strategic areas.	20 m, 30 m, 40 m riparian buffers on all mapped streams will be assessed (variable buffers cannot be spatially assessed).
Buffer all Zone 1 habitat from harvesting or thinning operations.	Not currently buffered.	Buffer all Zone 1 habitat by 100 m.
Buffer all pre-1900 or senescent trees.	Pre-1900 trees are not harvested but there is no buffer.	Buffer by 100 m.
Place the majority of ash forests within the range of Leadbeater's Possum in a new Great Forest National Park.		Based on the image on the website http://www.greatforestnationalpark.com.au/park-plan.html
Exclude logging from fire refuge areas (from the 2009 fires and subsequent fires).	Salvage prescriptions may include these areas dependent on definition.	Fire refuges as identified in the Forest Biodiversity project (Lumsden *et al*. 2013).

3.3.3 Stage 2 – Quantitative assessment of actions

Stage 2 involved the use of a range of modelling approaches and economic analysis to quantitatively assess the expected costs and benefits of each on-ground action identified in Stage 1 as continuing to Stage 2. The same three groups of on-ground actions were used as identified in Stage 1, i.e.:

- actions with resource implications for the timber industry and where the impact can be calculated using spatial or other means (e.g. exclusion zones around colonies);
- actions with resource implications for the timber industry, but where the impact cannot be estimated with any certainty due to a lack of data (e.g. buffers around all senescent trees); and
- actions with no resource implications for the timber industry (e.g. nest boxes).

All actions were assessed for their estimated benefits to Leadbeater's Possum, with the costs to the timber industry only estimated for those actions with measurable area implications (i.e. the area that would be taken out of timber production as a result of an action).

3.3.3.1 Quantification of costs to the timber industry

Performance indicators were developed to provide a proxy for the cost to the timber industry of individual actions and alternative packages of actions. The indicators used were:

- estimated impact on available volume – derived as annualised estimates of the percentage reduction in foregone ash sawlog resulting from potential actions; and
- estimated annual timber supply cost – derived as annualised estimates of the direct and opportunity cost to the timber industry resulting from actions.

This section presents the methodology for estimating the volume and cost indicators in Stage 2. Unlike the preliminary estimates for volume and cost indicators provided in Stage 1 (Section 3.3.2), these indicators are presented as single estimated values rather than ranges. This was considered appropriate at this stage, as a more transparent and rigorous process was undertaken in the development of Stage 2 indicators.

3.3.3.1.1 Performance Indicator 1: Annualised estimates of the percentage reduction in foregone ash sawlog resulting from potential actions

Available timber resource projections are generally undertaken using a complex resource allocation model that considers available forest, forest growth and other constraints. This process is detailed and requires extensive preparation of input data. Due to the range of potential actions being considered, it was not possible to undertake this process within the Advisory Group's timeframe. A simplified approach was therefore undertaken to provide an indicative impact of each action. Due to the characteristics of the forest and time frames available, this was considered a conservative, yet pangenetic approach to ensure that timber impacts could be considered. This conclusion was verified by an external consultant as described in Section 3.3.3.2 below.

The first step undertaken to quantify the impact on the timber industry was to determine the area of forest impacted by each action. To do this it was necessary to determine the area of ash forests available and suitable for timber harvesting over the next 20-30 years, termed the 'available resource'. This was determined via GIS spatial analysis factoring in the ash forests within the range of Leadbeater's Possum that will be suitable for harvesting within the next 30 years (i.e. mapped ash forests originating from between 1901 and 1960). Areas that are not operationally available (i.e.

mapped areas on steep slopes and riparian buffers as defined in the Code of Practice for Timber Production) or cannot be harvested according to zoning restrictions (e.g. SPZs) were excluded.

This analysis estimated that there is approximately 36,655 hectares of ash forest within areas zoned as GMZ or SMZ in the range of Leadbeater's Possum available and suitable for harvest in the next 20-30 years (Figure 8). This is a subset of the 62,600 hectares of State forest potentially available for timber harvesting outlined in Table 1, with the main differences being that forest younger than 1960 (e.g. areas burnt or harvested since this time) or areas that are unsuitable for harvesting (e.g. due to steep slopes) have been excluded.

Not all of this area is likely to be actually harvested within this timeframe. This is due to several factors. Firstly, triggers-based prescriptions (i.e. in-field prescriptions based on areas that are only identified through site inspections due to the lack of spatial data layers, e.g. Leadbeater's Possum habitat zones) cannot be spatially identified. Secondly, operational constraints such as steep slopes or proximity to unmapped waterways can also not be fully anticipated in advance. As a result, approximately 30-35 per cent of the area available to harvest will not actually be harvested. This percentage is estimated on the basis of historic data, comparing available area and net area harvested at an operational level. Given this, it is estimated that approximately 24,000 hectares of ash forest within the range of Leadbeater's Possum is likely to be harvested in the next 20-30 years. As it is not possible to map these additional excluded areas, the calculations for the area of the available resource impacted by the actions are based on the figure of 36,655 hectares of ash forest, but these excluded areas were accounted for when timber volumes were calculated. While it is not possible to determine the location of the prescriptive and operational exclusions from the available area, over the range of the Leadbeater's Possum it is assumed that the relative reduction will align with historical estimates. Over time exclusion percentages have increased; however, it was not possible to quantify future increases so this was also not considered.

The area and proportion of the available resource impacted by each potential action outlined in Table 9 was then calculated using spatial (GIS) analysis. This was done by spatially identifying and mapping the areas that would be excluded from harvesting by each action and then intersecting these areas with the area of ash forest considered suitable and available for harvesting over the next 20-30 years. This determined the area of foregone ash resource relative to business as usual. These area calculations were determined by VicForests using a GIS tool specifically developed for the Leadbeater's Possum Advisory Group process (the VicForests' Leadbeater's Possum Action Impact Assessment Tool; Arnold *et al*. 2013 unpublished). Combining the output from all the analyses into a single non-GIS tool allowed the Advisory Group to easily evaluate any possible combination of actions for which the area impacted could be assessed. DEPI undertook an cross-check of the analysis, and the tool was independently verified by the consultancy company URS Australia Pty Ltd. These figures were then used to compare the relative impact of different actions, as well as different scales of the same action (e.g. various sized timber exclusion zones around colonies).

Outputs from the VicForests Leadbeater's Possum Action Impact Assessment Tool included:
- the area and proportion of merchantable and available ash that would be impacted;
- the corresponding proportion of annual sawlog production that would be impacted (as a percentage of sawlog production within the range of Leadbeater's Possum); and
- the corresponding proportion of annual pulpwood production that would be impacted (as a percentage of sawlog production within the range of Leadbeater's Possum).
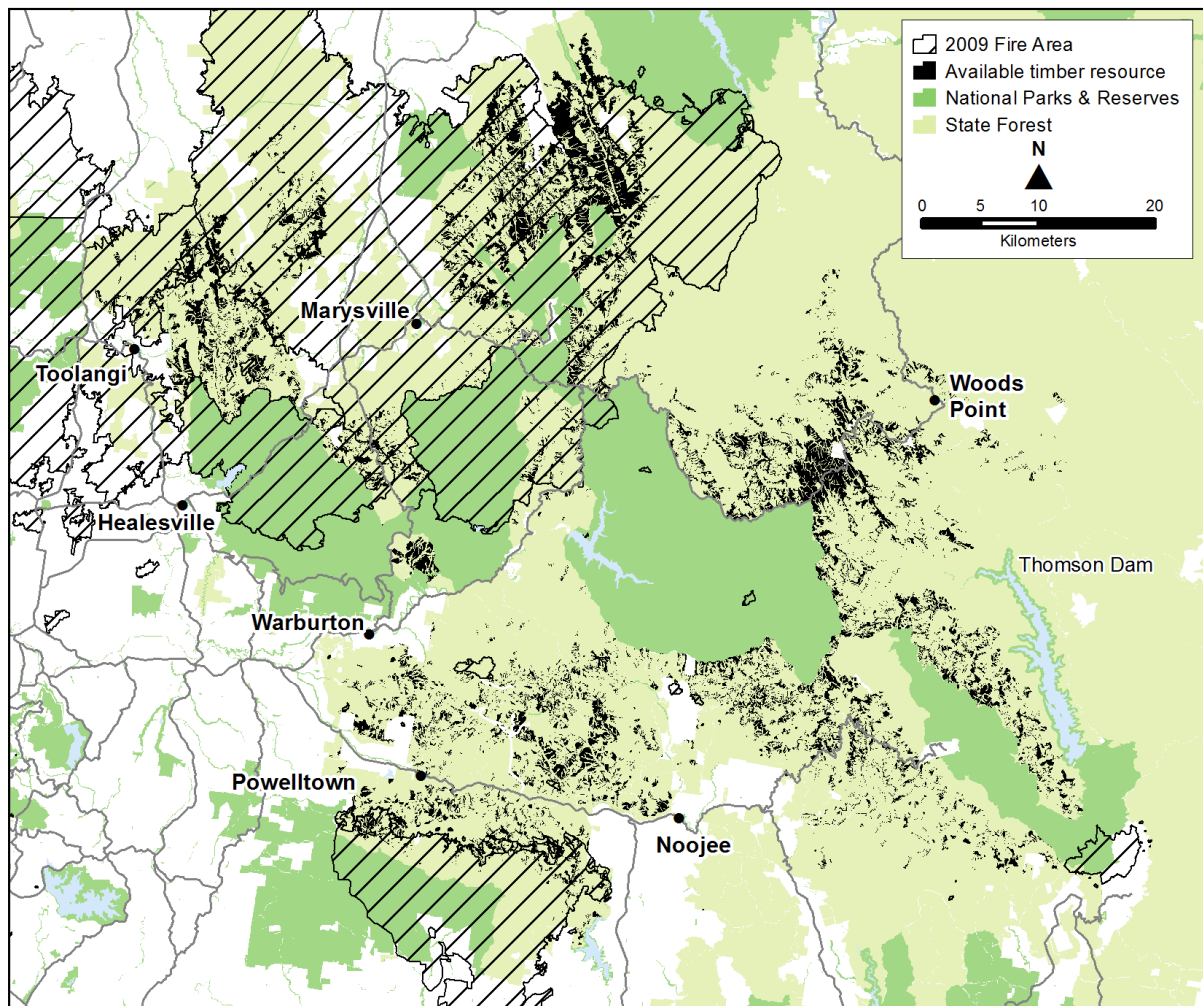
Figure 8. The ash timber resource that is available and suitable for harvesting over the next 20-30 years within the range of Leadbeater's Possum (shown as dark shading). The area burnt during the 2009 fires is shown with cross hatching. Within this area where the fire severity was low, not all ash trees were killed resulting in these areas remaining available and suitable for harvesting.

In undertaking these calculations it was assumed that percentages in area and volume terms are equivalent – that is a reduction in 10% of available area corresponds to a reduction of 10% in timber volumes. It was noted that in reality areas suitable for the Leadbeater's Possum are likely to have higher than average productivity, and that this assumption is likely to understate percentage volume reductions from actions.

It was relatively straightforward to estimate the area impacted by some actions, while others required more assumptions and calculations. Consequently there are varying degrees of uncertainty in the area estimations across different actions and in general it is considered that the resource impact assessments are conservative.

The area likely to be impacted by Leadbeater's Possum habitat zones was difficult to estimate. There is no comprehensive, current spatial layer showing the location of hollow-bearing trees across the range of Leadbeater's Possum. As a result it is not possible to map the extent of Zone 1A or 1B Leadbeater's Possum habitat, nor assess how the area would vary under different definitions of Zone 1 habitat. As protecting high-quality Leadbeater's Possum habitat is a key action to support the recovery of Leadbeater's Possum, it was important to have a way of at least broadly assessing potential actions relating to habitat zones.

Habitat assessments undertaken at sites sampled for Leadbeater's Possum during the Forest Biodiversity project (Lumsden *et al*. 2013) (see Section 2.1.3) documented the number of mature, senescent and dead hollow-bearing trees on 170 sites in ash forest throughout the species' range. The proportion of sites that contained various densities of hollow-bearing trees per hectare was used as the basis for estimating the area that may contain the required density of trees to meet the current and proposed alternative definitions of Zone 1 habitat. Most sites were 1 hectare in size (although a small number were 0.5 hectares) with the size of the sampling plot incorporated into the calculations. The sites sampled during the Forest Biodiversity project were randomly selected, across both parks and State forest, and hence it is possible to extrapolate from this data across the range of the species, albeit with a large number of caveats.

The assumptions/caveats that need to be considered when interpreting the extrapolation of this data are outlined below.

- The data is based on the sampling of 170 sites – a larger sample size would provide greater confidence in extrapolating across the whole range of Leadbeater's Possum.
- All sites were located adjacent to roads. If roads are not distributed randomly across the range of the species and randomly in relation to differing densities of hollow-bearing trees, there will be a bias in the extrapolation.
- Zone 1 habitat is based on the number of trees per 3 hectares. The habitat assessments were undertaken over (predominantly) 1 hectare areas. In the extrapolation it had to be assumed that there was a uniform density of hollow-bearing trees in the surrounding area to scale up to 3 hectares. As this is unlikely to always be the case, this is likely to over-estimate the area meeting the Zone 1A definition.
- The DEPI Leadbeater's Possum habitat zone survey standards (DEPI 2013b) specify that for a tree to be included in Zone 1 habitat it is to be within 100 m of another hollow-bearing tree. In addition, the polygon around all potential trees is to have no side greater than 100 m in length. These factors could not be considered in this analysis, especially when extrapolating from the 1 to 3 hectare areas. This will also likely result in an overestimate of the true area of Zone 1 habitat.
- There are different interpretations of the definitions of hollow-bearing trees. As the Forest Biodiversity project habitat assessments were not undertaken for the purpose of identifying Zone 1 habitat, there is likely to be some variation between the interpretation of what constituted a hollow-bearing tree for the purpose of the habitat assessments compared to the definition of a hollow-bearing tree in the DEPI Leadbeater's Possum habitat zone survey standards and associated maturity guidelines.

Despite these limitations, this data provided some basis for comparison of the area of habitat likely to be affected under different definitions of Zone 1.

The actions focused on excluding thinning operations were assessed separately, as these do not operate within the available resource area because they involve younger regrowth forest (i.e. post-1960s forest).

3.3.3.1.2 Performance Indicator 2: Annualised estimates of the annual timber supply cost resulting from the options

The annual timber supply cost is defined to be the annualised cost to VicForests resulting from changes to the supply of available timber due to actions undertaken that change that supply. The annualised estimates of the supply cost to the timber industry are disaggregated into direct and opportunity costs. These are defined to be:

- **Direct costs**: **additional costs that will be directly incurred as a result of undertaking the action.** These include increased transport and harvest costs for VicForests associated with sourcing alternative timber supplies, or increased operational costs for VicForests in cases where potential actions result in smaller coupes. In the case where ash sawlogs are sourced from outside of Victoria, the increased harvest costs include administrative costs of sourcing the timber from elsewhere in this analysis.
- **Opportunity costs: foregone revenue resulting from undertaking the action.** This comprises the net value of timber foregone (revenue less harvest and haulage cost) in cases where a potential action is likely to reduce the volume of timber harvested in Victoria.

The costs have been developed as annualised costs over a twenty year period. This period was deemed to be a reasonable time to assess likely outcomes past the duration of VicForests' current contracts, without requiring forecasts of costing parameters too far into the future. The analysis derives costs prior to 2017, when existing contracts end, and costs post 2017. This is because it could be expected that VicForests would source additional timber from outside of Victoria to meet contractual obligations within the duration of existing contracts, but would not be expected to allocate above their capacity to supply for new contracts post 2017.

This analysis does not quantify all costs to VicForests, as it does not cover costs or benefits outside VicForests' supply of sawlogs and pulplogs. It also does not determine who bears the cost. The estimated annual timber supply cost is a subset of the total cost to the timber industry. The supply cost was chosen as a performance measure because of the lack of data and because the complexity associated with measuring the total cost to the timber industry made this unfeasible in the timelines required. Specifically, this means that flow-on impacts to mills and secondary processing (e.g. furniture or floorboards) are not considered. Difficulties in disaggregating ash sourced from within Victoria from other wood products and a lack of information on consumer preferences (or demand elasticities) for ash products relative to available substitutes both contribute to the challenges faced in quantifying flow-on impacts. This is a limitation in this analysis, as these flow-on effects do represent an additional cost to the timber industry which is not captured in the supply cost indicator. While there is no quantification of flow-on impacts, there is an understanding that these will be strongly correlated with reductions in volume of ash sawlogs, and that the impacts will be highest for appearance grade products for which substitutes are less readily available. It should be noted that the output of this analysis is an estimate of cost, and it does not provide information on how these costs are distributed across regions. Compensation costs are also not included in this analysis as they represent wealth transfers from one group to another (e.g. government to industry) rather than an economic cost born by society as a whole.

