

Consultation Document on Listing Eligibility and Conservation Actions

Gymnobelideus leadbeateri (Leadbeater's Possum)

- 1) the eligibility of *Gymnobelideus leadbeateri* (Leadbeater's Possum) for inclusion on the EPBC Act threatened species list in the Critically Endangered category; and
- 2) the necessary conservation actions for the above species.

Evidence provided by experts, stakeholders and the general public are welcome. Responses can be provided by any interested person.

Anyone may nominate a native species, ecological community or threatening process for listing under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or for a transfer of an item already on the list to a new listing category. The Threatened Species Scientific Committee (the Committee) undertakes the assessment of species to determine eligibility for inclusion in the list of threatened species and provides its recommendation to the Australian Government Minister for the Environment and Energy.

Responses are to be provided in writing either by email to:

species.consultation@environment.gov.au

or by mail to:

The Director
Terrestrial Species Conservation Section
Wildlife, Heritage and Marine Division
Department of the Environment and Energy
PO Box 787
Canberra ACT 2601

Responses are required to be submitted by date.

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General background information about listing threatened species

The Australian Government helps protect species at risk of extinction by listing them as threatened under Part 13 of the EPBC Act. Once listed under the EPBC Act, the species becomes a Matter of National Environmental Significance (MNES) and must be protected from significant impacts through the assessment and approval provisions of the EPBC Act. More information about threatened species is available on the department's website at:

<http://www.environment.gov.au/biodiversity/threatened/index.html>.

Public nominations to list threatened species under the EPBC Act are received annually by the department. In order to determine if a species is eligible for listing as threatened under the EPBC Act, the Threatened Species Scientific Committee (the Committee) undertakes a rigorous scientific assessment of its status to determine if the species is eligible for listing against a set of criteria. These criteria are available on the Department's website at:

<http://www.environment.gov.au/biodiversity/threatened/pubs/guidelines-species.pdf>.

As part of the assessment process, the Committee consults with the public and stakeholders to obtain specific details about the species, as well as advice on what conservation actions might be appropriate. Information provided through the consultation process is considered by the Committee in its assessment. The Committee provides its advice on the assessment (together with comments received) to the Minister regarding the eligibility of the species for listing under a particular category and what conservation actions might be appropriate. The Minister decides to add, or not to add, the species to the list of threatened species under the EPBC Act. More detailed information about the listing process is at:

<http://www.environment.gov.au/biodiversity/threatened/nominations.html>.

To promote the recovery of listed threatened species and ecological communities, conservation advices and where required, recovery plans are made or adopted in accordance with Part 13 of the EPBC Act. Conservation advices provide guidance at the time of listing on known threats and priority recovery actions that can be undertaken at a local and regional level. Recovery plans describe key threats and identify specific recovery actions that can be undertaken to enable recovery activities to occur within a planned and logical national framework. Information about recovery plans is available on the department's website at:

<http://www.environment.gov.au/biodiversity/threatened/recovery.html>.

Privacy notice

The Department will collect, use, store and disclose the personal information you provide in a manner consistent with the Department's obligations under the Privacy Act 1988 (Cth) and the Department's Privacy Policy.

Any personal information that you provide within, or in addition to, your comments in the threatened species assessment process may be used by the Department for the purposes of its functions relating to threatened species assessments, including contacting you if we have any questions about your comments in the future.

Further, the Commonwealth, State and Territory governments have agreed to share threatened species assessment documentation (including comments) to ensure that all States and Territories have access to the same documentation when making a decision on the status of a potentially threatened species. This is also known as the '[common assessment method](#)'. As a result, any personal information that you have provided in connection with your comments may be shared between Commonwealth, State or Territory government entities to assist with their assessment processes.

The Department's Privacy Policy contains details about how respondents may access and make corrections to personal information that the Department holds about the respondent, how respondents may make a complaint about a breach of an Australian Privacy Principle, and how the Department will deal with that complaint. A copy of the Department's Privacy Policy is available at: <http://environment.gov.au/privacy-policy>.

Information about this consultation process

Responses to this consultation can be provided electronically or in hard copy to the contact addresses provided on Page 1. All responses received will be provided in full to the Committee and then to the Australian Government Minister for the Environment.

In providing comments, please provide references to published data where possible. Should the Committee use the information you provide in formulating its advice, the information will be attributed to you and referenced as a 'personal communication' unless you provide references or otherwise attribute this information (please specify if your organisation requires that this information is attributed to your organisation instead of yourself). The final advice by the Committee will be published on the department's website following the listing decision by the Minister.

Information provided through consultation may be subject to freedom of information legislation and court processes. It is also important to note that under the EPBC Act, the deliberations and recommendations of the Committee are confidential until the Minister has made a final decision on the nomination, unless otherwise determined by the Minister.

Gymnobelideus leadbeateri

Leadbeater's Possum

Taxonomy

Conventionally accepted as *Gymnobelideus leadbeateri* McCoy, 1867

Species/Sub-species Information

Description

Leadbeater's Possum is a small, nocturnal, arboreal possum. It has a prominent dark brown stripe along its back and is pale underneath. Its ears are thin, large and rounded and it grows up to 17 cm in length. Its thick tail grows to 18 cm in length (Strahan 1988; Cronin 1991).

Distribution

Leadbeater's Possum is endemic to Victoria.

Leadbeater's Possum consists of two genetically-distinct subpopulations that have historically occupied different habitats (Hansen et al. 2009). An outlier 'lowland population' is located at Cockatoo Swamp near Yellingbo (Smales 1994) within 181 ha of lowland floodplain forest where less than 20 hectares provides suitable habitat (D. Harley 2014, pers. comm., cited in Department of Environment and Primary Industries (2014)). The small subpopulation is a surviving remnant of a lowland subpopulation that has historically been, and remains, isolated from others (Hansen et al. 2009). The Yellingbo population occurs at 110 m elevation (Harley 2004).

The core location of the species is an area of approximately 70 x 80 km in the Central Highlands of Victoria at altitudes between 400–1,200 m above sea level (Lindenmayer et al. 1989) where it is patchily distributed (Macfarlane et al. 1997) and occupies montane ash forest and subalpine woodland comprising *Eucalyptus regnans* (Mountain Ash), *Eucalyptus delegatensis* (Alpine Ash), *Eucalyptus nitens* (Shining Gum) and *Eucalyptus pauciflora* (Snow Gum). Prior to the 2009 fires, the greatest numbers were considered to occur at Lake Mountain, Mt Bullfight, and Mt Baw Baw.

Fossils and historical records indicate that the species was more widely distributed in the past (Lindenmayer et al. 1991b; Bilney et al. 2010). It was once distributed from Mt Willis in north-eastern Victoria to the Yarra Valley near Melbourne, and south to the Westernport region (Department of Environment and Primary Industries 2014). Leadbeater's Possum has always been considered a rare species (Smith 1984) and the scarcity of specimens, together with the clearing in the late 1800s of areas thought to be its only habitat, led to the belief that the species was extinct (Rawlinson & Brown 1977; Smith 1984). Specimens were collected after the 1960s in new localities in the Central Highlands ((Wilkinson 1961; Rawlinson & Brown 1977).

Recent survey work by the Arthur Rylah Institute, Department of Environment, Land, Water and Planning, has shown Leadbeater's Possum to be distributed widely across the Central Highlands (Nelson et al. 2017) but has demonstrated that an earlier occupancy model (Lumsden et al. 2013) while effective at identifying broad population strongholds, was less effective in finer scale predictions. A recent species distribution model identified a relatively wide area of suitable habitat, with highest probability of occurrence of Leadbeater's Possum around the Baw Baw Plateau and Lake Mountain areas (Taylor et al. 2017).