Figure 9 shows a representation of the current timber flows from the Leadbeater's Possum range area and the part of the supply chain that is covered by the 'estimated annual timber supply cost' performance indicator.

The method used for identifying supply outcomes and relevant cost components for each option is shown in Figure 10.

In calculating the net value of foregone timber for the potential actions, ash sawlog, ash residual and mixed species are considered separately.

The estimation of direct and opportunity costs as a result of these reductions in timber volumes assumes that:

- revenues, and harvest / haulage costs remain at a similar level over the next 20 years;
- up to 20,000 cubic metres of uncommitted ash sawlog would be available from southern New South Wales as alternative supplies for VicForests to meet existing contracts (prior to 2017); and
- up to 50,000 cubic metres of uncommitted ash residual would be available from north-eastern Victoria as alternative supplies for VicForests to meet existing contracts (prior to 2017).

Current revenues are set in contracts; however, they would be expected to reflect market changes in the longer term. Costs may increase in line with the shift toward more remote and less productive forests in recent years due to management practices and the impact of fire. Forecasting how revenues and costs may change over time is beyond the scope of this work. In order to provide a conservative estimate of opportunity costs of reduced timber volumes it is assumed that revenue and harvest / haulage costs remain at the same level in real terms.
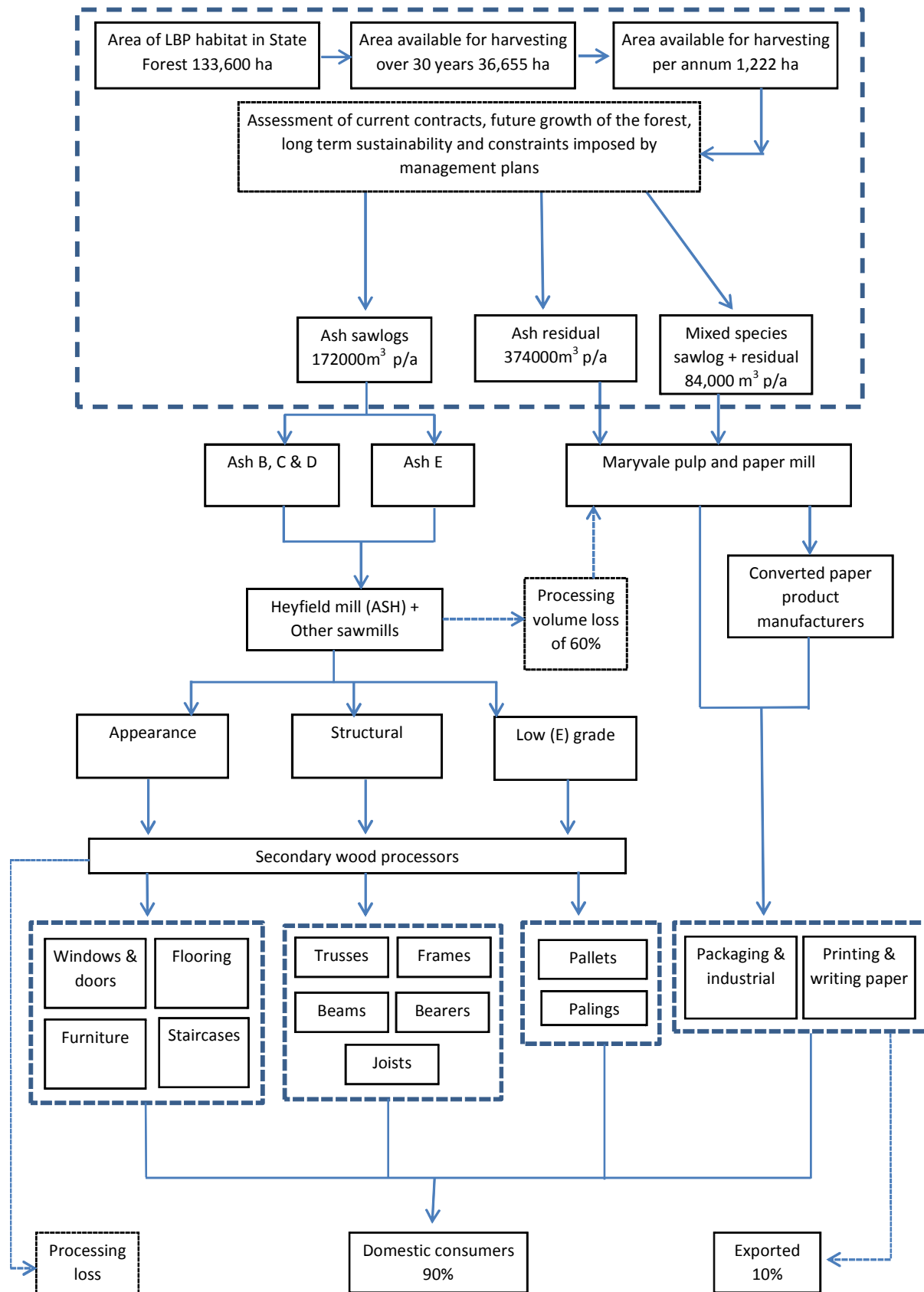
Figure 9. Representation of current timber flows from the range of Leadbeater's Possum. The assumptions used to derive this representation are outlined below.

The assumptions used to derive the representation of current timber flows include:

- the area currently harvested was provided by VicForests;
- current timber volumes generated for sawmills within the range of Leadbeater's Possum was taken from VicForests "Future Ash Project";
- timber volumes generated for Australian Paper was provided by VicForests;
- assumes the only mixed species timber generated is from within ash coupes within the range of Leadbeater's Possum (VicForests);
- the breakdown of sawlog volumes generated by grade taken from Wood Products Victoria's hardwood production survey for 2010/11;
- the breakdown of finished volumes of hardwood going into specific wood products from Wood Products Victoria's hardwood production survey for 2010/11;
- the assumptions used to derive product figures for ash from Wood Products Victoria's hardwood production survey were:
    - no mixed species sawlog used for appearance products; and
    - all low grade (E) sawlog used for palings and pallets;
- the breakdown of finished volumes of residual timber going to specific paper and paper products based on Australian production data for the two categories of products produced at Maryville – "packaging and industrial" and "printing and writing". Data is from Australian Forest and Wood Products Statistics for the year 2011-12 published in June 2013;
- proportion of paper and paper products exported is based on Australian export data (not mill specific) – data from Australian Forest and Wood Products Statistics for the year 2011-12 published in June 2013;
- assumes average processing loss of 60% during primary processing (VicForests);
- assumes similar production losses occur across products during secondary processing (magnitude of losses are not quantified here – likely percentage breakdown only is presented);
- sources of information (other than VicForests data):
    - Wood Products Victoria 2011 Victorian Sawn Hardwood Production Survey 2010/11; and
    - ABARES 2013 Australian Forest and Wood Products Statistics: September and December quarters 2012.

Pre 2017 annual costs

Likely reduction in volume of timber produced

Can timber be supplied from elsewhere?

Yes

No

Within Victoria

Outside Victoria

Direct cost = extra costs of transport and harvest

Direct cost = extra costs of transport and administration

+

Opportunity cost = net value of timber foregone

Opportunity cost = net value of timber foregone

Does the option result in smaller coupes for any remaining supply from the LBP home range?

Yes

No

Post 2017 annual costs

Likely reduction in volume of timber produced

Can timber be supplied from Elsewhere in Victoria?

Yes

No

Direct cost = extra costs of transport and administration

Opportunity cost = net value of timber foregone

Does the option result in smaller coupes for any remaining supply from the LBP home range?

Yes

No

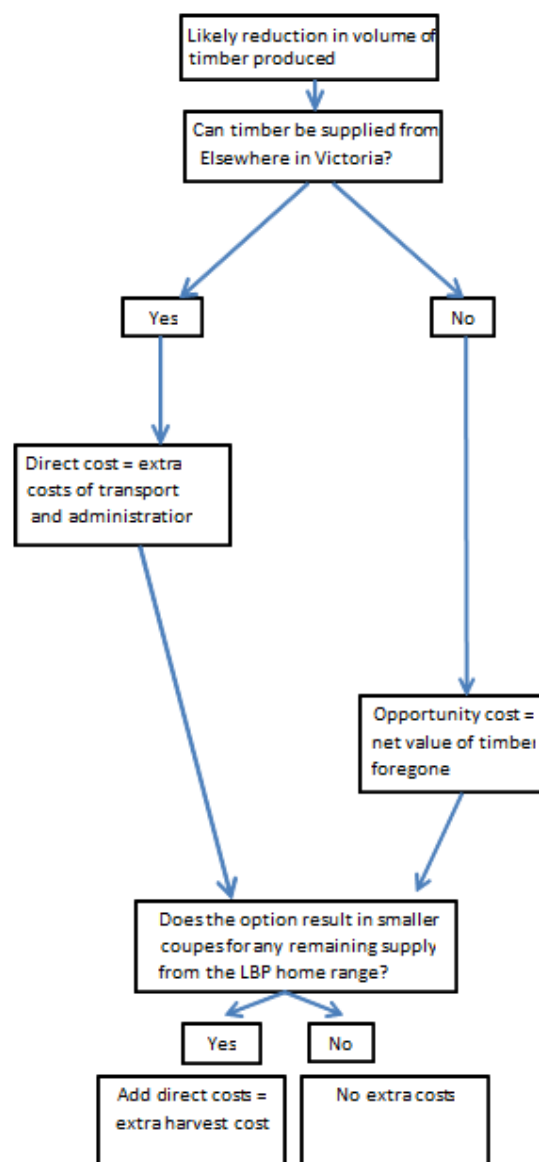Add direct costs = extra harvest cost

No extra costs

Figure 10. Method for estimating the annual costs of options that impact on timber volumes for pre and post 2017.

3.3.3.2 Validation of volume and cost estimates to the timber industry

To validate the estimation of the indicators for the impact on the timber industry:

- a workshop was conducted with relevant members of the Advisory Group, DEPI and VicForests; and
- URS Australia Pty Ltd was engaged to provide an independent review of the estimation of the indicators.

The purpose of the workshop was to explore the detail of the estimation process, including transparently validating and refining the estimates of annualised volume and cost indicators for the timber industry. The workshop was also used to agree on baseline information used to compare the impacts of on-ground actions for supporting the recovery of Leadbeater's Possum. This included the likely future timber prices, volumes of timber demanded and direct costs (e.g. harvest and haulage).

This workshop acknowledged the appropriateness of the methodology used given the timeframes. However, it noted that there were a range of factors that introduced conservatism into the estimates. The most significant of these factors was the conclusion that ash volumes are equal across the range, while it was suggested that the impacted areas are likely to contain higher than average timber yields. The model was not modified to account for this conservatism.

URS Australia Pty Ltd assessed the costs to industry from the actions under consideration. In particular, URS reviewed the estimation of the volume of foregone ash sawlog due to potential forest management interventions within the Leadbeater's Possum range and costs to the timber industry resulting from potential actions to support the recovery of Leadbeater's Possum.

The review considered the appropriateness of the methodology for estimating the indicators for the impact on industry, taking into account:

- the effectiveness of the methodology, incorporating the Advisory Group's decision-making requirements, data integrity and alternative methodologies;
- the clarity and transparency of the methodology; and
- the accuracy of the methodology and articulation of the data precision.

URS concluded that the methodology provided a narrow, but reasonable, approach that was specific to purpose to estimate impacts on the timber industry and that it provided a reasonable construction and application given the timeframes and data availability. URS also noted the conservatism of the likely impact estimates.

3.3.3.3 Quantification of benefits to Leadbeater's Possum using a Bayesian Network model

A Bayesian Network model was developed to compare the likely relative benefit for the recovery of Leadbeater's Possum from the individual potential actions (Stage 2), and then the likely benefit to the species from different combinations of actions as part of Stage 3 (refer section 3.3.4). The Bayesian Network model is a conceptual model of the causal relationships between the most significant factors influencing the status of Leadbeater's Possum in the Central Highlands, encompassing all ash forest and Snow Gum woodland habitat and populations. The Bayesian Network model included factors such as actions, threats, population variables and habitat variables, with the values and relative weightings contributed by experts from DEPI and other organisations.

The value of using a Bayesian Network model lies in its ability to combine empirical data and expert opinion to represent current understanding of system function, including reflecting levels of uncertainty about the status of particular variables and the relationships between different variables. Bayesian Network models are good tools for building consensus due to their relatively simple graphical presentation and their ability to allow 'scenarios' to be tested. Bayesian Network models can be refined over time with the incorporation of empirical data, which serves to confirm or challenge the assumptions made in the original model. Ben-Gal (2007) provides additional information on the characteristics and use of Bayesian Network models.

In a Bayesian Network model, each factor is represented by a 'node' and each node can exist in two or more states. The nodes are connected by 'arcs' (arrows) indicating the direction of influence. The likelihood that a node exists in a particular state is a function of any influencing nodes (known as parent nodes). For example, the likelihood that bushfire is severe, moderate or negligible is in part a function of the severity of drought and the degree to which fire protection has been undertaken (including consideration of its likely effectiveness in mitigating the risk of bushfire). Each node includes a conditional probability table which sets out the probabilities, based on expert opinion from DEPI, that the node will be in a particular state, given the states of the parent node(s).

The Bayesian Network model developed for Leadbeater's Possum culminates in an 'asset status' node (Figure 11). The asset status node provides the estimated likelihood or probability (as a percentage) that status of the Leadbeater's Possum is in 'good', 'fair' or 'poor' condition, based on the various combinations of actions and the states of other factors in the model. While the states 'good', 'fair' and 'poor' do not strictly relate to the probability of persistence or eventual recovery of Leadbeater's Possum, the greater the likelihood of Leadbeater's Possum being in 'good' condition, the more likely it is to persist and potentially to recover.

In the analysis undertaken to support the Advisory Group, the focus was on the degree to which the likelihood of the status of Leadbeater's Possum being 'good' was increased by the potential actions and packages of actions.

In developing the Leadbeater's Possum model, nodes were identified which represent management actions (13 nodes), threats (7 nodes) and population and habitat factors (9 nodes) that impact Leadbeater's Possum population status (Figure 11).

The on-ground management actions included in the model were the 18 short-listed groups of actions from Stage 1 that were endorsed for inclusion in Stage 2 analysis (Table 6). Each management action was assigned a set of states based on the scale or extent of each action that was agreed to for inclusion in Stage 2. For example, the action to protect known colonies of Leadbeater's Possum with a timber exclusion zone (buffer), was defined as having the following states: no buffer, 100 m buffer, 200 m buffer, 500 m buffer and 1 km buffer. The action nodes were:

- protecting colonies through applying a timber exclusion zone (shortened to 'buffering colonies' in the display of the Bayesian model);
- protecting additional habitat through using the ARI Leadbeater's Possum occupancy model, or the proposed Great Forest National Park;
- implementing retention harvesting practices;
- modifying coupe regeneration practices;
- buffering areas of old growth ash forest;

- protecting existing suitable habitat (Leadbeater's Possum habitat zones = 'protecting hollow-bearing trees' in the display of the model);
- targeting areas for future old growth;
- implementing greater fire protection;
- installing nest boxes;
- translocating colonies;
- accelerating hollow development;
- expanding riparian buffers; and
- excluding thinning from the vicinity of Leadbeater's Possum permanent reserves.

Seven key threats to Leadbeater's Possum were identified and included in the model:

- bushfire;
- drought cycle;
- natural loss of hollow-bearing trees;
- wattle senescence;
- timber harvesting (clearfelling) practices (representing how harvesting is undertaken);
- thinning practices; and
- forest allocation (representing how much harvesting is undertaken).

States were identified for each of these threats representing the degree to which the threat is considered to operate. For example, the threat 'bushfire' was defined as the proportion of potential Leadbeater's Possum habitat (i.e. ash forests and Snow Gum) expected to be burnt within the next 30 years. The state (i.e. impact) of this threat was considered 'severe' if greater than 30 per cent of potential habitat is expected to be burnt within the next 30 years, 'moderate' if 10 – 30 per cent is expected to be burnt and 'low' if less than 10 per cent is expected to be burnt (Appendix 2). The probability of each of these states occurring was based on past fire history of the Central Highlands. Details on the other threats are provided in Appendix 2.

Nine population and habitat variables operate at a local scale, with the remaining five operating at a landscape scale.

Population and habitat variables – local scale:

- direct mortality;
- den site availability;
- mid-storey connectivity; and
- cluster size (a cluster is a group of colonies).

Population and habitat variables – landscape scale:

- number of clusters;
- cluster distribution;
- current habitat distribution;
- current landscape-scale habitat connectivity; and
- future supply of hollow-bearing trees.

States for each of the nine variables were defined based on the amount of each variable present (Appendix 2). For example, den site availability was defined as the number of potential den trees available per hectare. The states defined for this variable were: 'sufficient' – >3 potential den sites/hectare; 'marginal' – 1-3 potential den sites/ hectare; and 'insufficient' – < 1 potential den site/ hectare. These states and their probabilistic values were based on published data on the relationship between the presence and abundance of Leadbeater's Possum on survey sites and the number of hollow-bearing trees.

The outcome of the model depends on a range of factors including:

- which management actions, or combination of management actions, are implemented;
- the degree to which these actions mitigate the identified threats; and
- the likely response in the population and habitat variables for the species and, hence, the status of the population.

Modelling different scenarios allows a quantitative assessment of the relative value of the possible management actions to Leadbeater's Possum.

Initial work to develop the Bayesian Network model was undertaken in a full day workshop attended by university and agency-based scientists with expertise in Leadbeater's Possum ecology and/or modelling. Attendees were asked to identify the most important threats affecting Leadbeater's Possum and the population and habitat variables that are most important and/or indicative of the status of Leadbeater's Possum. DEPI staff with experience in Bayesian Network modelling then further developed the model and provided the relative weightings. Key challenges included adequately representing site and landscape scale factors and developing current and future scenarios. The Bayesian Network model continued to be refined, based on clarification of assumptions and further consideration of benefits.

The conditional probability tables were populated using simple weighting (i.e. making an assessment as to the relative influence of each parent) and assuming (as a starting point) that influences were additive. Probabilities were assigned to achieve an appropriate pattern from 'best' to 'worst' cases. Probabilities were adjusted for nodes where an additive approach was not appropriate, for example where one factor might largely override others.

The model is focused on the next 30 years. The management of Leadbeater's Possum habitat and the occurrence of bushfire and other environmental threats over this period will play a critical role in determining the likelihood that Leadbeater's Possum will emerge from the 50-70 year bottleneck, caused by the predicted shortage of hollow-bearing trees, and persist beyond 2100.

Under the current situation, the likelihood that Leadbeater's Possum is in a 'good' condition is 18 per cent. 'Poor' is clearly the most likely state at 52 per cent (with 'fair' at 30 per cent). Under the various potential actions, the likelihood that Leadbeater's Possum is in 'good' condition varies. For example, changing the definition of Leadbeater's Possum habitat zones (Zone 1A) from 12 to 10 hollow-bearing trees increases the likelihood that Leadbeater's Possum is in a 'good' condition by 1 per cent, whereas buffering all senescent trees by 100 m increases it by 4 per cent. Under the Great Forest National Park proposal the likelihood that Leadbeater's Possum is in 'good' condition improves further still, by 10 per cent. Note that none of the proposals can guarantee persistence or recovery, due largely to the loss of hollow-bearing trees and the risk of future bushfire.

It is important to note that values generated from the Bayesian Network model should not be used in an absolute sense – they reflect the relative benefit likely to be derived from the different actions, compared to the current situation. There are also a range of uncertainties in the model due to some knowledge gaps of various threats, habitat and population variables and the extent of the influence of variables on each other. There are also uncertainties in how effective various actions will be in mitigating threats and their influence on population and habitat variables. In addition, only limited testing and truthing of the model was possible within the timeframe. Finally, the model itself is simply one of many ways to represent the current and likely future situation for Leadbeater's Possum.

3.3.3.4 Outputs from Stage 2

The output from Stage 2 was a table of all actions considered in this stage with estimates of the area of available timber resource impacted and direct and opportunity costs, and the relative benefit to Leadbeater's Possum as estimated by the Bayesian Network model (Table 10). Refer to Table 9 for more detail on these actions. Impacts were calculated using limited data in some cases and the wide range of assumptions also affected the benefit and impact assessments. The Advisory Group used this information to guide further detailed discussions when developing the package of actions in Stage 3.

Figure 11. The Bayesian Network model produced for Leadbeater's Possum in the Central Highlands showing actions (yellow), threats (orange and blue), habitat and population variables (local scale, green; landscape scale, pink) and the final asset status of Leadbeater's Possum (tan). This figure shows the titles of each node and the connections with the arrows indicating the direction of influence. Refer Appendix 2 for a more detailed version of the model plus additional information on the assumptions and factors considered in each node.
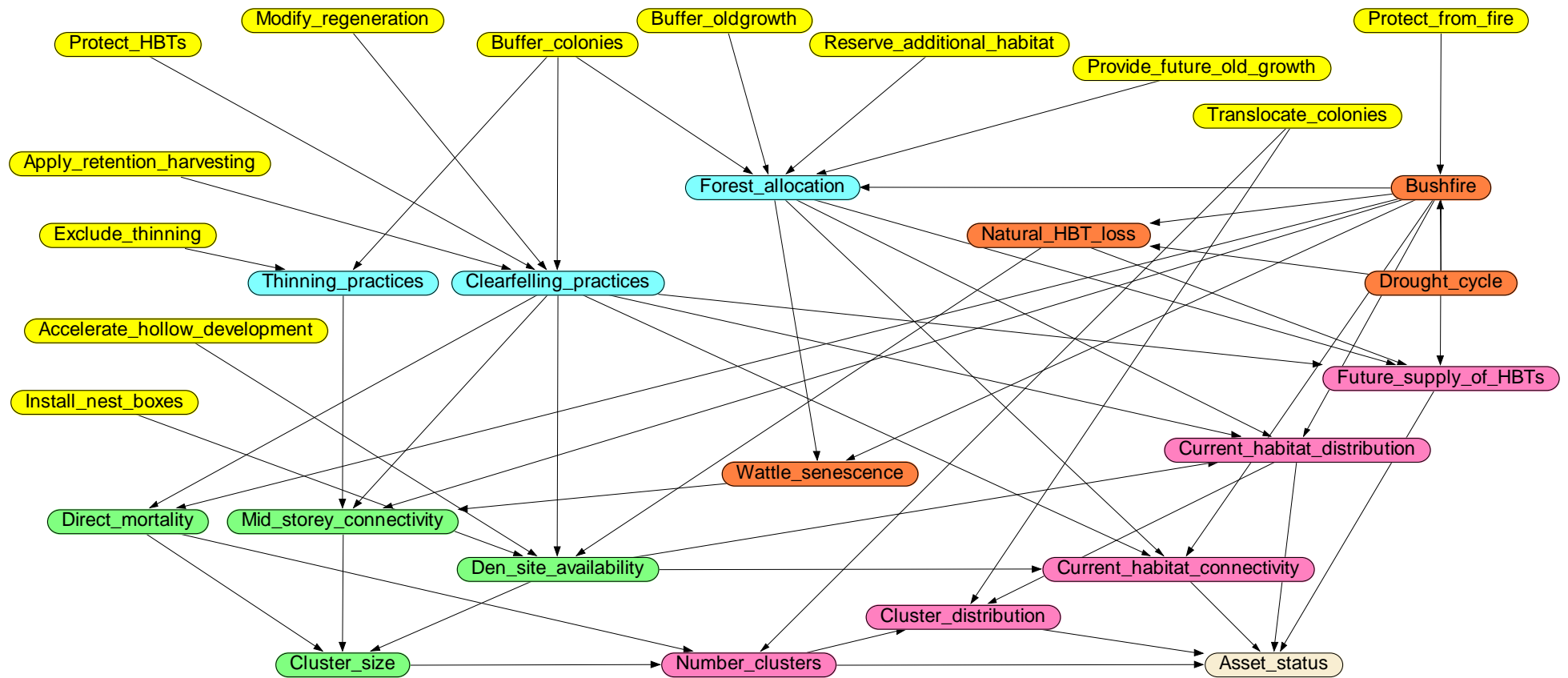
Table 10. The potential actions considered as part of Stage 2 with the estimated area and percentage of the available and suitable timber resource impacted, the direct and opportunity costs and benefits to Leadbeater's Possum. Direct and total costs are shown separately for pre 2017 and post 2017 where they differ, with post 2017 figures shown in brackets. The costs do not include implementation costs. Benefits to Leadbeater's Possum as shown by the Bayesian Network (BN) model by the estimated relative probability that the status of the species would be in a 'good', 'fair' or 'poor' state. Note that all figures are estimates, based on a range of assumptions, and should be considered indicative only and used to compare between actions rather than as absolutes.

Action	Scale of action	Estimated area of available resource (ha)	Estimated % of available resource	Estimated direct supply costs ($ millions)	Estimated opportunity costs ($ millions)	Estimated total supply costs ($ millions)	Benefit BN 'good'	Benefit BN 'fair'	Benefit BN 'poor'
Current situation							18	30	52
Protect colonies [1]	100 m radius exclusion zone existing records	63	0.2	0.2	0.03	0.2	19	30	51
	200 m radius exclusion zone existing records	218	0.6	0.2	0.1	0.3	19	30	51
	500 m radius exclusion zone existing records	1,262	3.4	1.1 (0.7)	0.5	1.6 (1.2)	19	31	50
Reserve additional habitat	Where ARI occupancy model > 85%	0	0.0	0	0	0	18	30	52
	Where ARI occupancy model > 65%	879	2.4	0.8 (0.5)	0.4	1.2 (0.9)	19	31	50
	Where ARI occupancy model > 50%	3,782	10.3	3.0 (1.9)	1.6	4.5 (3.4)	20	31	49
Implement retention harvesting	30% of ash harvested [2]	0	0	0	0	0	19	30	51
	50% of ash harvested [2]	0	0	0	0	0	19	31	50
	100% of ash harvested [2]	20	0.1	0	0.01	0.01	20	31	49
Regeneration practices	Implement/investigate at small scale	n/r					19	30	51
	Implement/investigate at large scale	n/r					19	31	50
Buffer old growth ash forests	Buffer by 100 m	198	0.5	0	0.1	0.1	19	31	50
Revise Zone definition [3]	Living mature or senescent at 8/3 ha	1,979	5.4	1.6 (1.0)	0.8	2.4 (1.9)	19	31	50
	Living mature or senescent at 10/3 ha [2]	0	0	0	0	0	19	30	51
	Living mature or senescent at 12/3 ha	0	0	0	0	0	18	30	52
	Living/dead mature or senescent 8/3 ha	8,027	21.9	3.6 (2.4)	3.6	7.3 (6.0)	21	32	47
	Living/dead mature or senescent 10/3ha	4,289	11.7	3.4 (2.1)	1.8	5.1 (3.8)	21	31	48
	Living/dead mature or senescent 12/3ha	4,289	11.7	3.4 (2.1)	1.8	5.1 (3.8)	20	31	49
	Living/dead mature and senescent 8/3 ha	3,079	8.4	2.3 (1.4)	1.3	3.6 (2.7)			
	Living/dead mature and senescent 10/3 ha	660	1.8	0.5 (0.3)	0.3	0.8 (0.6)			
	Living/dead mature and senescent 12/3 ha	660	1.8	0.5 (0.3)	0.3	0.8 (0.6)			

Action	Scale of action	Estimated area of available resource (ha)	Estimated % of available resource	Estimated direct supply costs ($ millions)	Estimated opportunity costs ($ millions)	Estimated total supply costs ($ millions)	Benefit BN 'good'	Benefit BN 'fair'	Benefit BN 'poor'
Future old growth	Target future old growth 30% ash forest	274	0.7	0	0.1	0.1	19	30	51
Fire management	Small scale to protect habitat & colonies	n/r					19	30	51
	Large scale to protect habitat & colonies	n/r					19	30	51
Install nest boxes	Small scale	n/r					19	30	51
	Large scale	n/r					19	30	51
Translocation	Small scale	n/r					19	31	50
	Large scale	n/r					21	32	48
Accelerated hollow development	Small scale	n/r					19	30	51
	Large scale	n/r					19	30	51
Exclude thinning	Buffer reserves by 100 m	21	0.1	0.2	0.01	0.16	18	30	52
	Buffer reserves by 200 m	45	0.1	0.2	0.02	0.17	18	30	52
Expand riparian buffers	20 m buffer	39	0.1	0.2	0.02	0.17	18	30	52
	30 m buffer	828	2.3	0.6 (0.4)	0.3	0.96 (0.72)	19	30	51
	40 m buffer	2,639	7.2	2.0 (1.2)	1.1	3.08 (2.28)	19	30	51
Buffer Zone 1 habitat	Buffer by 100 m	n/a		n/a	n/a	n/a			
Senescent trees	Buffer all senescent trees by 100 m	n/a		n/a	n/a	n/a	22	32	47
Great Forest NP	Implement as mapped in website proposal	34,333	93.7	3.5 (2.2)	17.3	20.9 (19.6)	28	34	38

n/a not available;   n/r not relevant

[1] these figures are based on records from the last 15 years; the impact of future records is incorporated later.

[2] at the time of the assessment it was not possible to fully consider the impact of these actions with estimates of the impact more fully developed in later stages of the process.

[3] there are a large number of assumptions in these estimates – refer text for full explanation.

3.3.4   Stage 3 – Development of packages of actions

Stage 3 involved further consideration of actions and progressive short-listing of various packages of actions, using the outputs from Stage 2. During Stage 3 the following principles were applied, with a focus on identifying alternative combinations of actions that:

- were effective in the short term and long term;
- covered protecting known colonies, protecting high quality habitat and further reducing the risk of habitat decline;
- spread the risk both geographically and temporally;
- ensured that all major threats are addressed, with the actions relating to the highest threats given priority in relation to the extent/scale of the action; and
- delivered the most positive outcome for Leadbeater's Possum while minimising cost to industry and/or implementation costs.

To assist with the development of packages under Stage 3, the costs and benefits of actions from Stage 2 were assessed in different combinations with a view to determining which combinations provided the most positive outcome for Leadbeater's Possum while minimising cost to industry. The VicForests' Leadbeater's Possum Action Impact Assessment Tool was used to spatially estimate the total area impacted by all area-based actions included in a package. This tool enabled the overlap of multiple actions to be combined so that areas were not double-counted (e.g. where timber harvesting exclusion zones around colonies overlapped with areas considered under other potential actions), providing the overall area expected to be impacted by the packages of actions. As there was not sufficient data regarding the spatial location and extent of a number of the potential actions, the extent of the impact was determined using available distribution data and the overlap with other proposals was estimated rather than determined spatially. These areas were then translated into a percentage reduction in annualised volumes using the same approach used for individual actions in Stage 2. The Bayesian Network model was used to estimate the relative impact of various combinations of actions on the benefit to the possum.

Using this approach, the relative benefits and costs of 16 packages of actions were developed and assessed, ranging from the current situation to the implementation of the Lindenmayer *et al*. (2013b) prescriptions (which include the establishment of a Great Forest National Park; Table 11). The reduction in timber volumes, the annualised cost to the timber industry and the benefits to Leadbeater's Possum through the Bayesian Network model were calculated for each package.

After considering the assessment of the estimated relative costs and benefits of the 16 packages of actions, the Advisory Group narrowed its focus to options 4 and 5, as these options were deemed to offer the best potential to fit within the Advisory Group's Terms of Reference in terms of supporting recovery of Leadbeater's Possum while maintaining a sustainable timber industry. Aspects of option 4 and option 5 were combined and refined into eight new alternative packages of actions to test the relative estimated benefit and impact of the extent of individual actions within these packages (Table 12). The feasibility of implementing actions relating to fire management, nest boxes, translocation and hollow development was more fully considered at this stage and a realistic level of each action was included consistently across all packages in order to enable valid comparisons between the other actions being tested. Using these eight packages as the basis for further discussion, a single preferred package was developed (Table 13) that most closely aligned with the Terms of Reference.

Table 11. Examples of 16 possible alternative packages of actions to explore the relative value and impact of potential packages of actions, from the current situation (Option 1) to the Lindenmayer *et al*. (2013b) prescriptions including Great Forest National Park (Option 16).