Cultural Significance

Leadbeater's Possum is the faunal emblem of the state of Victoria.

Relevant Biology/Ecology

Leadbeater's Possums live in small groups of between two to twelve individuals containing one breeding pair, and shelter in tree hollows during the day (Lindenmayer 1996). Colonies live in territories that contain multiple den sites (Lindenmayer & Meggs 1996). Female dispersal is greater than male dispersal (Smith 1984) and females are subject to higher rates of mortality. Among young adults, males outnumber females by three to one (Lindenmayer 1996) and the general adult population is thought to have a sex ratio approaching 3:1 (Smith 1984).

Breeding is limited by the number of mature females (Lindenmayer 1996). Observations of mating behaviour in captivity suggest that Leadbeater's Possum is strictly monogamous, that only one adult male per colony is reproductively active (Smith 1984) and colonies typically contain only a single adult female (Smith 1984; Harley & Lill 2007), although other studies have found colonies with two breeding females (Lindenmayer & Meggs 1996). Breeding females reproduce twice per year and mean litter size is approximately 1.5 (Smith 1984; Harley & Lill 2007). Adult longevity is approximately ten years and age at first breeding is typically two years (Lindenmayer et al. 1993; Lindenmayer & Possingham 1995). Generation length ($[\text{longevity} + \text{age at maturity}]/2$) for Leadbeater's Possum is six years.

Leadbeater's Possum habitat is usually defined as montane ash forest dominated by Mountain Ash, Alpine Ash and Shining Gum with a dense understorey of *Acacia* and an abundance of large hollow-bearing trees. The species also inhabits sub-alpine woodland dominated by Snow Gum containing a dense midstorey of mountain tea tree (*Leptospermum grandiflorum*) along drainage lines (Jelinek et al. 1995) or forest dominated by mountain swamp gum (*Eucalyptus camphora*) with a dense midstorey of *Melaleuca* and *Leptospermum* species (Smales 1994).

Colonies live in territories of 1–3 ha that contain multiple den sites and are actively defended from neighbouring colonies (Lindenmayer & Meggs 1996). Leadbeater's Possum is typically sedentary and territorial, with resident animals travelling between den trees and feeding areas, or between alternative den trees (Smith 1984; Lindenmayer & Meggs 1996; Lindenmayer et al. 2017b) with the distance between a set of nest sites used by a colony possibly exceeding 100 m (Lindenmayer & Meggs 1996; Lindenmayer et al. 2017b). The species appears to have long-term site fidelity (Lindenmayer et al. 2013a).

Leadbeater's Possum may be a central place forager. Nest trees are spaced close to the centre of a relatively exclusive home range (Smith 1984), and linear strips of habitat (e.g. 80 m) may be insufficient for their social and dietary requirements (Lindenmayer et al. 1994).

Leadbeater's Possums feed on carbohydrate-rich plant and insect secretions (e.g. sap, manna, honeydew) and invertebrates (Smith 1980; Smith 1984). In montane ash forest, the species has been recorded incising acacias and feeding on the gum that exudes into the wound (Smith 1980). Smith (1980) also highlighted the dietary importance of an undescribed species of tree cricket. Paperbarks and tea trees may also be incised in lowland swamp forest.

Tree hollows are a critical resource for Leadbeater's Possum and the species' abundance is positively correlated with hollow availability (Lindenmayer et al., 1991a). The majority of trees occupied by Leadbeater's Possum are dead hollow-bearing trees. Living hollow-bearing trees are also used and become the next cohort of dead hollow-bearing trees in the future (Lindenmayer et al. 2013a). Leadbeater's Possum rarely descends to the ground and is highly reliant upon dense, continuous vegetation with interconnecting lateral branches and/or high stem density (Lindenmayer 1996).

The key attributes of Leadbeater's Possum habitat across all forest types are:

- Large, hollow-bearing trees (for nest sites and refuge) with large internal dimensions in the order of 30 cm in diameter, (Lindenmayer et al. 2013a). Trees of this size are usually >150 years old.
- Density of hollow-bearing trees is recognised as a critical habitat feature (e.g. Department of Environment and Primary Industries (2014)). There are strong and

quantified links between the abundance of hollow-bearing trees and the occurrence of Leadbeater's Possum (Lindenmayer et al. 1991a; Lindenmayer et al. 1994), with nest hollow availability the limiting factor to population size.

- Predominance of smooth-barked eucalypts (with loose bark hanging in strips providing shelter for insect prey and material for nests) or gum-barked eucalypts (related to foraging behaviour) (Lindenmayer 1996; Harley 2004). Forest types of Leadbeater's Possum are most commonly ash forest typically dominated by Mountain Ash, Apine Ash and Shining Gum but it is also known to occur in subalpine woodlands and lowland swamp forest dominated by Snow Gum or Mountain Swamp Gum respectively (Smith & Harley 2008).
- A structurally dense interlocking canopy or secondary tree layer of continuous interconnecting structure (to facilitate movement)(Lindenmayer 1996; Harley 2004), and
- A wattle understorey (providing food) (Smith 1980; Lindenmayer 1989).

Leadbeater's Possums do not occur on burned sites, including those subject to low and moderate severity fire, clear-fell logged, or regenerated montane ash forest where hollow-bearing trees are largely absent (Lindenmayer et al. 2013b; Lumsden et al. 2013) until required conditions have returned.

Habitat of the lowland population is different to that throughout the possum's core range of montane ash forest (Harley et al. 2005). The lowland population occupies lowland swamp forest of varied densities of Mountain Swamp Gum with *Melaleuca* spp or *Leptospermum* spp in the middle-story. Densities of Leadbeater's Possum are highest in young (e.g., 20–40 years old) stands of forest supporting high stem density. Like the montane population, the lowland population habitat has a predominance of smooth-barked eucalypts (that provide exudates from the trunks), hollow-bearing trees (that provide den sites) and is highly-connected in the middle-story or canopy (Harley et al. 2005). Given the genetic distinction of this population (Hansen et al. 2009), its gene pool may include genes involved in adaptation to a lowland swamp environment, adding to the conservation importance of this population.

Threats

Table 1: Threats impacting Leadbeater's Possum in approximate order of severity of risk, based on available evidence

Number	Threat factor	Threat type and status	Evidence base
1.0	Habitat loss and fragmentation		
1.1	Collapse of hollow-bearing trees	Known current	The majority of Leadbeater's Possum's range is across the Mountain Ash forest of the Central Highlands of Victoria. Within ash forest Leadbeater's Possum is dependent on hollow-bearing trees as a nest resource. Hollows only form in trees from approximately 150 years of age. Most of the Central Highlands was burned in an extensive wildfire in 1939, leaving a limited number of suitable trees standing. As these trees age and collapse, the pool of nesting resources is declining, while the 1939 regrowth trees are not expected to recruit significant numbers of hollow bearing trees until after 2060 (Lindenmayer et al. 2012; Lindenmayer et al. 2013c; Lindenmayer et al. 2017a; Lindenmayer & Sato 2018). The

			rate of collapse of hollow-bearing trees is also influenced by the other main threats listed here, fire and logging (e.g. Lindenmayer et al. 2018).
1.2	Extensive wildfire	known current	<p>Fire results in direct mortality of Leadbeater's Possums (Lindenmayer et al. 2013b) and loss of habitat (extent and fragmentation).</p> <p>The Central Highlands have a history of occasional extensive wildfires. The 1939 fire burned most of the potential Ash habitat of Leadbeater's Possum (Lindenmayer & Ough 2006) so that currently approximately 98% of the Mountain Ash ecosystem is <80 years old (Lindenmayer & Sato 2018). Thirty six per cent of the potential ash forest habitat was burnt in 2009 (Lumsden et al. 2013). Lumsden et al. (2013) noted that over the last century, bushfires have occurred in the Central Highlands on average every ten years.</p> <p>The frequency and intensity of wildfires are likely to increase under climate change scenarios, which predict increased rates of extreme climatic events (Lumsden et al. 2013; Baker et al. 2017). The last decade has seen a significant and measurable increase in the number, intensity and area burnt by bushfires and projections suggest that this will continue to escalate (Emergency Management Victoria 2014).</p>
1.3	Logging	Known current	<p>Clear-felling is currently the conventional form of logging in Victorian Mountain Ash forests (VicForests 2015). Clear-felling is a method of harvesting a coupe in which all merchantable trees, apart from those to be retained for wildlife habitat, are removed in a single operation. In the Central Highlands, harvesting predominantly involves clear-felling in coupes averaging 16.5 hectares (Attiwill et al. 2013). A 'regeneration' or 'slash burn' fire is then usually undertaken of the debris (logging slash) before sowing takes place (Attiwill et al. 2013; VicForests 2015). Hollow-bearing trees retained for 'wildlife habitat' are of little immediate habitat value to Leadbeater's Possum when there is no surrounding foraging habitat, but may be used when surrounding foraging habitat vegetation and structure is regrown (i.e. 10-20 years (Lumsden et al. 2013)).</p> <p>It should also be noted that the added exposure to wind and drying can increase mortality and collapse rates not only of</p>

			<p>habitat trees left during the clearing, but also of trees in adjacent unlogged patches (Lindenmayer et al. 1997; Lindenmayer et al. 2016; Lindenmayer et al. 2018).</p> <p>The amount of logging to occur is determined by the VicForests and has been reduced in recent years due to a policy of applying a 200m radius protection zone around new detections of Leadbeater's Possums within the harvestable area (VicForests 2017).</p>
1.4	Climate change	Suspected future	<p>Climate change may have a range of effects. The potential for increasing frequency and intensity of fires is noted above.</p> <p>Other effects may include reduced productivity of Mountain Ash and reduced recruitment. Stand density is expected to be reduced by approximately 15% by 2080 and the area of the Central Highlands suitable for natural regeneration may be reduced by up to 80% (Baker et al. 2017).</p>
2.0	Invasive species		
2.1	Predation by Feral Cats	suspected current	<p>Feral Cats are known to prey on the species (McComb et al. in press) however it is difficult to estimate the overall impact.</p>
2.2	Competition for nest hollows with Sugar Gliders (<i>Petaurus breviceps</i>)	suspected current	<p>Sugar Gliders are similar size to Leadbeater's Possum and also nest in hollows. They are increasing in abundance in Mountain Ash forest and thus may exclude Leadbeater's Possums from critical nesting resources.</p>

Assessment of available information in relation to the EPBC Act Criteria and Regulations

Criterion 1. Population size reduction (reduction in total numbers) Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4			
	Critically Endangered Very severe reduction	Endangered Severe reduction	Vulnerable Substantial reduction
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3, A4	≥ 80%	≥ 50%	≥ 30%
A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased. A2 Population reduction observed, estimated, inferred or suspected in the past where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible. A3 Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [(a) <i>cannot be used for A3</i>] A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.	based on any of the following (a) direct observation [<i>except A3</i>] (b) an index of abundance appropriate to the taxon (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat (d) actual or potential levels of exploitation (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites		

Evidence:

Outline of approach

Assessment against this criterion is possible for the past (Criterion 1A2) for both direct observation of possum densities (Criterion 1A2(a)) and using the abundance of the key nesting resource, hollow bearing trees, as an index of abundance appropriate to the taxon (Criterion 1A2(b)). Given the substantial research work that has been undertaken into the rates of transition of hollow bearing trees from one form to another, and through to collapse, the status of Leadbeaters Possum can also be assessed against criteria 1A3(b) and 1A4(b) using hollow bearing trees (HBT) as the index of possum abundance.

It should be noted that criterion 1A4 uses a moving window of three generations, and IUCN guidance is that the particular window should be chosen to provide the maximum estimate of reduction (IUCN Standards and Petitions Subcommittee 2017). Similarly, if a species is shown to be eligible for listing against more than one of these sub-criteria, the appropriate designation is the highest level.

Assessment against Criterion 1A2(a) (direct observation)

The relevant assessment period for this sub-criterion is **2000-2018**. The ANU research group have been monitoring possums directly since 1997 on a large number of long term field sites, each of one hectare. This is the only longitudinal dataset of appropriate scale for this assessment. The presence or absence of possums on these sites has been recorded annually since 1997 (Lindenmayer et al. 2011; Lindenmayer et al. 2017a), using the stag-watching method (Seebeck et al. 1983; Smith et al. 1989).

Analysis of the long term monitoring data has recently been published showing a decline in Leadbeater's Possum across all the ANU sites over the relevant time period of approximately 60% (Blair et al. 2017; Lindenmayer & Sato 2018). There is a decline in the proportion of sites where possums are observed, from around 20% to around 10% of sites. On top of this effect, there is a decline in the number of sites with hollow-bearing trees, from 166 sites to 139 sites.

The 60% decline is considered to be a low end estimate (Lindenmayer 2017), in part because sites with no hollow bearing trees are no longer surveyed, thus reducing zeros and inflating the later estimates. Additionally, these data come from the set of sites selected on the basis that they were high quality habitat. As possum occurrence is more likely in such habitats, the decline seen in these sites is likely less than is occurring across the broader landscape (Lindenmayer 2017).

Importantly, the surveys include sites that were burned in 2009 and thus represent the effects of the fire but the sites have not been logged (Lindenmayer 2017). Approximately 1000 ha/year has been harvested since 2000 (VicForests 2014) and thus the loss of habitat to logging adds an additional 10% decline in the possum population (explained in detail under Criterion 1A2(b) below). The directly observed decline of Leadbeater's Possum is thus at least 64% in the Mountain Ash forests (60% decline x 90% habitat + 100% decline x 10% habitat).

An additional 8,483 ha (4% of combined total) of potential habitat is Snow Gum woodland (Leadbeater's Possum Advisory Group 2014). Assuming that a similar proportion burned in 2009, but was not logged, the adjusted total estimated decline is at least 62.8% (64% x 96% + 35% x 4%) and is likely higher given the biases noted above.

Therefore the Committee considers that the above data appear to demonstrate that Leadbeater's Possum is eligible for listing as Endangered under Criterion 1A2(a).

However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Assessment against Criteria A2(b), A3(b), A4(b) (index of abundance appropriate to the taxon)

Hollow bearing tree abundance as an index of abundance of Leadbeater's Possum

Here the Committee reiterates that it is not attempting to estimate population size of Leadbeater's Possum, nor the trend in population size, directly. In that regard, the size of the population *per se* is not important in the context of this criterion if it can be shown that a critical resource is declining in a manner likely to produce a matching decline in population size.

There are abundant data to show that Leadbeater's Possum is dependent on hollows in old trees (Smith & Lindenmayer 1988; Lindenmayer 1989; Lindenmayer et al. 1991a; Lindenmayer & Meggs 1996; Lindenmayer et al. 2011). Leadbeater's Possum occurrence/abundance typically shows a decline in density or probability of occurrence of possums when the density of hollow bearing trees decreases (Lindenmayer et al. 1991a; Lindenmayer et al. 1994) with that decline accelerating as HBT density becomes lower (Figure S3 Lindenmayer and Sato 2018 Supplementary material). Leadbeater's Possums show preferences for hollows in old, dead trees rather than hollows in living trees but may be forced to use hollows in living trees with increasing concentrations of several arboreal marsupial species competing for a reduced number of hollows (Lindenmayer et al. 2011). Thus, initial losses in HBT density may not be matched by a corresponding decline in the probability of possum occurrence. Nevertheless, such a compensatory response is limited and as the number of hollow bearing trees continues to decrease, decline will inevitably occur in the Leadbeater's Possum population. Because of the potential breakdown in tree form preferences, the assessments that follow are applied to hollow bearing trees overall, rather than the nominally preferred forms (which are considerably more limiting).