Action	Scale of action	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16 [1]
Protect colonies	100 m exclusion zone		X														
	200 m exclusion zone			X	X			X		X							
	500 m exclusion zone					X	X		X		X	X	X	X	X	X	X [a]
Reserve additional habitat	Where ARI occupancy model > 85%		X	X		X	X				X						
	Where ARI occupancy model > 65%				X			X	X	X		X					
	Where ARI occupancy model > 50%												X	X	X	X	
Retention harvesting	30% of ash harvested		X					X									
	50% of ash harvested			X	X												
	100% of ash harvested					X	X		X			X	X	X	X	X	X
Regeneration practice	Implement at small scale			X		X		X		X		X		X		X	
	Implement at large scale		X		X		X		X		X		X		X		X
Buffer old growth	Buffer by 100 m						X		X			X			X	X	X
Habitat definition	Live mature or senescent at 8/3 ha											X			X	X	
	Live mature or senescent at 10/3 ha		X		X	X		X	X	X	X		X				
	Live mature or senescent at 12/3 ha	X		X			X										
	Live/dead mature or senescent 8/3 ha															X	X
Future old growth	Target future old growth 30% ash															X	X [b]
Fire management	Small scale for habitat & colonies		X		X		X		X		X		X		X		
	Large scale for habitat & colonies			X		X		X		X		X		X		X	X
Install nest boxes	Small scale	X		X		X		X		X		X		X		X	X
	Large scale		X		X		X		X		X		X		X		
Translocation	Small scale		X		X		X		X		X		X		X		
	Large scale			X		X		X		X		X		X		X	X
Hollow development	Small scale			X		X		X		X		X		X		X	X
	Large scale		X		X		X		X		X		X		X		
Exclude thinning	Buffer reserves by 100 m				X			X		X	X	X		X			
	Buffer reserves by 200 m			X		X	X		X				X		X	X	
Riparian buffers	20 m buffer	X	X	X	X	X											
	30 m buffer							X	X			X	X	X			
	40 m buffer										X	X			X	X	X [c]
Buffer Zone 1	Buffer by 100 m																X
Senescent trees	Buffer all senescent trees by 100 m																X [d]
Great Forest NP	Implement entire national park																X
Area of resource [2]		0	102	500	1,345	1,365	1,515	1,921	3,153	3,659	3,811	4,771	5,826	7,312	8,994	13,819	35,061
% available resource [2]		0.0	0.3	1.4	3.7	3.7	4.1	5.2	8.6	10.0	10.4	13.0	15.9	19.9	24.5	37.7	95.7 [3]
Supply cost to industry	Annualised cost [4]	0.0	0.1	0.4	1.3	1.3	1.4	1.8	2.9	3.4	3.5	4.4	5.0	5.7	6.6	9.1	20.2

Action	Scale of action	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16 [1]
Benefit to possum [5]	Bayesian model probability – 'good'	18	24	24	26	28	27	26	29	26	25	30	30	31	31	34	34
	Bayesian model probability – 'fair'	30	33	34	34	35	34	34	35	34	34	35	35	35	35	35	35
	Bayesian model probability – 'poor'	52	43	42	41	38	39	40	36	40	41	35	35	34	34	31	31
	Increase in probability of 'good'		6	6	8	10	9	8	11	8	7	12	12	13	13	16	16

Footnotes

[1] The Lindenmayer *et al*. (2013b) prescriptions actions differ in some places than what is presented in this table. They are indicated next to the scale of the closest action considered in Stage 2 with the following difference: [a] colony buffer recommended 1 km; [b] target future old growth of 50%; [c] riparian buffer of 100 m; [d] buffer all hollow-bearing trees by 100 m.

[2] The estimated area and percentage of the timber resource available for harvesting over the next 20-30 years. Projected future harvest timber supply levels were based upon data of varying quality and include broad estimates for some actions. The projected impact was produced to provide a relative impact of the packages and is not definitive. For detailed impact analysis each package of actions would require inclusion in VicForests full timber supply model. Due to the time constraints of the Leadbeater's Advisory Group process (and existing data limitation) this was not possible.

[3] The impact of the Lindenmayer *et al*. (2013b) prescriptions is estimated at 95.7%, however due to modelling limitations this figure is likely to underestimate this impact.

[4] The total annualised supply cost has been derived by discounting the estimated costs pre-2017 and post-2017 over the next 20 years (at the Department of Treasury and Finance recommended rate of 3.5% per annum) and deriving an equivalent single annualised estimate for the 20 year period.

[5] The benefits to Leadbeater's Possum are shown as the relative probability that the species would be in a 'good', 'fair' or 'poor' condition, based on expert opinion. The increase in 'good' is in comparison to the current situation.

Table 12. The refined alternative short-listed packages of actions used to test the relative benefit and impact of different scales of key actions. The column headings summarise the main differences between the packages (RH – retention harvesting; OM – occupancy model; FOG – future old growth; Z1A – Zone 1A; CB – colony buffer; RB – riparian buffer). The current situation (Option 1) and the Lindenmayer *et al*. (2013b) prescriptions including Great Forest National Park (Option 16) are shown for comparison. All footnotes are the same as for Table 11. All non-area based actions (e.g. translocation) were kept consistent between packages to enable valid comparisons between the variables under consideration.

Action	Scale of action	1	Package (with 50% RH)	Package (with 100% RH)	Package (with 100% RH, without OM)	Package (with100% RH, without OM, with FOG)	Package (with Z1A at 8 trees)	Package (with 50% OM)	Package (with 500m CB)	Package (with 30m RB)	16 [1]
Protect colonies	200 m exclusion zone existing records		X	X	X	X	X	X		X	
	500 m exclusion zone existing records								X		X [a]
Reserve additional habitat	Where ARI occupancy model > 65%		X	X			X		X	X	
	Where ARI occupancy model > 50%							X			
Retention harvesting	50% of ash harvested		X				X	X	X	X	
	100% of ash harvested			X	X	X					X
Regeneration practice	Implement at small scale		X	X	X	X	X	X	X	X	
	Implement at large scale										X
Buffer old growth	Buffer by 100 m		X	X	X	X	X	X	X	X	X
Habitat definition	Live mature or senescent at 8/3 ha						X				
	Live mature or senescent at 10/3 ha		X	X	X	X		X	X	X	
	Live mature or senescent at 12/3 ha	X									
	Live/dead mature or senescent 8/3 ha										X
Future old growth	Target future old growth 30% ash					X					X [b]
Fire management	Small scale for habitat & colonies		X	X	X	X	X	X	X	X	
Install nest boxes	Small scale	X	X	X	X	X	X	X	X	X	
Translocation	Small scale		X	X	X	X	X	X	X	X	
Hollow development	Small scale		X	X	X	X	X	X	X	X	
Exclude thinning	Buffer reserves by 100 m		X	X	X	X	X	X	X	X	
Expand riparian buffers	20 m buffer	X	X	X	X	X	X	X	X		
	30 m buffer									X	
	40 m buffer										X [c]
Buffer Zone 1	Buffer by 100 m										X
Senescent trees	Buffer all senescent trees by 100 m										X [d]
Great Forest NP	Implement entire national park										X

Action	Scale of action	1	Package (with 50% RH)	Package (with 100% RH)	Package (with 100% RH, without OM)	Package (with100% RH, without OM, with FOG)	Package (with Z1A at 8 trees)	Package (with 50% OM)	Package (with 500m CB)	Package (with 30m RB)	16 [1]
Area of available resource [2]		0	1,345	1,365	497	705	3,073	1,365	2,371	2,108	35,061
% available resource [2]		0.0	3.7	3.7	1.4	2.0	8.4	3.7	6.5	5.8	95.7 [3]
Supply cost to industry	Annualised cost [4]	0	1.3	1.3	0.4	0.7	2.9	1.3	2.2	2.0	20.2
Benefit to possum [5]	Bayesian model probability – 'good'	18	25	25	24	25	25	25	25	25	34
	Bayesian model probability – 'fair'	30	33	34	33	34	34	34	34	34	35
	Bayesian model probability – 'poor'	52	42	41	42	42	41	41	41	42	31
	Increase in probability of 'good'		7	7	6	7	7	7	7	7	16

Table 13. The recommended package of actions plus the current situation and the Lindenmayer *et al*. (2013b) prescriptions (including the Great Forest National Park).

Action	Scale of action	Current situation	Advisory Group Recommendations	ANU prescriptions [1]
Protect colonies	200 m exclusion existing records, plus review after 200 new records		X	
	200 m exclusion existing records, plus review after 2 years			
	500 m radius exclusion zone			X [a]
Delay harvesting	Where ARI occupancy model > 65%		X	
Retention harvesting	50% of ash harvested		X	
	100% of ash harvested			X
Regeneration practice	Investigate alternative practices		X	
	Implement at large scale			X
Buffer old growth	Buffer by 100 m		X	
Habitat definition	Live mature or senescent at 10/3 ha		X	
	Live mature or senescent at 12/3 ha	X		
	Live/dead mature or senescent 8/3 ha			X
Future old growth	Target future old growth 30% ash		X	X [b]
Fire management	Small scale for habitat & colonies		X	
Install nest boxes	Small scale	X	X	
Translocation	Undertake feasibility study		X	
Hollow development	Investigate techniques for hollow development		X	
Exclude thinning	Buffer reserves by 100 m			
Expand riparian buffers	20 m buffer	X	X	
	40 m buffer			X [c]
Buffer Zone 1	Buffer by 100 m			X
Senescent trees	Buffer all senescent trees by 100 m			X [d]
Great Forest NP	Implement entire national park			X
Area of available resource [2]		0	1,857	35,061
% available resource [2]		0.0	5.0	95.7 [3]
Supply cost to industry	Annualised cost [4]	0	1.7	20.2
Benefit to possum [5]	Bayesian model probability – 'good'	19	26	38
	Bayesian model probability – 'fair'	31	34	35
	Bayesian model probability – 'poor'	50 *	40	27
	Increase in probability of 'good'		7	19

Footnotes as for Table 11. * refinements to the model resulted in variation to the baseline figures of the current situation compared to those shown in earlier Tables.

This preferred package, which was assessed as providing the potential for the most positive outcomes to Leadbeater's Possum while minimising cost on industry, was then compared with the two options at either end of Table 11 – the current situation and the Lindenmayer *et al.* (2013b) prescriptions – to provide a relative assessment of the estimated benefits and impacts of this package (Table 13). Although deemed outside the Terms of Reference due to the expected profound impact on industry that would result from implementing this option, the Lindenmayer *et al.* (2013b) prescriptions were used as a point of comparison because that option was considered likely to have the potential to result in the most benefit to Leadbeater's Possum. Furthermore, there was a high level of support for this option in the stakeholder engagement process and an expectation amongst these stakeholders that this option would be considered. Considering this option was also informative as it illustrated that even this option could not guarantee a secure outcome for the future of the species, with a roughly even probability that the status of Leadbeater's Possum was in a 'good', 'poor' or 'fair' condition in the Bayesian Network model.

When considering the final package of actions it became apparent that some actions could not be fully implemented at the present time due to a lack of knowledge. As a result the scope of two actions (translocation and accelerated hollow development) changed from implementing to examining feasibility. These revisions resulted in changes to the expected benefit to Leadbeater's Possum in the Bayesian Network model, as direct benefits would not result until the findings of these studies were implemented.

The action based on the protection of identified colonies could not be fully assessed spatially, as it is unknown how many colonies are likely to be located in the future. To assist with the assessment of impact of this proposed action the potential extent of future colony detections was explored further. This was done on the basis of estimates of colonies that would possibly be recorded following targeted surveys spanning two years and five years. These calculations factored in the number of surveys likely to be undertaken by government, other institutes and agencies and environment groups, the areas in which the surveys were likely to be undertaken, the expected detection rates, and the estimated overlap with the available timber resource. It was estimated that after two years of intensive surveys, including by government and environmental groups, that up to 280 new colonies within the available timber resource may be located, although there is a high level of uncertainty in these figures. The associated area of available resource impacted was calculated and used to update both the Bayesian Network model outputs and the estimated costs to the timber industry for further consideration. The Advisory Group's recommended package of actions is based on establishing a 200 m radius exclusion zone around existing records in the available resource area (approximately 67 records) was likely to impact 691 hectares of available resource (1.9%). After two years of intensive survey it was estimated that the full package of actions may impact up to 2,572 hectares of available resource (7.0%) (noting that these figures are estimates only and there are significant levels of uncertainty in both on how many new colonies would be located and what impact that would have on the available resource).

As the recommended package included actions that provide protection of spatially-identified areas as well as actions that rely upon assessment of forest characteristics or response to identification of new colonies, it was recognised that this introduced a level of uncertainty to forest managers and the timber industry. This uncertainty could potentially lead to ever increasing impacts on the timber industry if large areas of Leadbeater's Possum habitat zones or many new Leadbeater's Possum colonies were identified. Given the rarity of the possum this may be unlikely. However, to ensure

that the balance of prescriptive measures responds to improved understanding of the distribution of colonies and suitable habitat over coming years, the Advisory Group recommended that the effectiveness of the colony protection action in supporting the recovery of the Leadbeater's Possum while maintaining a sustainable timber industry, be reviewed after two years of surveying or once 200 new colonies are located whose exclusion zones impact on the General Management Zone or Special Management Zone, whichever comes first. The introduction of trigger points for a review provides an increased level of certainty for forest managers and the timber industry.

The assumptions used for estimating the impact of the additional 200 new records is outlined in Table 15. It is important to note that these are estimates only and there is a high level of uncertainty around these estimates. They did, however, give the Advisory Group some broad information to guide decision-making on the potential impact of implementing the action to protect Leadbeater's Possum colonies.

Table 15. Assumptions used to estimate the area likely to be impacted by the location of an additional 200 records of Leadbeater's Possum within the available resource area.

Assumptions	Figures
Records from government-based surveys	
Number of sites with Leadbeater's Possum located during government-based surveys. As the government surveys are proposed to be extensive and targeted it is assumed, for these calculations, that 75% of the 200 new records would result from these surveys.	150 records
Area impacted if all of the 200 m exclusion zone around each new record was within the available timber resource area, based on exclusion zones of approximately 12 ha.	1800 ha
Area impacted once overlap with other buffers, existing SPZs, areas unsuitable for harvesting etc. is factored in. The available timber resource is often in small patches, and so it is unlikely that all of each 12 ha exclusion zone would fall within the available resource area. Using the existing records as a guide, where on average only one third of each exclusion zone is in the available resource area, it is assumed that half of each exclusion zone may be within the available resource. This is due to these surveys being more likely to target larger patches of available resource.	900 ha
Records from environmental groups	
Number of sites with Leadbeater's Possum based on 40 new records resulting from environment groups.	40 records
Area impacted if all of the 200 m exclusion zone is within the available timber resource area. As environment groups are more likely to target proposed timber harvesting coupes (which are entirely within the available timber resource area), 100 per cent of each exclusion zone has been included.	480 ha
Records from other organisations	
A small number of additional records are likely to come from other organisations – e.g. Zoos Vic, ANU. Many of these studies are based at sites with existing records (e.g. the ANU long term monitoring sites) or in areas already reserved, and so it is assumed that additional records may be limited.	10 records
Area impacted once overlap with other buffers, existing SPZs, areas unsuitable for harvesting etc. is factored in, assuming a 50 per cent overlap with the available resource, as for the government surveys.	60 ha
Total area impacted by the 200 new records	**1440 ha**
Percentage of the available resource	**3.9%**

The final package of actions recommended by the Advisory Group is presented in the Recommendations Report, and further detail on each action is provided in Section 4 of this Technical Report. The final package of actions is estimated to impact approximately 1,857 hectares (5%) of the timber resource available for harvesting over the next 20-30 years, although it is noted that there is significant uncertainty associated with these figures.

4   The Advisory Group's Recommended Package of Actions

This section provides additional information on the recommended package of actions presented in the Recommendations Report. It provides a general rationale of the benefit of each action and definitions to assist in unambiguously interpreting each action. Refer to the Recommendations Report for further information on the intent of the recommendations, responsible agencies, timing and risks.

4.1   Protect Leadbeater's Possum colonies

Action:

- Establish timber harvest exclusion zones of a 200 metre radius centred on the detection site to protect each identified colony.
- Review the effectiveness of this action in supporting the recovery of the Leadbeater's Possum while maintaining a sustainable timber industry after two years of surveying or once 200 new colonies are located whose exclusion zones impact the General Management Zone or Special Management Zone, whichever comes first.

Supporting and enabling actions:

- Develop management prescriptions that can be unambiguously applied by practitioners in the field, to protect identified colonies from harvesting activities and other forest management activities (e.g. roads).
- Undertake targeted Leadbeater's Possum surveys focusing on predicted high occupancy areas, as identified through the ARI 2013 occupancy model and aligned with VicForests' harvest plan, to identify and map colonies and clusters of colonies within the known range (with surveys designed to maximise increasing records while also contributing to improving habitat models and the understanding of habitat requirements).
- Actively seek out Leadbeater's Possum records from groups and institutions that are known to have undertaken survey work.
- Undertake surveys where required to verify records generated by the community (using standards for verification outlined in an updated DEPI survey standard).
- Refine distribution and habitat models based on new data to improve predictions of areas most likely to contain colonies.
- Ensure that all records are published in the DEPI Victorian Biodiversity Atlas in a timely manner.
- Ensure that all known Leadbeater's Possum records and timber harvesting exclusion zones are mapped, consolidated and published as datasets in DEPI's Corporate Spatial Data Library and replicated in VicForests' information systems.
- Ensure this information is accessible to stakeholders to inform forest management planning, timber planning, compliance, enforcement and auditing, and fire planning and suppression.
- Improve survey techniques.