The Committee has hereafter adopted the approach of treating all Mountain Ash forest and Snow Gum woodland within the species' range in the Central Highlands as potential habitat as per Leadbeater's Possum Advisory Group (2014) with 204,400 hectares available in 2000 (3 generations ago) (VicForests 2014). 96% of that total is ash forest (Leadbeater's Possum Advisory Group 2014). Adopting this broader approach has the advantage of being able to directly apply estimates of loss to fire and logging to estimate proportional loss, as both are typically not subdivided according to Leadbeater's Possum habitat quality categories. Overall,

the assessment of the trend in the population of Leadbeater's Possum is an assessment of the trend in their critical nesting resource, hollow bearing trees. There are no data on the decline or otherwise of nesting resources in Snow Gum woodland and it is not subject to logging, and thus the effects of fire are the only source of potential decline addressed in this assessment.

The Committee notes here that the discussion that follows focusses on the population of Leadbeater's Possum in the Mountain Ash forests and Snow Gum woodlands and does not reference the lowland population of Leadbeater's possum at Yellingbo Nature Conservation Reserve. Data collected between 1995 and 2004 indicated that the size of the population over that period was stable at 80–100 individuals (Harley et al. 2005). The number of individuals recorded peaked at 112 at 2003. At 2012 the number had dropped to 60 individuals (Harley & Lindenmayer 2013) and in 2014 to only 40 individuals. This is a decline of approximately 64%. The Committee notes that this is a robust estimate of decline, but that the Yellingbo population is so small relative to that of the Mountain Ash forests and Snow Gum woodlands that it has little numerical influence over the assessment against this criterion.

Assessment under Criterion 1A2(b)

The relevant assessment period for this sub-criterion is **2000-2018**. The overall decline in hollow bearing trees is a combination of the ongoing decline of trees due to natural decay (hereafter referred to as ambient decline) and the effects of fire and logging.

The collapse rates of hollow bearing trees have been estimated a number of times, based on multiple surveys of trees which began in the 1980s (e.g. Lindenmayer et al. 1997, 2011, 2012, Lindenmayer and Sato 2018). However, the ambient rate of decline has changed during that time and for conciseness only rates estimated for the relevant periods are included here (Table 2). There are no estimates of the abundance of hollow bearing trees for the specific years relevant to this assessment (2000 and 2018) and thus it has been necessary to extrapolate them from the available data. Two key studies (Lindenmayer et al. 2012, Lindenmayer and Sato 2018) (Table 2) provide the most recent estimates of ambient decline and also include the effects of the 2009 fires. The relevant figure from Lindenmayer and Sato (2018), Figure 1, is reproduced below as Figure 1.

As referred to above, the fires in 2009 had a substantial effect on the availability of hollow-bearing trees in the Mountain Ash forest. Thirty four per cent of the potential Mountain Ash forest and Snow Gum woodland habitat was burnt in the Black Saturday fire (Leadbeater's Possum Advisory Group 2014). Surveys after the fire showed that Leadbeater's Possum were effectively absent on burned sites, and reduced even on unburned sites adjacent to areas burnt (Lindenmayer et al. 2013b; Lumsden et al. 2013).

Additionally, approximately 19,000 hectares were harvested for logging between 1997 and 2014 (Lindenmayer et al. 2014). The rate of clearing is relatively consistent between years (although it spiked in 2009/10 due to salvage logging after the 2009 fires)(Leadbeater's Possum Advisory Group 2014) and thus an approximation of 20,000 ha harvested can be made for the relevant three generation time span (2000-2018).

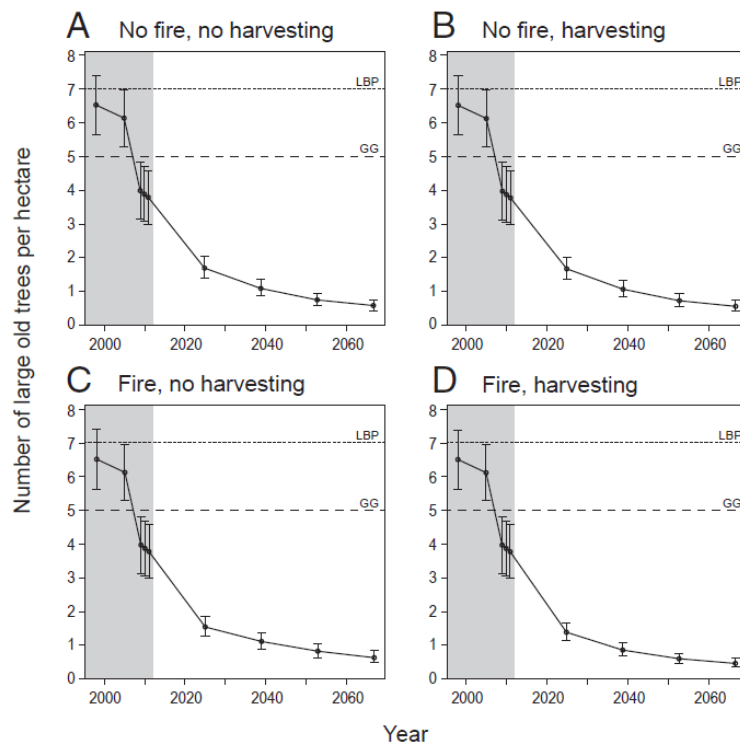


Figure 1 (=Figure 1 Lindenmayer and Sato 2018). Temporal changes in the existing abundance and projected future abundance of large, old-cavity trees in the Mountain Ash ecosystem in response to fire and logging. The horizontal lines on each diagram show the approximate number of cavity trees per hectare required to achieve a 0.4 probability of the occurrence of these species [seven trees per hectare for Leadbeater's Possum (LBP) and five trees per hectare for the Greater Glider (GG)].

Table 2. Estimated rates of collapse of hollow bearing trees from studies of the Mountain Ash forests, used to estimate decline over the period of time relevant to Criterion 1A2(b). Where available, annual rates are those quoted directly in the text. Otherwise, rates of decline are estimated as indicated for each row.

Note that observations spanning 2009 include the effect of the 2009 fires. No observations include logging.

Times/Time period of direct measurement	Observed decline (time span)	Annual rate of decline (assumed approximately exponential)	Estimated Decline 2000-2018 (3 Leadbeater's Possum generations)	Reference
1993-2007	27% (14 years)	2.2%	33% (ambient)	Lindenmayer and Wood (2010)
1997,2006	13.6% (9 years)	1.8%	28% (ambient)	Lindenmayer et al. (2011)
1997,2006, 2009, 2010, 2011	39% (14 years) ^a	3.42% (2000-2011), 2.52% (2011-2018)	43% (ambient + fire)	Lindenmayer et al. (2012)
1997,2006, 2009, 2010, 2011	39% overall, 49.6% burnt areas, 29.6% unburnt areas (14 years) ^b	2.47% unburnt areas only (2000-2011) 2.52% all areas (2011-2018)	45.9% ^c (ambient + fire)	Lindenmayer et al. (2012)
1997,2006, 2009, 2010, 2011	40.7% (14 years)	5.6% (2011-2018) ^c	56% ^d (ambient + fire)	Lindenmayer and Sato (2018) – all data read from Figure 1A (above)

^a This paper estimated rates of transition between forms for 1997-2011. Three transition matrices were produced for: unburnt sites; low intensity burn sites, and; high intensity burn sites. Here the rate of decline is estimated by applying the transition matrices as above for 1997-2011, then the unburnt transition matrix to all sites for 2011-2025. Results are then adjusted assuming exponential decline annually.

^b As per ^a but effect of fires treated as a single step-change so not adjusted for exponential change from 1997-2011 to 2000-2014.

^c Estimating using 2.47% decline 2000-2011 for unburned areas, 2.52% from 2011-2018 for entire area.

^d Read from Fig 1A of Lindenmayer and Sato (2018) (see Figure 1 above).

The baseline for the pre-logging figure was 204,400 hectares (Leadbeater's Possum Advisory Group 2014) and thus equivalent to 9.8% decline in Leadbeater's Possum habitat due to logging. Combining the effects of fire and logging an estimated 57.7% would remain. If estimates of ambient decline, excluding fire effects (28-33%: Table 2) are applied to the remaining 57.7%, the overall estimated decline is 58-60% over the relevant three generation period. The calculations are summarised in the box below.

Details of calculations:

- Start with 204,400 ha total habitat (195,517 ha Mountain Ash, 8483 ha Snow Gum)
- less 20,000 ha Mountain Ash logged (90.2% total habitat remaining)
- less 36% fire across Mountain Ash forest and Snow Gum woodland (57.7% total habitat remaining – 112,587 ha Mountain Ash, 5429 ha Snow Gum)
- less 28-33% ambient decline in remaining Mountain Ash forest (40-42% remaining)

Using similar calculations, if estimates of both fire and ambient decline (45.9-56%: Table 2) are combined with the estimated loss of trees due to logging, the overall estimate is 55.7-65.8%.

The decline of hollow-bearing trees, including that due to logging and fire, over the relevant period can also be derived directly from the graphs presented in Lindenmayer & Sato (2018). Figure 1D of that paper (Figure 1D above) shows observed decline 1997-2013 then modelled decline through to 2067. Reading directly from the graph for the values at 2000 and 2018, the decline is 61%.

Therefore the Committee considers that the above data appear to demonstrate that Leadbeater's Possum is eligible for listing as Endangered under Criterion 1A2(b).

However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Assessment under Criterion 1A3(b)

The relevant assessment period for this sub-criterion is **2018 to 2036**.

Potential habitat at 2018 is approximately 186,000 based on the 204,400 ha cited under criterion 1A2 above, logging 2009-2013 and projected logging 2013-2018. In this assessment, the area burned in 2009 is included in estimates of potential habitat, based on the ongoing presence of hollow-bearing trees (albeit reduced number)(Lindenmayer et al. 2012), regrowth of foraging habitat since the fire and increasing records of possums up to three kilometres from the fire edge.

The maximum potential future harvest of Mountain Ash (Snow Gum is not logged) is approximately 40,000 ha, or 22% of the current potential habitat. This estimate is based on the estimate of all forest available for logging from the previous conservation advice and sources therein (Leadbeater's Possum Advisory Group 2014; VicForests 2014; Threatened Species Scientific Committee 2015), less approximate harvest since the estimate was made. The Committee includes this estimate to provide an upper bound on the potential logging, but notes that it is extremely unlikely that this level would be reached.

A more plausible approximation of expected future harvest can be derived from anticipated future areas of harvest provided to the previous assessment (VicForests 2014), adjusted for the revision of the VicForests Resource Outlook (VicForests 2017). Because the Resource Outlook is provided as volume of logs, it is necessary to estimate the conversion to area logged.

In 2013 the estimated available harvest per year was 220,000 m³ of ash sawlog but this has been revised down to 153,000 m³ until 2020/21. From 2020/21 onwards the estimated available harvest per year is 130,000 m³. This estimate is based on a range of regulatory restrictions including the Timber Harvesting Exclusion Zones around identified Leadbeater's Possum records and a projection that the rate of Leadbeater's Possum detections will continue at the current rate for the next 7 years (VicForests 2017). As noted earlier, actual area harvested has been approximately 1,000 ha in recent years. Thus if a future 18,000 ha of harvest is corrected for the reduced Resource Outlook (130,000 m³/220,000 m³), then it is anticipated that overall harvest would be 10,600 ha or approximately 5.7% of existing potential habitat.

Significant bushfires are likely to occur within Leadbeater's Possum habitat within the three generation timeframe. Bushfires are inherently difficult to predict in timing, scale and distribution. Nevertheless, attempts have been made, with perhaps the most relevant by Baker et al. done as part of the 2017 Victorian Environmental Assessment Council Fibre and Wood Supply Assessment Report (Baker et al. 2017; Victorian Environmental Assessment Council 2017). The focus of that work was the valuable timber in the 1939 regrowth forest in the Central Highlands, but the authors noted that the estimates applied to the Central Highlands broadly (Baker et al. 2017). Further, Lindenmayer and Sato (2018) estimate that 98.8% of the Mountain Ash ecosystem is dominated by regrowth that is 80 years old or younger.

Baker et al. (2017) based the model on observed burnt areas during the 20 year periods 1950-70, 1970-90, 1990-2010, noting that the total area burnt within these periods has been

increasing with time. The mean estimate of proportion of 1939 regrowth expected to be burnt in the next 20 years was 20%, with a minimum of 3% and a maximum of 47% (Figure 2), with the risk significantly higher in the northern part of the range. The authors also noted that activities such as planned burns may reduce the extent of fires, but that climate change effects may have the opposite effect.

Baker et al. (2017) also spatially modelled fires using LANDIS-II, concluding that their results highlighted that it is highly unlikely that the entire 1939 resource would be lost over the next 20 years due to the spatial distribution of the resource and varying risk of bushfire across Fire Management Areas. Similar to the result described above, the landscape fire simulation modelling suggested that, on average, 20% of the 1939 ash stands may be affected by fire in the next 20 years with a worst case scenario of ~50% of the resource being impacted.

The previous status assessment of Leadbeater's Possum (Threatened Species Scientific Committee 2015), and recent assessments of the effectiveness of the Leadbeater's Possum Reserve (Todd et al. 2016) and the potential for Mountain Ash ecosystem collapse (Lindenmayer & Sato 2018) also used 50% as maximum extent in future fire scenarios.

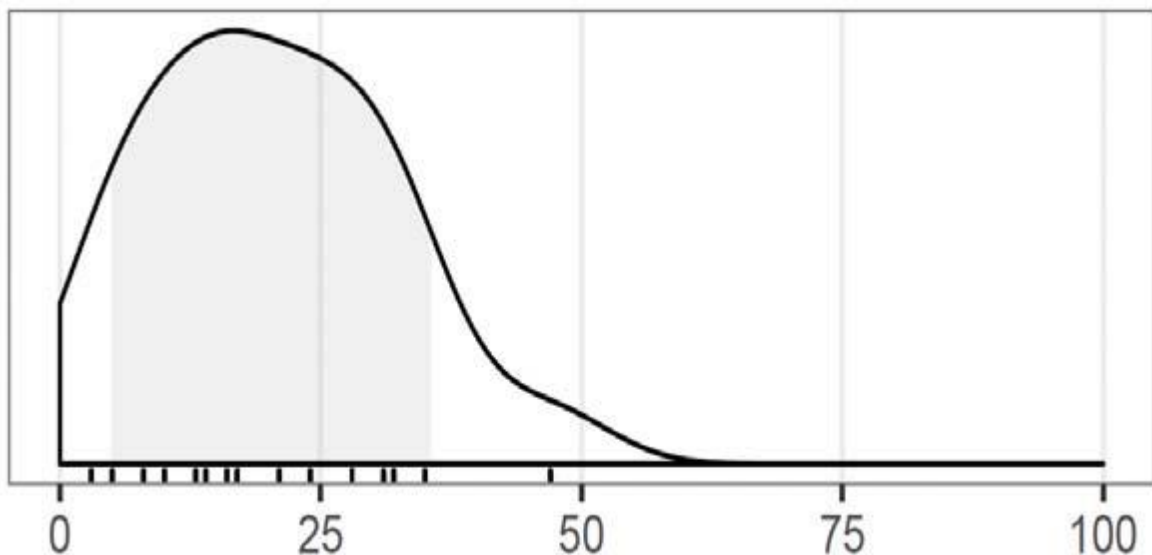


Figure 2. (=Figure 15 from Baker et al. (2017)): Predicted percentage of 1939 ash area burnt over 20 year period (n= 20). The black line is a smoothed probability density curve; the black ticks are the modelled observations; and the shaded area is the 5 to 95 percentile range.