Rationale:

Bushfires in February 2009 and ongoing habitat decline have led to a reduced population of Leadbeater's Possums. The remaining wild population is therefore critical to the species' recovery.

There is currently no specific protection for known colonies. Ensuring the remaining colonies are protected will maximize capacity for the species to recover. As it is likely that the locations of only a relatively small proportion of all colonies are known, it is important to undertake further surveys to locate additional colonies to support the implementation of the action and improve our understanding of the population, so that they can be protected from threats that can be directly controlled or to implement programs that minimise the risk of unplanned impacts.

Definitions:

- A colony is defined as any confirmed record of a Leadbeater's Possum, based on the premise that an individual is part of a colony.
- The timber harvesting exclusion zone will be a circular area with a radius of 200 m centred on the detection point. This is equivalent to an area of 12.6 hectares.
- A timber harvesting exclusion zone is to be established around all records from within the previous 15 years (based on verified records within the Victorian Biodiversity Atlas).
- An exclusion zone will be established around all new records as soon as the record is verified. This includes all future records and any existing records that are not currently on the Victorian Biodiversity Atlas.
- The trigger for a review of establishing timber exclusion zones once 200 new colonies have been located and protected will be based on new colonies being defined as:
  - no closer than 200 m from an existing record. This distance is based on the typical home range size of up to 3 hectares, which, if circular, has a diameter of 200 m. Therefore any record of an animal within 200 m of an existing record could be from the same colony;
  - new records closer than 200 m to an existing record can only be included in the tally of 200 new colonies if there is clear evidence that the new record represents an additional colony; and
  - any new records which impact on GMZ or SMZ will be included, even if the record itself is outside the GMZ or SMZ. Records where there is no overlap between any of the 200 m radius area and GMZ or SMZ will not be included in the tally for the trigger for the review.
- Survey standards will be developed to outline the criteria required for a verified record of a Leadbeater's Possum.
- Records from community groups will be assessed by DEPI against these survey standards. If the record cannot be verified from the information provided, field surveys will be undertaken to verify the record. If the budget recommended to be allocated for verification surveys is not fully expended, the remaining funding will be allocated to conduct additional surveys in the following year, of areas planned for harvesting.
- Exclusion zones will be removed from records where the location has been severely burnt (burn category 1 or 2 as per DEPI burn severity mapping). This applies to bushfires within the last 15 years and also to future bushfires if the record was prior to the fire.
- All harvesting activities, including thinning, are to be excluded from the timber harvesting exclusion zones around colonies.
- New roads are not to be created through the timber harvesting exclusion zones without the approval of DEPI.
- Where a road exists within the exclusion zone, works can be undertaken where they do not impact the vegetation beyond the existing road footprint and verge. Any understorey or

canopy connectivity above the road will be retained to allow animals to move across the road as a colony's home range may span both sides of a road if there is connectivity.

4.2   Delay harvesting in areas of anticipated high probability of occupancy

Action:

- Delay harvesting for two years in areas that the ARI 2013 occupancy model predicts has a greater than 0.65 probability of being occupied by Leadbeater's Possum to allow surveys to be undertaken as per action 4.1.

Supporting and enabling actions:

- Ensure that these areas are mapped, consolidated and published as datasets in DEPI's Corporate Spatial Data Library and replicated in VicForests' information systems to indicate the area in which harvesting is delayed for two years.
- Ensure this information is accessible to stakeholders to inform forest management planning, timber planning, compliance, enforcement and auditing, and fire planning and suppression.

Rationale:

To minimise the risk of harvesting in areas with a high probability of occurrence of Leadbeater's Possum, timber harvesting will be delayed for two years to enable surveys to be undertaken in these areas. The area of predicted high probability of occurrence will be based on the ARI occupancy model for Leadbeater's Possum (Lumsden *et al*. 2013). This model was developed using broad-scale survey data collected during the Forest Biodiversity Project, and predicts current strongholds for the species based on the probability of occupancy across the species' range. Ground-truthing is required as the model could not incorporate the density of hollow-bearing trees as this was not available as a spatial layer across the whole area.

Definitions:

- The area in which harvesting will be delayed is based on the ARI occupancy model in areas with a >0.65 probability of occurrence (Figure 12). The area of available timber resource that is within the area of >0.65 probability of occurrence is 879 hectares (2.4% of the area available for harvesting in the next 20-30 years).
- The probability layers of the occupancy model will be published as a dataset in DEPI's Corporate Spatial Data Library and replicated in VicForests' information systems, with the areas where harvesting is to be delayed (i.e. where probability is > 0.65) clearly indicated.
- Surveys for Leadbeater's Possum colonies within the first two years would initially focus on areas with >0.65 probability of occurrence that overlap with areas available for harvesting in State forest. The overlap between the high probability areas and the available timber resource can be seen more clearly using an enlarged map, with the Baw Baw region used as an example (Figure 13).
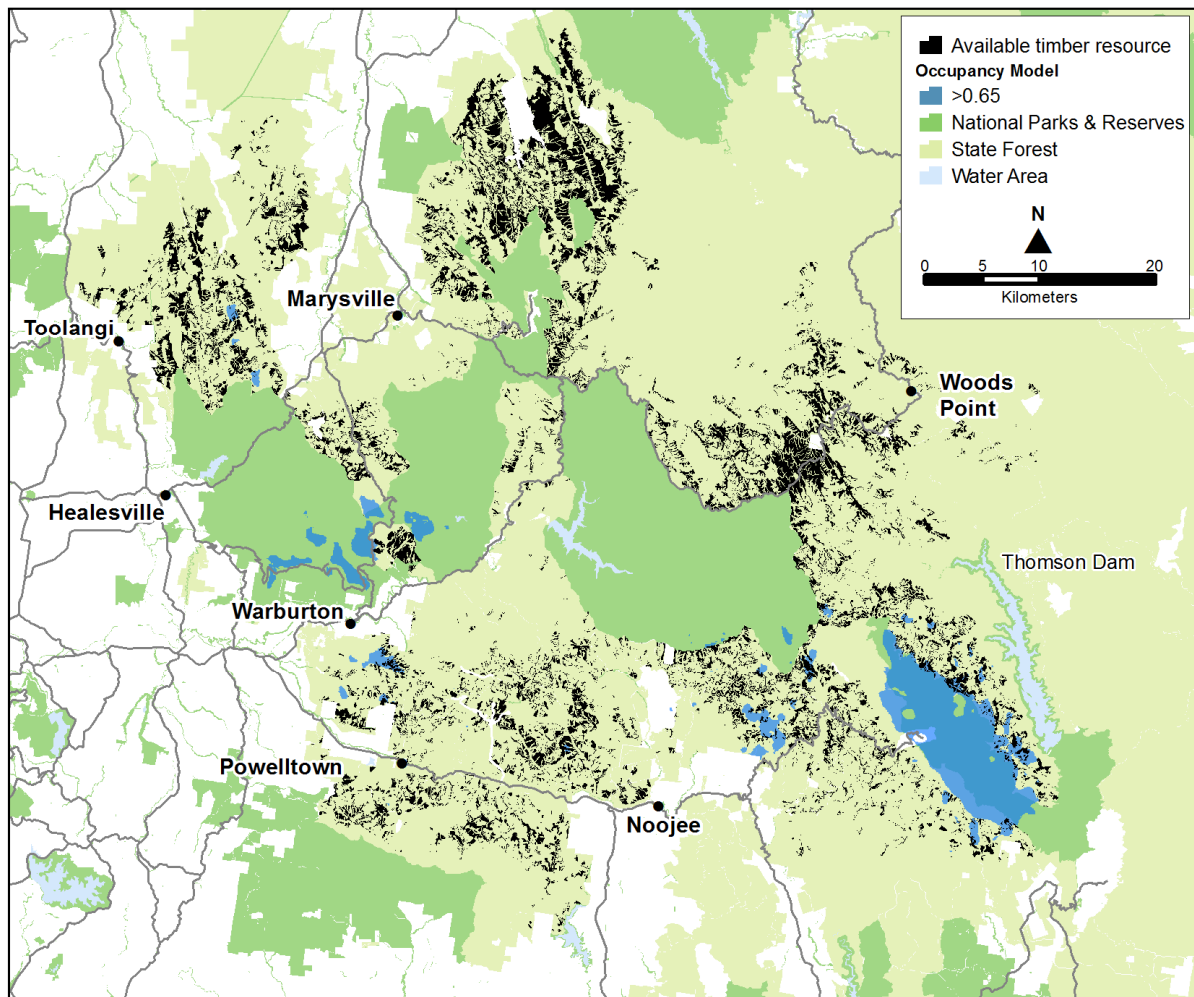
Figure 12. The area represented by a greater than 65% probability of Leadbeater's Possum currently occurring (dark blue shading) and the overlap with the available and currently suitable ash timber resource (black shading). Note that the dark blue shading is semi-transparent to show land tenure underneath.
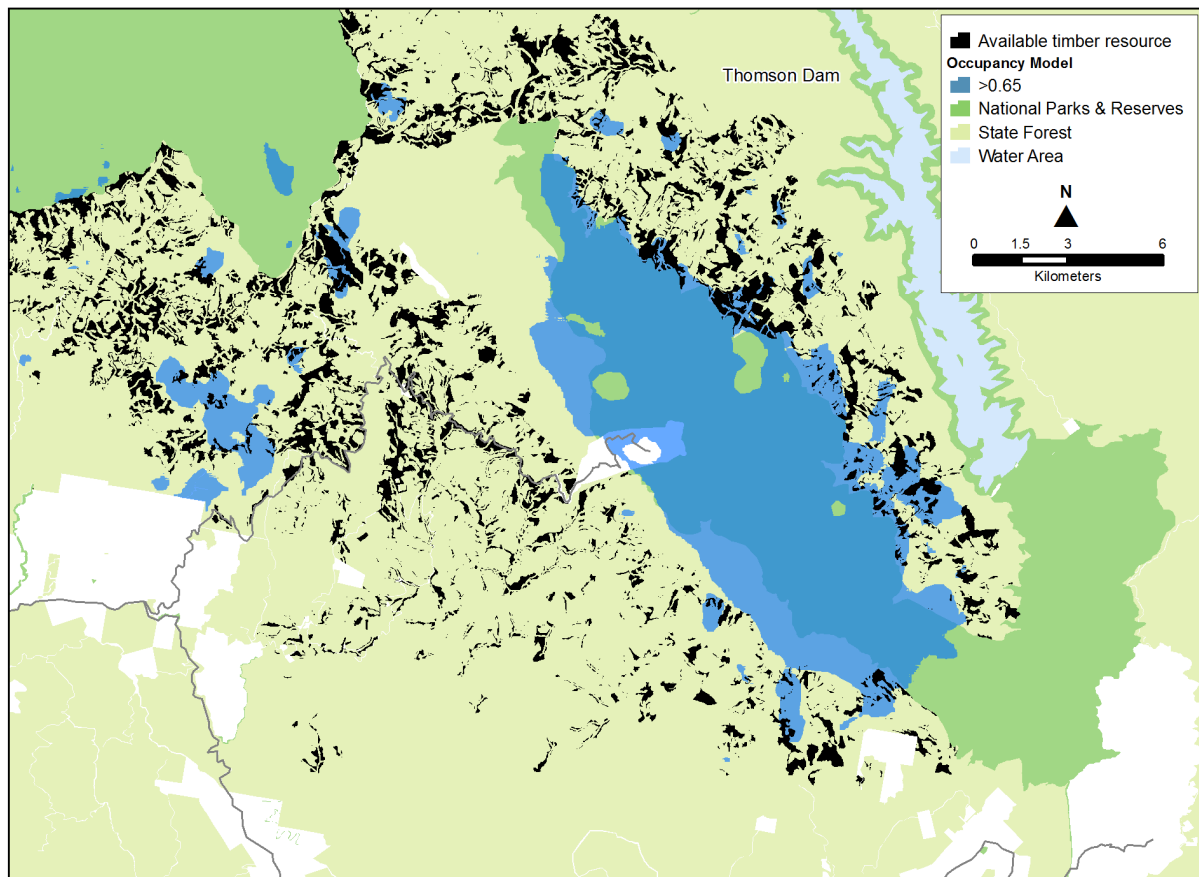
Figure 13. An enlarged version showing the Baw Baw region and the overlap between the available timber resource (black shading) and the area predicted to have a greater than 65% probability of Leadbeater's Possum currently being present (dark blue shading). Note that the dark blue shading is semi-transparent to show land tenure underneath.

4.3   Transition to retention harvesting

Action:

- From July 2014, undertake retention harvesting in at least 50 per cent of the area of ash harvested within the Leadbeater's Possum range.
- Begin planning for retention harvesting immediately.
- Raise the target for retention harvesting towards 100 per cent if the system proves to be operationally achievable.
- Implement research, planning and implementation of retention harvesting.

Rationale:

Long-term silviculture trials investigating alternative harvesting regimes commenced in 2003, conducted by the Australian National University in partnership with VicForests and DEPI. These variable retention harvesting trials examined the effects of retaining future habitat 'islands' in clearfelled areas for species with mixed-age habitat requirements, such as Leadbeater's Possum. It is expected that retaining clusters of trees within a coupe should reduce the time for Leadbeater's Possum habitat to develop in clearfelled areas (normally ≥ 200 years) by allowing trees to mature and develop hollows along with the younger regrowth to provide foraging substrate. This design allows some hollow-bearing trees to be preserved within an 80-year harvest rotation.

Definitions:

- A specific retention harvesting definition relevant to the Central Highlands ash forests has been developed by VicForests (VicForests Instruction – Regrowth Retention Harvesting version 1.0 2013) that aligns with internationally agreed definitions of retention harvesting (Gustafsson *et al.* 2012).

- The definition of retention harvesting contains a number of indicators, with the most significant being that at least 50 per cent of the cut area must be within one tree length of retained habitat which will be retained for at least one full rotation. This ensures a variable age class across the landscape.

- A three year rolling average of the area of ash forests harvested within the range of Leadbeater's Possum will be used to determine the proportion of area harvested under retention harvesting.

- The range of the Leadbeater's Possum is defined as the area of ash forest within the Leadbeater's Possum Management Units (refer Figure 14).

- The status of harvesting within each coupe will be determined at the completion of harvesting, when the final net area and the area of retained forests can be confirmed. Therefore, only completed coupes can be included in the reconciliation of harvest areas in any one year.

- Harvest areas will be reconciled through VicForests logging history, and reported to DEPI on an annual basis.

4.4 Revised regeneration practices

Action:

- Investigate alternatives to high intensity regeneration burns linked to post-burn retention harvest criteria.

Supporting and enabling actions:

- Change regulatory requirements to enable regeneration practices to consider ecological objectives (as opposed to a sole focus on regeneration of over-storey eucalypt species) when planning, undertaking and assessing post-harvest regeneration.

Rationale:

High intensity burning has been identified as a threat to retained habitat within and adjacent to areas harvested. However, high intensity burning is the most effective, safe and cost effective method of regenerating ash harvesting coupes. The move to alternative methods of regeneration therefore requires consideration of how the risks to retained habitat may be managed while maintaining effective regeneration post-harvest. This investigation may include consideration of the objectives of post-logging regeneration which currently focuses heavily on eucalypt species regeneration. Alternative methods may produce reduced eucalypt regeneration but provide an improved ecological outcome.

It is anticipated that following this investigation alternative techniques will be introduced into the regeneration practices of VicForests in critical habitat areas.

Definitions:

- Investigations into the feasibility of moving to alternatives to high intensity regeneration burns will be undertaken within the first year of the implementation of these recommendations.

4.5 Buffer old growth

Action:

- Exclude harvesting from within 100 metres of modelled old growth ash forests (from the DEPI spatial layer) within the Leadbeater's Possum range.

Supporting and enabling actions:

- Ensure that these areas are mapped, consolidated and published as datasets in DEPI's Corporate Spatial Data Library and replicated in VicForests' information systems.
- Ensure that this information is accessible to stakeholders to inform forest management planning, timber planning, compliance, enforcement and auditing, and fire planning and suppression.

Rationale:

Old growth ash forests contain the highest densities of hollow-bearing trees (Lindenmayer *et al.* 2000). Hollow-bearing trees are an essential habitat component for Leadbeater's Possums. However, past and current disturbances and management practices, such as fire and timber harvesting, have resulted in old growth Mountain Ash forest now comprising less than 3% of the Mountain Ash forest estate in the Central Highlands (Lindenmayer *et al.* 2012). These areas are sparsely distributed as small and highly fragmented patches spread across the landscape. The rarity of old growth ash forest is a significant conservation and management issue in the Central Highlands. All existing patches of old growth ash forest are currently protected from timber harvesting. Applying a 100 m buffer around old growth forest patches should provide additional protection for patches adjacent to timber harvesting coupes.