With respect to ongoing ambient rates of hollow-bearing tree collapse, the only data available to address that period are the projections of tree transitions from the ANU research. The most recent publication by that group suggested decline due solely to collapse of hollow-bearing trees of approximately 59% (38-72 95% CI) over the next 18 years (Lindenmayer & Sato 2018)(estimated from Figure 1A above). These are the highest published estimates of rate of decline in hollow-bearing trees to date. Estimates from previous studies (Lindenmayer et al. 2011; Lindenmayer et al. 2012)(Table2) correspond to declines of approximately 35% from 2018 to 2036. The decline of hollow-bearing trees does not apply to the approximately 8,500 ha of snowgum woodland. It is also important to note that projections of the decline in hollow bearing trees are based on observed data to date, and thus cannot formally incorporate the effects of increasing changes in landscape context (Lindenmayer et al. 2018) or factors such as future climate change (Lindenmayer et al. 2012) both of which are expected to accelerate the loss of hollow-bearing trees.

Combining the above estimates, the maximum plausible overall expected decline in potential Leadbeater's Possum habitat over the relevant time period is:

- logging 5.7% of Ash forest (not Snowgum woodland);
- fire 50% (maximum estimate) of Mountain Ash forest and Snow Gum woodland, and;
- collapse of hollow bearing trees 59% (38-72 95% CI) of the unlogged and unburnt remainder of the Ash forest.

Incorporating the error estimates for collapse of hollow-bearing trees (Figure 1A), the future decline is estimated at 79% (70-85%).

Details of calculations:

- Start with 186,000 ha total habitat (177,517ha Mountain Ash, 8483 Snow Gum)
- less 10,600 ha Mountain Ash logged (94% total habitat remaining)
- less 50% fire across Mountain Ash forest and Snow Gum woodland (47.2% total habitat remaining)
- less 59% decline of hollow-bearing trees in remaining Mountain Ash (20.7% total habitat remaining)

The combined model of hollow-bearing tree collapse, logging and an additional fire (approximating the 2009 fire and occurring in the period 2014-2028) provided by Lindenmayer and Sato (2018) (Figure 1D) provides comparative figures of 71% (57-81% CI). However, Lindenmayer and Sato (2018) note, as has the Committee above, that these estimates do not account for demonstrable increases in collapse rate of trees due to fire and logging in the surrounding landscape (Lindenmayer et al. 2018), nor the effect of climate change on drought and increased fire risk or regeneration potential of Mountain Ash (e.g. Baker et al. 2017).

The Committee notes that the cumulative figures above very closely approach the threshold between the Endangered and Critically Endangered category and that only a very small effect of the abovementioned unquantified variables (landscape context, climate change) is necessary to exceed that threshold. Additionally, the Committee notes that the decline in hollow-bearing trees will continue until at least 2060 and that, while a 50% fire has been used as the maximum scenario for modelling purposes, far more substantial conflagrations have occurred in the past. The 1939 wildfires burned up to 85% of the Mountain Ash forest of the Central Highlands (Burns et al. 2015).

Cumulatively, the Committee therefore considers that Leadbeater's Possum appears to have met sufficient elements of criterion 1A3(b) to be eligible for the Critically Endangered category.

However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Assessment under Criterion 1A4(b)

Criterion 1A4 uses a moving window of three generations, and IUCN guidance is that the particular window should be chosen to provide the maximum estimate of reduction (IUCN Standards and Petitions Subcommittee 2017) as explained above.

The last measured observations before the 2009 fires were in 2006 and thus this is an appropriate start time for the **assessment period, 2006-2024**. The baseline estimate for available area of habitat is 198,400 ha (204,400 at 2000 less approximately 6,000 logged to 2006). Snow Gum is 8,483 ha, leaving Mountain Ash baseline habitat 189,900 ha.

Although 36% of Mountain Ash burned in 2009, by 2024 foraging resources will have partly recovered, enabling possums to reinhabit available hollow-bearing trees. However, the number of hollow-bearing trees will have declined as per Lindenmayer and Sato (2018) (70% from

Figure 1A) which incorporates estimation of the hollow-bearing trees remaining standing within the burned areas. However, a future 50% fire, across both Mountain Ash forest and Snow Gum woodland (see Assessment under Criterion 1A3(b) above) would remove that habitat for the remainder of the assessment period.

Logging within the relevant period would be approximately 1000 ha/year from 2006 to 2017, then approximately 600 ha/year 2018-2024, totalling 15,200 ha.

Combined, these total to a decline of approximately 84.7%.

Details of calculations:

- Start with 198,400 ha total habitat (189,900 ha Mountain Ash, 8483 Snow Gum)
- less 15,200 ha Mountain Ash logged (94% total habitat remaining)
- less 50% fire across Mountain Ash forest and Snow Gum woodland (46.2% total habitat remaining)
- less 70% decline of hollow-bearing trees in remaining Mountain Ash (15.3% total habitat remaining)

The Committee therefore considers that Leadbeater's Possum appears to have met sufficient elements of criterion 1A4(b) to be eligible for the Critically Endangered category.

However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Criterion 2. Geographic distribution as indicators for either extent of occurrence AND/OR area of occupancy			
	Critically Endangered Very restricted	Endangered Restricted	Vulnerable Limited
B1. Extent of occurrence (EOO)	< 100 km ²	< 5,000 km ²	< 20,000 km ²
B2. Area of occupancy (AOO)	< 10 km ²	< 500 km ²	< 2,000 km ²
AND at least 2 of the following 3 conditions indicating distribution is precarious for survival:			
(a) Severely fragmented OR Number of locations	= 1	≤ 5	≤ 10
(b) Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals			
(c) Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals			

Evidence:

Significance of surveys since 2014 using new methodology for assessment of Leadbeater's Possum habitat

Since 2014, extensive work has been put into surveying for Leadbeater's Possum, most notably by scientists from the Arthur Rylah Institute, as well as community groups and the logging industry (Department of Environment Land Water and Planning 2017). Large numbers of additional Leadbeater's Possum colonies have been identified and some have construed this as meaning that the Leadbeater's Possum population is much larger than estimated before and that it is therefore more secure or has recovered. The absence of a time series in this dataset

precluded its consideration under Criterion 1. Similarly, the method does not currently allow the generation of a population estimate.