Definitions:

- The DEPI Modelled Old Growth spatial layer (*mog2009_1.shp*) will be used to define the areas of old growth.
- A permanent 100 m exclusion zone will be placed around the area identified by this layer regardless of the stand age or quality of the forest.
- The excluded areas are to be defined in the field utilising an appropriate Geographic Positioning System.
- The excluded areas are to be mapped and published as datasets in DEPI's Corporate Spatial Data Library and replicated in VicForests' information systems.

4.6 Amend the definition of Leadbeater's Possum Habitat Zone 1A

Action:

- Amend the definition of Zone 1A to 10 live, mature or senescent hollow-bearing ash trees per three hectare patch. (The definitions of mature, senescent, hollow-bearing, patch and all

other definitions included in the survey methodology are to remain as described within the current DEPI Survey Standard: Leadbeater's Possum Habitat Zones.)

Supporting and enabling actions:

- Ensure that these areas are mapped, consolidated and published as datasets in DEPI's Corporate Spatial Data Library and replicated in VicForests' information systems.
- Ensure that this information is accessible to key stakeholders to inform forest management planning, timber planning, compliance, enforcement, and auditing, and fire planning and suppression.
- Undertake an estate-wide inventory to improve the understanding of the extent of Zone 1A habitat, building upon previous ARI assessments.

Rationale:

There is an extensive reserve system within the range of Leadbeater's Possum including a specific Leadbeater's Possum Reserve containing examples of high quality habitat. To compliment this reserve, the best examples of Leadbeater's Possum habitat outside the reserve system are also protected using in-field prescriptions described as Leadbeater's Possum habitat zones. It is recognised that these zones do not include all potentially suitable habitat within the areas available for harvesting.

Due to the impact of the 2009 bushfires on the Leadbeater's Possum reserve system it is appropriate to reconsider the extent of potential habitat protected outside the reserves. The Advisory Group has therefore proposed that the threshold of the number of suitable hollow-bearing trees required for an area of forest to be included in Leadbeater's Possum habitat zones be decreased. This could significantly increase the extent of potentially suitable habitat protected in comparison to the current definition.

Definitions:

- Reducing the number of live, mature, hollow-bearing trees required for Zone 1A is the only change to the current definitions.
- The definition of all other elements (e.g. mature, senescent, hollow-bearing, patch, dead and live trees) are those within the DEPI Survey Standards: Leadbeater's Possum Habitat Zones and the associated 'Maturity assessment of Mountain Ash, Alpine Ash and Shining Gum' document.
- The method of identifying patches of habitat in the field (including the separation of patches if trees are greater than 100 m apart, and the consideration of contiguous areas outside of the proposed coupe) are those in the DEPI Survey Standards: Leadbeater's Possum Habitat Zones.
- The definition for Zone 1B remains unchanged.

4.7 Target future old growth ash forests for protection

Action:

- Introduce a target specifying that at least 30 per cent of the ash forest within each Leadbeater's Possum Management Unit be protected so that it can mature into old growth forest in the future.

Supporting and enabling actions:

- Determine the most appropriate areas of forest and approaches for their protection.
- Ensure that these areas are mapped, consolidated and published as datasets in DEPI's Corporate Spatial Data Library and replicated in VicForests' information systems.
- Ensure this information is accessible to stakeholders to inform forest management planning, timber planning, compliance, enforcement and auditing, and fire planning and suppression.
- Improve understanding of habitat survival to identify landscape features and habitats that are resilient to natural disturbance processes such as bushfires.

Rationale:

The extent of old-growth forest changes over time – stands become 'old-growth' as trees reach their oldest growth stage, or as the effects of past disturbance become negligible. Currently less than 3 per cent of the ash forests in the Central Highlands is considered to be old growth forest. Prior to European settlement it is estimated that 30-60 per cent of the Mountain Ash forests of the Central Highlands were multi-aged or old growth (Lindenmayer *et al.* 2011). Targets for increasing the area of old growth aim to provide future habitat for Leadbeater's Possum and other hollow-dependent species. The reserve system within the Central Highlands allows for a significant proportion of the current forest to become old growth in the future if not disturbed by bushfire. Using the Leadbeater's Possum Management Units (LMU) as the basis for setting targets for future old growth ensures a spread across the range of the species. Currently across the range of Leadbeater's Possum, 54 per cent of ash forest on public land is reserved in parks or SPZs. However, two of the 21 LMUs have less than 30 per cent of their ash forests reserved. To reach the target of at least 30 per cent of the ash area protected within each LMU, an additional 274 hectares of ash forest would be required to be protected within these LMUs (66 hectares in LMU 1 and 208 hectares in LMU 15, Figure 14). There are a range of mechanisms for increasing the area of future old growth to meet this target, the most significant of which is fire protection. Future old growth can also be an objective of formal and informal reserve creation.

Definitions:

- The mechanism for reaching the 30 per cent target in each LMU will be determined by DEPI and VicForests.
- The general principal behind the selection of these areas is to choose those areas least likely to burn during bushfires (e.g. natural fire refuges), areas of the oldest age class that will develop into old growth the quickest, or areas to consolidate other patches that may develop into future old growth.
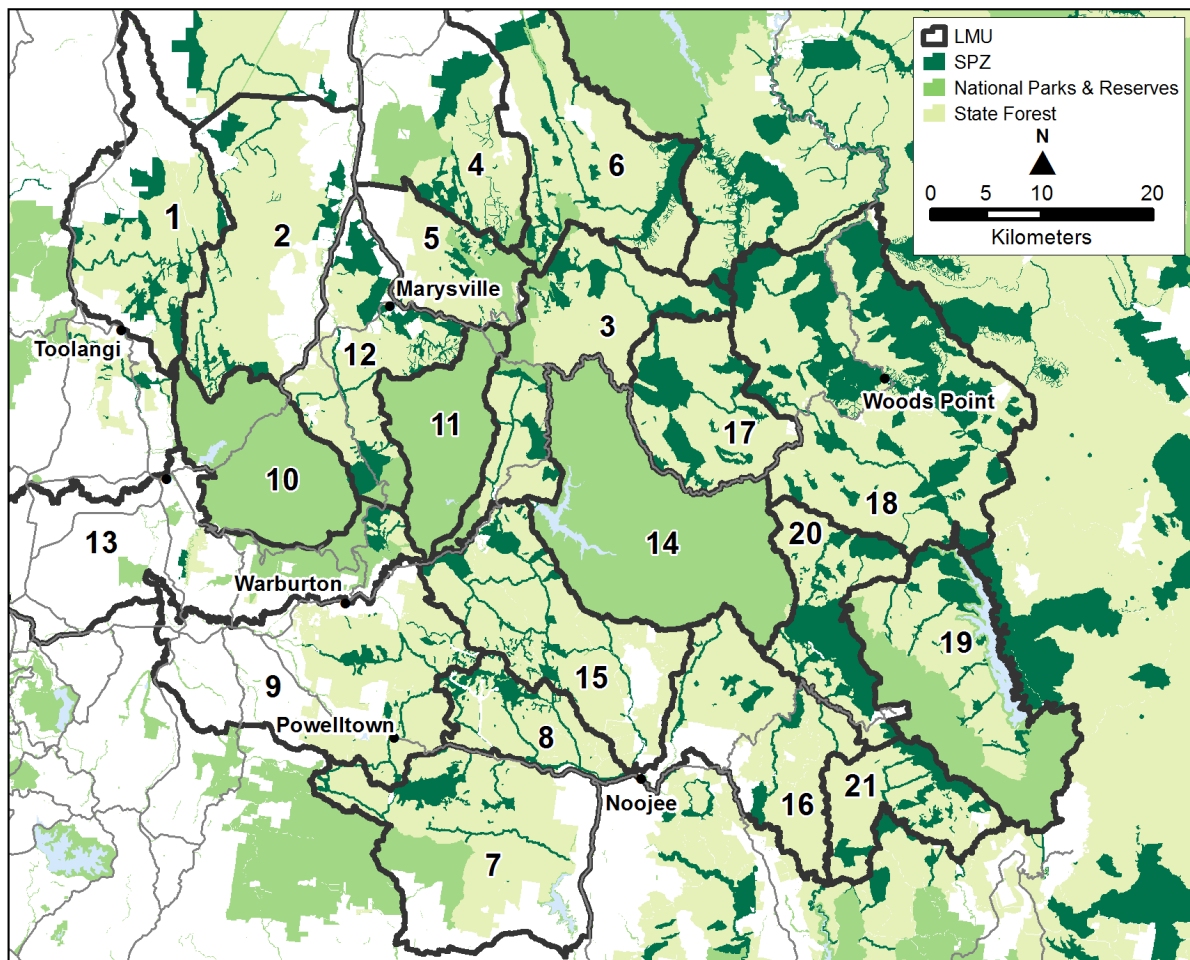
Figure 14. The 21 Leadbeater's Possum Management Units and the areas currently reserved as either parks (mid-green shading) or Special Protection Zones (dark-green shading). The two LMUs that do not currently have 30 per cent of their ash forests reserved are LMU 1, in the Toolangi area, and LMU 15, north-east of Powelltown.

4.8   Fire management of known colonies and high quality habitat

Action:

- Identify known colonies and high quality habitat as critical assets on the Natural Values database (part of DEPI's fire system) to inform fire operations and risk landscapes planning.
- Investigate and implement, where possible and appropriate, active fire management activities to protect identified colonies and high-quality habitat from bushfire, taking into consideration other threatened species requirements. This includes suppression activities and fuel management in adjacent drier forest types.
- Develop approved fire recovery protocols that can be enacted without delay following fire or other disturbance events that affect known colonies.

Supporting and enabling actions:

- Ensure that all recorded Leadbeater's Possum colonies and their associated timber exclusion zones and high-quality habitat, whether formally reserved or not, are mapped, consolidated and published as datasets in DEPI's Corporate Spatial Data Library. Ensure this information is

accessible to DEPI's fire operations and planning divisions to assist with fire operations planning, suppression and management.

Rationale:

Intensive, widespread bushfires are the biggest threat to the ongoing persistence of Leadbeater's Possum. These actions aim to increase the protection of Leadbeater's Possum colonies and habitat through intensified fire planning and management. In addition, the development of fire recovery protocols prior to the next large fire would assist in decision making and timely emergency management responses. Fire recovery protocols will assist incident management teams in how to protect or extract important or at risk colonies during an emergency event. Such extractions may remove animals from harm's way. The protocols would include planning, resources, logistics, deployment of field teams and recipient site considerations.

Definitions:

- All existing and new records of Leadbeater's Possum will be published as datasets in DEPI's Corporate Spatial Data Library to ensure this information is accessible to DEPI's fire operations and planning divisions to assist with fire operations planning, suppression and management.
- High quality habitat will be identified using a range of information and number of approaches, including, but not limited to:
  - the ARI occupancy model, with focus on the higher probability areas (e.g. > 0.50 probability of occurrence);
  - the DEPI Species Habitat Model for Leadbeater's Possum developed during the policy phase of the Forest Biodiversity project, focusing on the highest probability areas;
  - identified and mapped areas of Zone 1 habitat;
  - the Leadbeater's Possum reserve system;
  - areas known to contain comparatively large numbers or high densities of colonies (e.g. Dowey Spur Track in the Powelltown area);
  - areas that were unburnt in the 2009 bushfires but are surrounded by burnt forest that may be acting as fire refuges. Many of these areas provide suitable habitat now and could facilitate recolonisation of surrounding areas once they have regenerated. These areas will provide important multi-aged forest into the future if not re-burnt; and
  - areas that were old growth ash forest prior to the 2009 bushfires – these areas will provide high quality habitat in the next 10-15 years and it is critical that these areas are protected from future bushfires and planned burning to ensure the dead stags remain standing.
- Other important areas, such as the ANU long-term monitoring sites and the *Project Possum* nest box sites, will also be recorded as datasets in DEPI's Corporate Spatial Data Library. This will ensure this information is accessible to DEPI's fire operations and planning divisions to enable these areas to be protected where possible during bushfires and so as not be subjected to planned burning.
- Fire recovery protocols will be developed to address issues such as:
  - emergency management of known colonies after bushfire;
  - under what conditions would animals be brought into captivity;
  - under what conditions would supplementary feeding be considered;

o   under what conditions would supplementary nesting sites be established; and

o   who would be responsible for the work and for making decisions.

4.9   Install nest boxes

Action:

- Provide artificial nest boxes in a targeted manner at key locations to support existing populations by extending *Project Possum*.

- Maintain and monitor existing nest boxes in Snow Gum and selected ash forest sites through the *Project Possum* program in five areas throughout the Central Highlands. *Project Possum* sites are predominantly in national parks, catchment areas and other reserve areas.

- Nest boxes will also be installed to investigate the extent of other populations occurring in Snow Gum woodlands and ash forest, including the Baw Baw plateau and Mt Matlock.

Rationale:

In many areas, den sites are a limiting resource for Leadbeater's Possum populations. While the maintenance of hollow-bearing trees should always be considered the highest priority when considering den site availability, in certain circumstances, the decline in den sites can be ameliorated to some extent through the targeted provision of artificial nest boxes. The situations in which nest boxes have proved most successful are where the vegetation structure allows boxes to be placed at the height that animals typically move through the vegetation. These include Snow Gum woodlands such as at Lake Mountain, where nest boxes have been used extensively, and in regenerating ash forest where the understory is low and dense, such as areas of forest regenerating post the 1983 fires. Regular monitoring of nest boxes can provide additional information on populations, such as an estimation of the number of sites supporting Leadbeater's Possums following the February 2009 bushfires and recolonisation rates of burnt areas.

Definitions:

- The intent of this action is to install nest boxes to support existing colonies in areas of declining natural tree hollows, rather than an attempt to expand the species' range by installing boxes in currently unoccupied areas, which is considered to have a lower likelihood of success.
- *Project Possum* is a partnership between the Friends of Leadbeater's Possum, Parks Victoria, Zoos Victoria and DEPI to provide nest boxes for Leadbeater's Possum to supplement their declining forest habitat. Volunteers are involved in the installation and monitoring of the boxes. (http://leadbeaters.org.au/projects/project-possum/)
- A five-year plan will be developed to guide the implementation of this action, with nest boxes maintained and monitored at existing sites and expanded into new sites.
- There will be an evaluation of the success of the program at the end of the five-year period.

4.10   Accelerate hollow development

Action:

- Investigate accelerated hollow development through silvicultural or other forest management processes.

- Investigate accelerated hollow development through mechanical or other approaches that may provide hollows in the near future.

Rationale:

Mountain Ash typically do not start forming hollows until they are 120 years old, with the large cavities preferred by Leadbeater's Possum typically taking 190-220 years to form (Smith and Lindenmayer 1988). The abundance of these old trees is declining rapidly across the landscape as a result of numerous landscape-wide bushfires, natural attrition and timber harvesting (Lindenmayer *et al.* 2012). It is predicted that there will be a severe shortage of hollow-bearing trees suitable as nesting sites for Leadbeater's Possum over the next 50-70 years. This is due in part to the loss of dead stags from within 1939 regrowth forests before the live trees in this age class commence producing hollows.

While the highest priority is to protect existing hollow-bearing trees, this may not be enough to ensure sufficient hollows are available through the bottleneck period and it is recommended that approaches for accelerating the development of hollows be explored. If successful techniques could be developed there is potential to use them to transform areas that are currently unsuitable as habitat for Leadbeater's Possum due to a lack of sufficient hollow-bearing trees. However, it is currently unknown which techniques may be the most successful and cost-effective for creating the type of hollows needed by Leadbeater's Possum.

There are two broad approaches that could be taken. One is to use silvicultural or other forest management processes, such as ecological thinning practices that promote hollow development in younger forest through enabling trees to grow larger more quickly, or modified harvesting practices that promote damage to retained trees. Alternatively, accelerated hollow development could be undertaken through mechanical or other processes, such as drilling or cutting a hollow into a tree, manipulating/pruning tree branches, or introducing fungus to accelerate hollow development. Artificially creating hollows has been used with some success in the USA (e.g. Lewis 1998) but is untested in ash forests in Australia.

Definitions:

- An evaluation of the potential of these techniques, based on the recommended field-based research will be undertaken during the 4-year review, or sooner as appropriate.
- If successful, the most cost-effective techniques would be considered and funding sought for the implementation of broad-scale, artificial hollow development in areas lacking sufficient hollows.

4.11   Translocation

Action:

- Examine the feasibility of translocating Leadbeater's Possums from wild to wild.

Rationale:

- There are likely to be areas of suitable, but unoccupied, Leadbeater's Possum habitat within the Central Highlands, especially in areas that were burnt severely in the 2009 bushfires. Such areas where hollow-bearing trees are available and once the vegetation has recovered sufficiently to provide foraging habitat, may be ideal habitat but may take some time to be recolonised if there are not surviving colonies close enough for animals to naturally disperse

into the area. Due to the distances required for dispersal and the low dispersal rates, it may take many years or decades for the species to naturally recolonise these areas. This is where translocation could be effective. However, there are many unknowns regarding the efficacy of translocation in this situation.

Definitions:

- This project will investigate the desirability and feasibility of translocating Leadbeater's Possums to establish new colonies in suitable but unoccupied habitat. Subsequent translocation, and monitoring the success of any re-establishments, could be undertaken subject to the results of the feasibility study.
- The feasibility study could explore questions such as:
    - is translocation considered desirable and feasible?
    - what would be the criteria for locating a source population?
    - what would be the impact of removing animals from the source population?
    - is this impact considered acceptable? Can the impact be reduced?
    - should entire family groups be translocated or dispersing sub-adults?
    - what criteria would be used to select recipient locations?
    - how much survey work would be required to confidently ascertain that animals were not present in the proposed recipient location?
    - what are the most appropriate protocols for undertaking the translocation?
    - how much and what type of monitoring would be required to assess if the translocation was successful?
- Although it has been suggested that translocation into areas outside of the current range of the species be considered, this feasibility study will focus on unoccupied areas within the current range, as this is considered to be more likely to be successful.
- It is considered that 'wild to wild' translocation is likely to be the most effective rather than breeding animals in captivity for release, and hence this will be the focus of this feasibility study.

4.12   Community engagement

Action:

- Implement ongoing community engagement, including with environment and industry groups.
- Involve community stakeholders in monitoring activities.
- Continue to implement and enhance education programs to improve understanding of Leadbeater's Possums and their management.

Rationale:

The intent of these actions is to engage more closely with industry, environmental groups and the community on activities that would lead directly to improved outcomes for the Leadbeater's Possum.

4.13   Monitoring and review

Action:

- Review the implementation of the recommended package of actions in four years, with a view to assessing progress, capturing learnings and maximise benefits.
- With respect to Action 4.1 (establishing a timber harvest exclusion zone around colonies), review its effectiveness no later than after the completion of two years of surveying, or once 200 new colonies are located, whichever comes first, in order to assess the effectiveness of this action in supporting the recovery of the Leadbeater's Possum while maintaining a sustainable timber industry.
- Report on implementation progress periodically (e.g. every six months).

Rationale:

On-going monitoring and review will feed into an adaptive management cycle that is central to Victoria's forest management system to help ensure Victoria's forests are able to continue to provide the community with social, economic and environmental benefits into the future. It will also help ensure that the community has timely information on progress achieved in implementation, which will assist in meeting their expectations for increased transparency (which was a recurring theme raised during the Advisory Group's stakeholder engagement process). The results of this monitoring and reporting can feed directly into an assessment of the extent to which the government's objectives (i.e. to support recovery of Leadbeater's Possum while maintaining a sustainable timber industry) are being achieved.

Definitions:

- Establish an evaluation plan, based on an adaptive management approach, to progressively maximise the effectiveness of agreed actions.

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Glossary

Allocation Order – allocates areas of State forest to VicForests for the purposes of harvesting and selling timber resources. The Allocation Order is for a period of 15 years (divided into three 5-year periods) and may be varied and/or extended (VicForests 2013b).

Action Statement - means an Action Statement made under Section 19 of the *Flora and Fauna Guarantee Act* 1988 (DSE 2009b).

Ash - Mountain Ash *Eucalyptus regnans*, Alpine Ash *Eucalyptus delegatenis* and Shining Gum *Eucalyptus nitens* (DEPI 2014a).

Biodiversity – the natural diversity of all life: the sum of all our native species of flora and fauna, the genetic variation within them, their habitats, and the ecosystems of which they are an integral part (DSE 2007).

Bushfire – under the Code of Practice for Bushfire Management on Public Land, a bushfire is defined as a general term used to describe a fire in any vegetation (DSE 2012c). For the purposes of this report, the term bushfire is used exclusively for wildfires (i.e. those triggered through natural processes, lightning, accidental or deliberate human ignition) and does not encapsulate planned burning activities.

Central Highlands – the forested area to the north-east of Melbourne broadly encapsulated by the Central Highlands Regional Forest Agreement Area.

Central Highlands Forest Management Area - the Central, Central Gippsland (the part within Central Highlands Forest Management Plan) and Dandenong Forest Management Areas (FMAs) (DEPI 2014a).

Clearfall / clear-felling – silvicultural method of harvesting a coupe whereby all merchantable trees, apart from those to be retained for wildlife habitat, are removed (DSE 2007).

Code - the Code of Practice for Timber Harvesting Operations 2014 (DEPI 2014a).

Coupe – as defined in the *Sustainable Forests (Timber) Act 2004* means a specific area of State forest identified for the purposes of a timber harvesting operation in a timber release plan or, on private land a single area of forest or plantation of variable size, shape and orientation from which timber is harvested in one operation (DEPI 2014b).

DBH – Diameter at breast height used for measuring tree size.

DEPI – Department of Environment and Primary Industries – used here to also cover previous names of the department (e.g. Department of Sustainability and Environment).

Exclusion zone – an area within the GMZ or SMZ where timber harvesting operations are excluded.

Forest - an area with a high density of trees typically composed of an overstorey (canopy or upper tree layer) and an understorey (DEPI 2014a).

Forest Biodiversity project – project initiated under the Timber Industry Action Plan, undertaken by DEPI titled 'A New Strategic Approach to Biodiversity Management'. A summary of the research component is provided in Lumsden *et al.* (2013).

Forest Coupe Plan – a plan that must be prepared for each harvesting operation in State forest, containing a map identifying the area and a schedule incorporating the specifications and conditions under which the operation is to be administered and controlled (DSE 2007).

Forest Management Plan – a plan for public land applying to one or several Forest Management Areas, that is approved by the Secretary of DEPI, which addresses the full range of values and uses in the Forest Management Area (DSE 2007).

Forest stand – as defined in the *Sustainable Forests (Timber) Act 2004* means a group of trees within a State forest that share common characteristics relating to eucalypt species composition and age (DEPI 2014b).

General Management Zone (GMZ) – areas within State forest that is managed for a range of uses and values, with the sustainable production of timber and other forest products being a major use. Within the GMZ there are areas that are excluded from harvesting operations due to the requirements of the Code of Practice for Timber Production. These areas include stream buffers and slopes generally greater than 30° (DSE 2012b).

Hollow-bearing tree – any tree, dead or live, that contains a hollow of any shape or size.

Leadbeater's Possum Management Units (LMU) – 21 LMU's have been delineated for Leadbeater's Possum management covering the known distribution of Leadbeater's Possum in the Central Highlands, based on the extent and spatial distribution of ash forest. Each LMU generally contains between 6,000 – 10,000 hectares of ash forest and is composed of one or more adjacent forest management blocks containing contiguous patches of ash forest.

Leadbeater's Possum Reserve – an area in the Central Highlands of 30,500 hectares set aside in 2008 specifically for Leadbeater's Possum conservation, of which 58% is within national parks and 42% reserved in SPZs in State forest.

Mixed species – for the purpose of this report, mixed species are considered to be non-ash tree species.

National Park – areas of preservation and protection of the natural and cultural heritage values of parks and prescribe various matters as required by Section 17 of the National Parks Act 1975.

Native forest – an area originally naturally occurring, that is dominated by trees having usually a single stem and a mature or potentially mature stand height exceeding two metres and with existing or potential crown cover of overstorey strata about equal to or greater than 20 per cent. (DSE 2007).

Native vegetation – plants that are indigenous to Victoria, including trees, shrubs, herbs and grasses (DSE 2007).

Old growth forest – forest which contains significant amounts of its oldest growth stage – usually senescent trees – in the upper stratum and has been subjected to any disturbance, the effect of which is now negligible (DSE 2009c).

Permanent road – a generally high standard road permanently required for the continuing management of the forest including timber harvesting operations (DSE 2007).

Planned burn – the deliberate application of fire under specified environmental conditions to a predetermined area and at the time, intensity and rate of spread required to achieve planned resource management objectives (DSE 2012b).

Population viability analysis (PVA)– a modelling technique for the estimation of extinction probability based on threats to survival.

Public land – unalienated land of the Crown managed and controlled by the Minister for Environment and Climate Change, the Minister for Agriculture and Food Security, or the Secretary to the Department of Environment and Primary Industries, whether or not occupied under a licence or other right (DSE 2007).

Pulplog – logs that are too small or too defective to meet current sawlog specifications and would be left in the forest as waste if not harvested in conjunction with sawlogs. Widely used in the production of quality writing and office paper.

Regeneration – the renewal or re-establishment of native forest flora by natural or artificial means following disturbance such as timber harvesting or fire (DSE 2007).

Regional Forest Agreements (RFA) - establish the framework for the conservation and sustainable management of forests within each of the five Victorian RFA regions. The main objectives of the Victorian RFAs are to identify a Comprehensive, Adequate and Representative (CAR) Reserve System and provide for the conservation of those areas; to provide for the ecologically sustainable management and use of forests in each RFA region; and to provide for the long-term stability of forests and forest industries (DSE 2009a).

Retained trees – trees retained on a coupe during a harvesting operation because they are unmerchantable, are to serve as seed trees or wildlife habitat trees, or have been selected to grow on after thinning (DSE 2007).

Riparian vegetation – vegetation that requires free or unbound water, or conditions that are noticeably moist along the margins of streams, drainage lines, and lakes (DSE 2007).

Rotation – the planned number of years between the regeneration of a forest stand and its final harvesting, taking into account the full range of values and uses the owner wishes to derive from the forest (DSE 2007).

Salvage harvesting – harvesting operations conducted to recover timber following wildfire, storms, floods, disease, insect attack or other events that cause significant tree mortality or damage (DEPI 2014b).

Sawlog - a log considered suitable in size and quality for producing sawn timber.

Silviculture – the science and practice of managing harvesting, forest establishment, composition, and growth, to achieve specified objectives (DSE 2007).

Special Management Zone (SMZ) - areas of State forest that cover a range of natural or cultural values and are managed to conserve specific features. The protection or enhancement of these values requires modification to timber harvesting or other land use practices rather than their exclusion. Timber and other forest produce may be harvested from this zone under certain conditions.

Special Protection Zone (SPZ) - areas of State forest managed for conservation. Larger components of the zone are based on representative examples of vegetation communities and old growth, as well as localities of key threatened and sensitive flora and fauna species. This zone is managed to minimise disturbances or processes that threaten their respective values, and timber harvesting is excluded.

State forest - as defined in section 3 of the *Forests Act 1958*. State forest comprises publicly owned land which is managed for the conservation of flora and fauna; for the protection of water

catchments and water quality; for the provision of timber and other forest products on a sustainable basis; for the protection of landscape, archaeological and historical values; and to provide recreational and educational issues (DSE 2007).

Thinning – the removal of part of a forest stand or crop, with the aims of increasing the growth rate and/or health of retained trees and, in commercial thinning, obtaining timber from trees that would otherwise eventually die before final harvest (DSE 2007).

Timber – a general term used to describe standing trees or felled logs before processing into wood products. This includes timber from trees or parts of trees which are specified as available for timber harvesting operations, but does not include firewood collected for domestic use (DSE 2007).

Timber harvesting operation – means any of the following kinds of activities carried out by any person or body for the purposes of sale or processing and sale —
- (a)   felling or cutting of trees or parts of trees;
- (b)   taking or removing timber;
- (c)   delivering timber to a buyer or transporting timber to a place for collection by a buyer or sale to a buyer;
- (d)   any works, including road works and regeneration, ancillary to any of the activities referred to in paragraphs (a) to (c)—

but does not include the collection of firewood for domestic use (DEPI 2014b).

Timber Harvesting Plan – a plan prepared under the Code of Practice for private native forests and plantations, usually consisting of a map identifying the area(s) to be harvested and a statement of conditions applying to the operation, and lodged with the Responsible Authority. The plan may apply to a single coupe or to an area in which a number of coupes are to be harvested (DEPI 2014b).

Timber Release Plan – a plan prepared by VicForests in accordance with the Part 5 of the *Sustainable Forests (Timber) Act 2004*. Plans are required in respect of an area to which an allocation order applies for the purposes of harvesting timber resources and undertaking associated management activities in relation to those timber resources. The Timber Release Plan must be consistent with the Code of Practice and made publicly available (DSE 2007).

Appendix 1: Record of suggested actions from the stakeholder workshops

Suggested actions arising from the science workshop

- *Hollow-bearing tree development in 1939 forest regrowth (e.g. moving to a thinning regime to accelerate creation of new habitat)*
- *Captive breeding and release research to test in a wider range of suitable habitat*
- *Wider testing of nest boxes in suitable, potential future habitat sites*
- *Assess potential role of private land*
- *Identify and protect 'fire refuge' sites in areas scheduled for harvesting*
- *Investigate the role of bees or other pests in preventing the use of natural hollows*
- *Minimise potential fire ignition sources in key risk areas*
- *Maximise fire control and suppression capacity in key risk areas*
- *Lengthen rotations and increase variable retention silviculture to add hollows to regrowth*
- *Invest in greater value-adding and new products out of a reduced timber supply from ash forests*
- *New governance model to develop a shared landscape vision that is adaptive, including strong stakeholder participation to bring together all interests to support effective land use whilst protecting and restoring habitat*
- *Stop logging in Central Highlands until ecological sustainable forestry can be achieved*
- *Adopt a definition of ecological sustainable forestry*
- *Accept that fire regimes are changing and implement appropriate fire prevention and suppression*
- *Define a landscape scale plan/vision for the Central Highlands*
- *Explore ways of hollow formation in suitable forests*
- *Any suitable habitat (present and future) for Leadbeater's Possum should be managed for conservation*
- *Expand plantation estate*
- *Expand tools in fire management kit (a variety)*
- *Include current old growth in reserve system*
- *Manage a long-term process based on ash*
- *Reduce known threatening processes, including:*
    - *Loss of hollow-bearing trees (natural collapse)*
    - *Inappropriate fire regimes*
    - *Lack of recruitment habitats*
    - *Global climate change (not controllable)*
    - *Microclimate changes (controllable by letting it get to old growth)*
- *Identify and protect the 'next' old regrowth (i.e. 1939 regrowth)*
- *Nest boxes*
- *Breeding programs and reintroductions (Yellingbo/Central Highlands stock)*
- *Assisted translocation*
- *Identify and protect the current key habitat (occupied or not)*
- *Clarify the values of the community*
- *Managing and quantifying values to the community of: timber, water, forest biodiversity, carbon, fire proneness, tourism*
- *Avoid too narrow focus/TOR to debate*
- *Develop tools and mechanisms for long term planning and thinking (e.g. 190 years for hollows etc.)*
- *Policy and legislation changes to define LBP habitat and trees (mature, pre 1900) and promote 'ecologically sustainable forest management' and code of practice for harvesting*

- *Reduce intensity and extent of logging*
- *Increase reserve and protected habitat*
- *Protect well known colonies throughout LBP distribution*
- *Protect all hollow-bearing trees, alive and dead*
- *Add hollows to regrowth forest (plastic boxes)*
- *Investigate methods for hollow creation*
- *Protect existing unburnt forest (e.g. strategic use of planned burning – particularly 1939 regrowth)*
- *Implement variable retention harvesting systems*
- *Reduce sustainable yield*
- *Capture insurance population (genetically viable)*
- *Improve coupe placement to reduce habitat fragmentation and better landscape planning*
- *Expand existing LBP reserve, particularly 1939 regrowth*
- *Investigate the use of fire to increase wattle regeneration in areas where its reduced through ecological burning*
- *Increase size of streamside reserves*
- *Increase size of corridors between coupes so they can support colonies and facilitate dispersal*

Suggested actions from the environmental workshop

- *Captive breeding and release research to test in a wider range of suitable habitat*
- *Amend/develop process to require any logging activity to be demonstrably ecologically sustainable and amend the process under the Sustainable Forest (Timber) Act*
- *Use independent ecologists to advise on sustainability of logging (native forest) at planning stages*
- *Pre-logging surveys conducted by independent biologists to provide information on species and populations*
- *Extend and make permanent Special Protection Zones (i.e. formal reservation)*
- *Change Flora and Fauna Guarantee Act to make actions statements binding generally*
- *Flora and Fauna Guarantee Act needs to be implemented properly, which requires adequate resourcing of recovery teams, action statement preparation, and compliance*
- *New nation park created, with Parks Victoria resourced to manage it and ensure LBP management*
- *Hollow bearing trees totally protected by law*
- *Transition native forest logging into mixed-species plantations*
- *New national park - with adequately resourced landscape management*
- *Include a plantation sector as part of the solution*
- *Flexibility for VicForests not to have to honour any contracts from LBP habitat*
- *End clearfelling and revise logging methods*
- *Urgent implementation of Lindenmayer's proposed prescriptions - enormous economic and social benefit, water, carbon, ecological, fire regimes, new reserves and new truly sustainable jobs*
- *Need independent analysis of positive economic benefits of the creation of national parks*
- *Significant industry innovation and reform*
- *Independent assessment of fact sheets released by the Advisory Group, especially the timber industry (e.g. job figures relevant to LBP, forest areas include mallee woodland - not that relevant to the LBP)*
- *Expansion of scope of corridor plantation resource to secure jobs at Maryville*
- *Shut down VicForests for immediate financial saving and comparatively few job losses*
- *Stop logging in Central Highlands ash forest*
- *Establish the Great Forest National Park*
- *Immediate cessation of clearfell logging*