The newer techniques are based on observations of foraging possums. One technique uses call playback to draw in Leadbeater's Possum, a thermal imaging camera to detect them and a white spotlight to make the identification. Over 100 recent sightings have been confirmed by this technique, many by community groups or members of the public (Department of Environment Land Water and Planning 2017). The other technique uses motion-sensitive cameras mounted at elevations of 3-36 m on trees and baited with creamed honey (Nelson et al. 2015). The technique has been refined over time and has a very high probability (>0.80) of detection of possums if they are present (Nelson et al. 2017). Multiple detections across several nights suggests also that at least some possums are resident nearby, rather than transient. Between 2014 and January 2017 346 new colonies were found in State Forest, mostly using these new techniques (Department of Environment Land Water and Planning 2017). The abundance and wide dispersion of the new locations (Department of Environment Land Water and Planning 2017; Nelson et al. 2017) strongly suggests that the amount and connectivity of occupied habitat is more extensive than was previously thought.

It is also notable that the design of the first two years of the Arthur Rylah Institute surveys was deliberately heavily biased. The intent of the surveys in these years (2014/15 and 2015/16) was to identify areas for protection from logging and thus effort was focussed on areas available for logging and in habitats expected to be suitable to Leadbeater's Possum. They do not constitute a representative survey of habitat across the species' range. In contrast, surveys in 2016/2017 were undertaken at randomly selected sites across all tenures and forest ages to enable extrapolation across the whole of the species' range, model the areas most likely to be occupied, and investigate foraging habitat requirements. These data have yet to be fully analysed and the results are not available for this assessment. Despite the lack of formal analysis, it is notable that Leadbeater's Possum were detected at 37% of randomly selected sites across the Central Highlands (Arthur Rylah Institute 2017).

Assessment under Criterion 2

The extent of occurrence and area of occupancy of this species have been estimated based on all sightings for the last 20 years (ERIN 2017). Extent of occurrence is estimated to be 4,084 km². This is restricted under sub-criterion B1.

Area of occupancy based on the IUCN guidance to use a 2 x 2 km grid (IUCN Standards and Petitions Subcommittee 2017) is estimated to be 972 km² which is limited under sub-criterion B2. This value is likely to increase in the future due to the accumulation of new sighting locations.

The IUCN definition of severely fragmented in the context of this criterion is that more than half the individuals must be in small and isolated patches between which there is little or no demographic or genetic exchange (typically less than one successful migrant individual or gamete per year) (IUCN Standards and Petitions Subcommittee 2017). This is difficult to determine in the case of Leadbeater's Possum because it has been evaluated in a number of ways. For example, Lindenmayer *et al.* (2014) note that patches of old growth forest with high densities of hollow bearing trees are small and highly fragmented. The current (as at 2014) 1887 ha area of old growth Mountain Ash forest is distributed across 147 different patches, giving a mean patch size of 12.8 ha. Lindenmayer *et al.* (2014) considered these fragmented patches to be generally likely to support small populations of 20-30 animals (Lindenmayer *et al.* 2014). Similarly, the Leadbeater's Possum reserve is itself a collection of 127 patches greater than 50 ha in size of predominantly old growth forest (Lumsden *et al.* 2013)(although the fact that 45% of the reserve burned in 2009 means much is no longer old growth).

However, the recent surveys by the Arthur Rylah Institute show that possums are distributed over a wide area and in different forest age classes (Nelson *et al.* 2017), suggesting at least that possums can relatively easily move between patches of high quality habitat. Indeed, in modelling the population viability within the Leadbeater's Possum reserve Todd *et al.* (2016)

noted the context of the patches of the reserve as “part of the continuum of habitat available”. Where sampling by Arthur Rylah Institute has been intensive, the distribution of sightings is almost continuous across several kilometres between patches of the reserve, such as the eastern edge of Yarra Ranges (see Figure 3 in Nelson et al. 2017) and in many areas outside the Leadbeater’s Possum Reserve. Genetic analyses also showed considerable admixture across the northern highlands (Toolangi, Mt Margaret, Lake Mountain and Cambarville), but some differentiation from the southern highlands (Powelltown)(Hansen et al. 2009). The Committee also notes in this context the unpublished data from the 2016/17 surveys by Arthur Rylah Institute which were randomly located (and thus not biased by tenure or forest age) had a detection rate of 37% overall. The more recent data suggest that Leadbeater’s Possum is not severely fragmented *sensu* IUCN Guidelines.

This criterion also allows that distribution is precarious for survival if the number of locations is limited. In this context, “location” is a geographically defined area in which a single threatening event can rapidly affect all individuals of a taxon that are present (IUCN Standards and Petitions Subcommittee 2017). The extensive fire history of the Central Highlands suggests that the range of Leadbeater’s Possum can reasonably be considered to be a small number of locations. The 1939 wildfires burned up to 85% of the Mountain Ash forest of the Central Highlands (Burns et al. 2015), while the 2009 fires burned 36% of the potential ash habitat (Lumsden et al. 2013). Baker et al. (2017) suggest a loss of 20% to fire is likely in the next 20 years (and up to 50% or more is possible). The Committee considers that the Central Highlands can reasonably be inferred to be between two and five locations for the purposes of this assessment.

Continuing decline can be projected in quality of habitat. As described in detail under Criterion 1, hollow bearing trees are a critical resource for Leadbeater’s Possum and are subject to ongoing collapse across the Central Highlands (Lindenmayer & Wood 2010; Lindenmayer et al. 2011; Lindenmayer et al. 2012). While this can be a natural process, the fact that extensive areas of the Central Highlands were burned in 1939, killing most trees, means that recruitment of new hollow bearing tree is constrained until approximately 2060 (Lindenmayer & Wood 2010) and this critical resource will become more limited over the intervening period. Additionally, the area of habitat will decline due to the very high likelihood of additional fires and the planned future logging (see detail under Criterion 1).

The Committee considers that the extent of occurrence of Leadbeater’s Possum is restricted, it is found at a restricted number of locations and that continuing decline can be inferred in amount and quality of habitat. Leadbeater’s Possum thus appears to be eligible for inclusion in the Endangered category under criterion 2B1a,b(iii).

However, the purpose of this consultation document is to elicit additional information to better understand the species’ status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Criterion 3. Population size and decline			
	Critically Endangered Very low	Endangered Low	Vulnerable Limited
Estimated number of mature individuals	< 250	< 2,500	< 10,000
AND either (C1) or (C2) is true			
C1 An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future)	Very high rate 25% in 3 years or 1 generation (whichever is longer)	High rate 20% in 5 years or 2 generation (whichever is longer)	Substantial rate 10% in 10 years or 3 generations (whichever is longer)
C2 An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions:			
(i) Number of mature individuals in each subpopulation	≤ 50	≤ 250	≤ 1,000
(a) (ii) % of mature individuals in one subpopulation =	90 – 100%	95 – 100%	100%
(b) Extreme fluctuations in the number of mature individuals			

Evidence:

Three hundred and forty six new colonies of Leadbeater's Possum were found in state forest between March 2014 and 30 January 2017 in surveys of 6-10% of potential habitat (Department of Environment Land Water and Planning 2017). Eighty four new colonies have also been found in parks and reserves (DELWP 2016). Survey efforts by DEWLP/Arthur Rylah Institute have been completed but community groups, VicForests, Zoos Victoria and universities are continuing to find new colonies.