- *Assist transition of forest industry workers to restoration forestry and plantation forestry and exit from industry altogether for those who wish to do so*
- *Remove government 'subsidisation' of VicForests and apply funding to LBP and Great Forest National Park*
- *Change government - vote green*
- *Protect, survey, map all hollow trees*
- *Stop fuel reduction burns in wet forests*
- *Stop fire breaks - they don't work*
- *Implement the prescriptions of Lindenmayer ASAP*
- *Fund compliance actions to ensure the above prescriptions are implemented*

Suggested actions from the industry workshop
- *Fire prevention/protection of critical habitat*
- *Variable retention harvesting study*
- *More extensive habitat studies*
- *Retention of existing colonies*
- *Trust building/dialogue between NGO's, industry, community, other stakeholders*
- *Post fire, in fill burning, do not burn islands*
- *Nest box research to mimic the natural hollow (discourage non-targeted species)*
- *Understand foraging requirements*
- *Predator analysis*
- *Work out comprehensive plan*
- *Public awareness of the facts (channel resource currently spent on legal/media by industry/government/NGO's to solutions for the LBP*
- *Use new survey techniques outside current known areas, and investigate habitat possibilities for possible re-colonisation*
- *Research into detection techniques to enhance ability to detect*
- *Captive breeding program enhancement to ensure genetic diversity and other issues are overcome*
- *Habitat/hollow survey to determine unused/recoverable*
- *Open grown trees - leave all trees not for market (allow contractor input to improve outcomes)*
- *Continue best practice*
- *Awareness campaign (the industry, community, environment, sustainable harvesting)*
- *Continue current forest practice - most stringent in the world*
- *Better designed nest boxes, cheaper and more cost effective*
- *Better coupe management - VicForests contractor input (contractors currently hamstrung)*
- *Lindenmayer's recommendations - unworkable, too restrictive*
- *Less minority input, more liaison with contractors, harvest and haulage, VicForests*
- *Maintain buffers in old tree clusters, min 20m*
- *Forest 'offset' areas to compensate for any changes in access (national parks, conservation res etc.)*
- *On-going active forest and fire management*
- *R&D into developing hollows in large standing trees*
- *Differentiate forest management techniques (suite of options)*
- *Continue monitoring with new technologies, including other forest types*
- *Assisted translocation R&D and captive breeding*
- *3D print stag hollow trees*

Suggested actions from the community workshop
- *Better definitions of sustainability, ecologically sustainable forest, and an economically sustainable industry*

- *Explore Tasmania option (variable retention harvesting) for Victoria*
- *What are we doing to protect current habitat areas by fire management on surrounding areas*
- *We need to create a long-term management plan for a forest that has a sustainable regeneration cycle of 150 years*
- *Increase timber plantations*
- *Increase LBP range*
- *Release of additional forests reserve where LBP isn't present*
- *Research into other wood species (economic use)*
- *Retention harvesting or STS*
- *Holistic forest management (one group manage all values)*
- *Leverage Commonwealth direct action for local government to create carbon plantations using VicForests*
- *More flexibility in harvest area and longer rotations (i.e. 200 years and open conservation areas)*
- *Investigate national park areas to identify available resource*
- *Fully investigate socio-economic impacts on regional areas*

Appendix 2. The Bayesian Network model with assumptions and details on each variable.

The purpose of the model is the illustrate the relationships between the factors affecting the population and habitat variables that best represent the status of Leadbeater's Possum in the Central Highlands. In regard to forest management, the focus is on the allocation and management of unburnt ash forest that is available for harvesting or thinning over the next 30 years, while the broader landscape variables include all parks and forests with the range of Leadbeater's Possum. The groups of variables are colour coded as shown in the model.

Node	Specific variable	States and thresholds	Assumptions/Logic/Evidence	Influenced by	Influences
Environmental threats					
Bushfire	• percentage of potential (i.e. ash and Snow Gum), unburnt (i.e. status post 2009 bushfires) Leadbeater's Possum habitat, burnt within the next 30 years	• severe = >30% • moderate = 10-30% • negligible = <10%	• bushfire kills Leadbeater's Possum and ash trees (both regrowth and mature/senescent) and accelerates the collapse of stags	• drought • protect from fire	• forest allocation • wattle senescence • den site availability • mid-storey connectivity • direct mortality • current habitat distribution • current habitat connectivity • future hollow-bearing tree supply
Drought cycle	• percentage of years below long-term 10th percentile (based on period 1960-2010) of annual rainfall occurring over the next 30 years	• severe = >15% • moderate = 11-15% • negligible = <11%	• drought elevates risk and impact of bushfires and also contributes to loss of hollow-bearing trees through drought stress • years with rainfall below 10th percentile are strongly associated with significant bushfire events • if climate change results in more frequent and severe droughts, the incidence within the next 30 years of years below the long term 10th percentile will increase	• none	• bushfire • natural loss of hollow-bearing trees

Node	Specific variable	States and thresholds	Assumptions/Logic/Evidence	Influenced by	Influences
Natural loss of hollow-bearing trees	• percentage annual loss of live or dead hollow-bearing trees	• severe = >4% • moderate = 1-4% • negligible = <1%	• loss of live or dead hollow-bearing trees as a result of rotting, fire, windthrow or drought stress reduce the suitability of habitat by reducing den site availability • The background rate of decline is 3.6% (Lindenmayer et al. 1990)	• bushfire • drought	• den site availability • future hollow-bearing tree supply
Wattle senescence	• percentage of ash forest affected by substantial wattle senescence	• significant = >20% • insignificant = <20%	• wattle senescence commences 50-60 years post disturbance leading to loss of mid-storey connectivity • wattle regeneration is typically triggered by bushfire or mechanical disturbance especially where canopy gaps are created • bushfire and timber harvesting will reduce the extent of wattle senescence	• bushfire • forest allocation	• mid-storey connectivity
Forest management policy and practices					
Clearfelling practices	• percentage of currently suitable Leadbeater's Possum habitat within GMZ likely to be negatively affected by clearfall harvesting and high intensity regeneration burning over the next 30 years rendering the habitat unsuitable for occupation by Leadbeater's Possum in the short to medium term (up to 120 years)	• severe = >30% • moderate = 10-30% • negligible = <10%	• standard clearfelling and regeneration burning practices result in uniform regrowth forest lacking in suitable natural den sites. • current practices protect Zone 1 habitat but Leadbeater's Possum is known to occupy areas with <12 hollow-bearing trees/3ha. • current practices including Code Prescriptions protect ~35% of available area – some of this area	• protect hollow-bearing trees • apply retention harvesting • modify regeneration • buffer colonies	• direct mortality • den site availability • mid-storey connectivity • current habitat distribution • current habitat connectivity • future hollow-bearing tree availability

Node	Specific variable	States and thresholds	Assumptions/Logic/Evidence	Influenced by	Influences
			might be suitable habitat (such as rainforest buffers) and some might not be (such as steep or rocky areas without den sites).		
Thinning practices	• percentage of currently suitable Leadbeater's Possum habitat available for thinning that is affected by thinning over the next 30 years therefore rendering the habitat unsuitable for occupation in the short term (up to 20 years)	• severe = >20% • moderate = 5-20% • negligible = <5%	• thinning opens the forest structure and disturbs the understorey through the passage of machinery resulting in a loss of mid-storey connectivity, and potentially loss of dead trees.	• buffer colonies • exclude thinning near Leadbeater's Possum reserves	• mid-storey connectivity
Forest allocation	• percentage of the area of unburnt (in 2009) ash forest within the range of Leadbeater's Possum allocated to GMZ and available for harvesting over the next 30 years	• high = >25% • moderate = 10-25% • low = <10%	• 36,655 ha of unburnt ash forest is currently available and suitable for harvesting in the next 30 years; • this equates to 27.7% of the total area of unburnt ash within the range of Leadbeater's Possum • any significant bushfire affecting the currently available area will reduce the overall area harvested	• buffer colonies • provide future old growth • reserve additional areas as per occupancy model • buffer oldgrowth • bushfire	• wattle senescence • current habitat distribution • current habitat connectivity • future hollow-bearing tree availability
Population and habitat variables – local scale					
Direct mortality	• trend in mortality above baseline mortality rate	• stable • moderately elevated • greatly elevated	• direct mortality is likely to increase if Leadbeater's Possum habitat is harvested or if bushfires occur • 0.3 annual probability of death (i.e. background death rate due to normal population processes)	• clearfelling practices • bushfire	• cluster size • number of clusters

Node	Specific variable	States and thresholds	Assumptions/Logic/Evidence	Influenced by	Influences
Den site availability	• the number of potential den sites available per hectare	• sufficient = >3 potential den sites/ha • marginal = 1-3 potential den sites/ha • insufficient = <1 potential den sites/ha	• den sites are critical for Leadbeater's Possum • den sites are likely to be a limiting factor in many areas • Leadbeater's Possum can occur in areas with <12 hollow-bearing trees/3ha	• natural hollow-bearing tree loss • clearfelling practices • accelerate hollow development • install nest boxes	• current habitat distribution • current habitat connectivity • cluster size
Mid-storey connectivity	• percentage of mid-storey crown cover	• extensive – >50% • patchy – 10–50% • absent – < 10%	• mid-storey connectivity provides safe movement pathways • thinning and clearfelling reduce or remove connectivity • bushfire removes connectivity	• clearfelling practices • bushfire • thinning practices	• cluster size
Cluster size	• the mean number of proximate colonies within a 100 ha area form a cluster	• increasing • stable • decreasing	• more colonies within dispersal range will increase the likelihood that dispersing animals will find mates and that the cluster itself will persist • PVA analyses indicate single isolated populations inhabiting patches of ~<20 ha are highly susceptible to extinction	• den site availability • direct mortality • mid-storey connectivity	• number of clusters
Population and habitat variables – landscape scale					
Number of clusters	• the number of known clusters	• increasing • stable • decreasing	• more clusters will reduce the risk of catastrophic loss due to bushfire and therefore increase the probability of persistence; more clusters will also assist dispersal into unoccupied habitat	• cluster size • direct mortality	• cluster distribution • asset status

Node	Specific variable	States and thresholds	Assumptions/Logic/Evidence	Influenced by	Influences
Cluster distribution	• the distribution of clusters across suitable habitat within the range of Leadbeater's Possum	• expanding • stable • contracting	• widely distributed clusters will reduce the risk of catastrophic loss in a single bushfire	• number of clusters • current habitat distribution • translocation of colonies	• asset status

Current habitat distribution	• the extent to which suitable habitat is currently distributed across the range of Leadbeater's Possum	• good = >70% of Leadbeater's Possum Management Units have >70% of ash forest meeting suitable habitat definition
		• fair = 30-70% of Leadbeater's Possum Management Units have >70% of ash forest meeting suitable habitat definition
		• poor= <30% of Leadbeater's Possum Management Units have >70% of ash forest meeting suitable habitat definition
			• widely distributed suitable habitat across the species range will reduce the risk of catastrophic loss in a single bushfire
			• suitable habitat is defined as:
			   • >3 ha patches;
			   • >3 den sites/ha; and
			   • extensive or patchy mid-storey connectivity.
				• forest allocation
				• clearfelling practices
				• den site availability
				• bushfire
					• asset status

Current habitat connectivity	• the percentage of suitable habitat that exists in connected patches of >100ha	• good = >70% • fair = 30-70% • poor = <30%	• connected habitat patches will allow for dispersal and therefore higher levels of occupancy	• forest allocation • clearfelling practices • den site availability • bushfire	• cluster distribution • asset status

Node	Specific variable	States and thresholds	Assumptions/Logic/Evidence	Influenced by	Influences
Future supply of hollow-bearing trees	• the percentage of the range of Leadbeater's Possum that is predicted to support >3 hollow-bearing trees/ha (average) by 2070	• sufficient = >3 hollow-bearing trees/ha (average) predicted to occur over >70% of Leadbeater's Possum range by 2070 • marginal = >3 hollow-bearing trees/ha (average) predicted to occur over 30-70% of Leadbeater's Possum range by 2070 • insufficient = >3 hollow-bearing trees/ha (average) predicted to occur over <30% of Leadbeater's Possum range by 2070	• if sufficient area is set aside from harvesting or harvested in a manner which protects habitat value for Leadbeater's Possum it might be possible to provide for future den site requirements • bushfire is the major (uncontrollable) factor that would affect progression to maturity	• forest allocation • clearfelling practices • natural loss of hollow-bearing trees • bushfire	• asset status
Asset status	• the overall status of the Leadbeater's Possum metapopulation in the Central Highlands based on a range of current and future landscape variables			• number of clusters • cluster distribution • current habitat distribution • current habitat connectivity • future hollow-bearing tree availability	

The full Bayesian Network model produced for Leadbeater's Possum in the Central Highlands outlining the states within each of the nodes.

Actions are shown in yellow, threats in orange and blue, local-scale habitat and population variables in green; landscape-scale habitat and population variables in pink and the final asset status of Leadbeater's Possum in tan. The states illustrated in this version are based on the final recommended package of actions.

Protect_HBTs
Buffer_all_large_trees_100m	0
Protect_Z1_8_altered	0
Protect_Z1_10_altered	0
Protect_Z1_12_altered	0
Protect_Z1_8_existing	0
Protect_Z1_10_existing	100
Protect_Z1_12_existing	0

Modify_regeneration
Large_all_coupes	0
Small_half_coupes	100
None	0

Buffer_colonies
Buffer_200m_5yrs	0
Buffer_200m_2yrs	0
Buffer_200m_200cap	100
Buffer_200m_existing	0
No_buffer	0

Buffer_oldgrowth
Yes_100m	100
No_buffer	0

Reserve_additional_habitat
Great_Forest_NP	0
Above_30pcOM	0
Above_50pcOM	0
Above_65pcOM	0
None	100

Provide_future_old_growth
Large_scale_50pc_ash	0
Moderate_scale_30pc_ash	100
None_extra	0

Protect_from_fire
Large_scale_targeted	0
Small_scale_targeted	100
Current	0

Translocate_colonies
Large_scale	0
Small_scale	0
Trial_only	100

Apply_retention_harvesting
Large_100percentHA	0
Moderate_50percentHA	100
Small_30percentHA	0
None	0

Exclude_thinning
Exclude_200m_LBPRes	0
Exclude_100m_LBPRes	0
None	100

Accelerate_hollow_development
Large_scale	0
Small_scale	0
Trial_only	100

Install_nest_boxes
Large_increase	0
Small_increase	100
Current	0

Forest_allocation
Low	16.1
Moderate	57.9
High	26.0

Bushfire
Negligible	31.0
Moderate	37.3
Severe	31.7

Natural_HBT_loss
Negligible	25.8
Moderate	29.4
Severe	44.8

Drought_cycle
Negligible	45.0
Moderate	35.0
Severe	20.0

Thinning_practices
Negligible	20.0
Moderate	49.0
Severe	31.0

Clearfelling_practices
Negligible	19.0
Moderate	47.0
Severe	34.0

Future_supply_of_HBTs
Sufficient	27.5
Marginal	36.5
Insufficient	36.0

Wattle_senescence
Significant	21.7
Insignificant	78.3

Current_habitat_distribution
Good	28.4
Fair	35.9
Poor	35.8

Direct_mortality
Stable	20.9
Moderately_elevated	25.8
Greatly_elevated	53.4

Mid_storey_connectivity
Extensive	35.5
Patchy	35.5
Absent	28.9

Den_site_availability
Sufficient	25.7
Marginal	30.2
Insufficient	44.0

Current_habitat_connectivity
Good	28.0
Fair	36.0
Poor	35.9

Cluster_distribution
Expanding	20.2
Stable	22.9
Contracting	56.9

Cluster_size
Increasing	28.1
Stable	31.7
Declining	40.2

Number_clusters
Increasing	21.6
Stable	20.8
Decreasing	57.6

Asset_status
Good	25.8
Fair	34.0
Poor	40.2