While it has been noted above that a precise estimate of population size cannot be made, some consideration against the broad thresholds of this criterion is possible and necessary. Each new colony is protected by a Timber Harvesting Exclusion Zone (THEZ) of 200 m radius, and any subsequent sighting within that zone is considered to be the same colony (Department of Environment Land Water and Planning 2017). The 200 m THEZ is equivalent to 12.6 ha, which is substantially greater than the average Leadbeater's Possum home range of 1-3 ha (Department of Environment Land Water and Planning 2017) so a single THEZ may cover more than one colony. Nevertheless, the shape of the home range is not necessarily circular and it is possible that if the shape is elongated that part of the home range may not be within the THEZ. Home ranges may also be larger where resources such as hollow bearing trees are less common or where foraging and nesting habitat are spatially separate (Blair et al. 2017). It is possible then that counting the THEZ might either overestimate or underestimate the number of colonies of possums. Noting these concerns, but given that these are the most comprehensive data available to this assessment, the Committee cautiously adopts the following approach:

Three hundred and forty six colonies have recently been found during surveys in 6% of potential habitat, almost exclusively in state forest. If each colony making up the total is assumed to represent a "true" colony, it is equivalent to approximately 20% of the state forest habitat (6% x 142,000 ha potential habitat/43,000 ha state forest). If the sampled sites are reasonably representative of the state forest habitat, there may be 1730 colonies across the state forest (346 x 100/20). The Committee notes that sites chosen for sampling were those expected to have possums present and thus this part of the calculation is likely an overestimate. There is no quantitative adjustment that can be made here, but the Committee uses precaution below in using the low end of the likely range.

Further, If state forest is similar habitat to the parks and reserves, then an additional 3980 colonies ($1730 \times 99,000/43,000$) (total 5700) may be in the parks and reserves (this does not include the area burned in 2009). Typically a colony consists of one adult female and one to three adult males (Smith 1984) but more than one adult female is not uncommon (Lindenmayer & Meggs 1996). Colonies may consist of up to 12 individuals but are more commonly 6-12 and colony sizes have reduced in recent years (DELWP 2016). An estimate of three individuals per colony on average is thus appropriately cautious here. Notwithstanding the considerable uncertainty in these estimates, the population of possums may exceed 10,000 mature individuals, but is more likely in the range 2,500-10,000 which is low. The Committee also notes that unpublished data from the 2016/17 surveys by Arthur Rylah Institute which were randomly located (and thus not biased by tenure or forest age) had a detection rate of 37% overall. The data have not been formally analysed so the Committee considers it inappropriate to use them to generate a formal estimate but notes that they are broadly consistent with a larger population than was previously considered to be the case.

A likely scenario of future decline has been described above for Subcriterion 1A3(b) and 1A4(b). Here the timeframe and threshold vary, but as the decline is consistent and ongoing due to logging and hollow bearing tree collapse (but not fire which is stochastic) they can reasonably be projected for timeframes appropriate to this criterion. A decline of greater than 40% may be projected over a single generation, which is a very high rate.

With respect to Criterion 3C2, Yellingbo is clearly separate, as indicated by genetic differences (Hansen et al. 2009). Genetic analyses also showed considerable admixture across the northern highlands (Toolangi, Mt Margaret, Lake Mountain and Cambarville), but some differentiation from the southern highlands (Powelltown) (Hansen et al. 2009). Todd et al. (2016) defined regional groupings within the Leadbeater's Possum reserve but noted the reserve's context as "part of the continuum of habitat available" (see Criterion 2 above) so these groupings cannot reasonably be considered subpopulations in the context of this criterion. The genetic data suggest three subpopulations. Two of which are likely to be greater than 1,000 individuals. Leadbeater's Possum does not exhibit extreme fluctuations in population size (approximately at least an order of magnitude (IUCN Standards and Petitions Subcommittee 2017)). Therefore it does not meet the eligibility criteria for 3C2.

The Committee considers that the population size is limited and that it is projected to decline at a very high rate. Therefore the data presented above appear to indicate that Leadbeater's Possum is eligible for inclusion in the Vulnerable category under criterion 3C1.

However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Criterion 4. Number of mature individuals			
	Critically Endangered Extremely low	Endangered Very Low	Vulnerable Low
Number of mature individuals	< 50	< 250	< 1,000

Evidence:

As described above under Criterion 3, the Committee considers the population size of Leadbeater's Possum to be between 2,500 and 10,000.

The Committee consider that the population size is not low. Therefore Leadbeater's Possum appears not to be eligible for inclusion in any category under this criterion.

However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Criterion 5. Quantitative Analysis			
	Critically Endangered Immediate future	Endangered Near future	Vulnerable Medium-term future
Indicating the probability of extinction in the wild to be:	≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)	≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)	≥ 10% in 100 years

Evidence:

There have been a number of population viability analyses undertaken for Leadbeater's Possum (Lindenmayer et al. 1993; Lindenmayer & Lacy 1995a, b; Lindenmayer & Possingham 1995). Only one has been undertaken since the 2009 fires (Todd et al. 2016). However, the purpose of the Todd et al. (2016) study was specifically to assess the effectiveness of the Leadbeater's Possum Reserve. The population model was run for 40 generations (200 years) and does not provide specific probabilities within the timeframes specified under this criterion. The figure defined in the paper as being the criterion for success was less than 5% chance of falling below 500 adult females in 40 generations (Todd et al. 2016). The Committee considers that this study differs too greatly from the requirements of this criterion to enable an effective assessment. The model would need to be re-parameterised and re-run to enable its application in this context.

Therefore the data presented above appear to indicate that Leadbeater's Possum is data deficient and thus ineligible for inclusion in any category under this criterion.

However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Conservation Actions

Recovery Plan

A recovery plan was recommended by the Committee in 2015 (Threatened Species Scientific Committee 2015) and this recommendation was accepted by the Minister. The recovery plan is in the advanced stages of preparation. The Committee again recommends a recovery plan be prepared and that the current draft be finalised as soon as possible. The objectives and actions below are drawn from the draft recovery plan.

Conservation objectives

- 1: All relevant existing and future planning and policy settings are reviewed, refined where required and implemented in a manner that contributes appropriately to maximising the chances of long-term survival of Leadbeater's Possum in nature.
- 2: A whole of landscape management regime is in place ensuring that all current and future suitable habitat across the species' known range is maintained, enhanced and effectively managed to maximise its suitability for Leadbeater's Possum.
- 3: Where there is net long-term benefit (i.e. likelihood of increase in overall population viability), translocate individuals or colonies *within* the known range, and maintain a captive breeding colony for the lowland swamp forest subpopulation.
- 4: Seek to locate, or establish, additional populations *outside* the core range of the Central Highlands, and protect any such populations.
- 5: Targeted research addresses key knowledge gaps such that management options are better informed and management actions more effective.
- 6: An integrated monitoring program is effectively implemented and maintained that publicly reports in a timely manner on possum status, existing and future habitat extent, quality and connectivity, and effectiveness of management and research activities.
- 7: Stakeholders support and where relevant are involved in the implementation of recommended actions.

Conservation actions

Conservation and Management priorities

- Review and, where required, revise existing relevant planning and policy settings to ensure that they provide for maximising the chances of long-term survival of Leadbeater's Possum.
- Ensure that future relevant planning and policy settings provide for maximising the chances of long-term survival of Leadbeater's Possum.
- Protect all known colonies of Leadbeater's Possum in state forest, with a timber harvesting exclusion zone around all known (post 1998) verified records.
- Ensure no timber harvesting is permitted in any area of the Central Highlands montane ash forests unless comprehensive pre-harvest surveys (as per the approved Leadbeater's Possum survey standards) demonstrate, with a high level of confidence, absence of Leadbeater's Possum from the prospective harvest area
- Retain and protect, with appropriate buffers, all live and dead trees that are either large (>150 cm DBH) or hollow-bearing (where >80 cm DBH) in montane ash forests within the distribution of Leadbeater's Possum.
- Review the conservation effectiveness of other timber harvesting regulatory prescriptions and related guidelines relevant to the protection of Leadbeater's Possum and its habitat and revise where required.

- Refine and update occupancy and other relevant distributional and population viability modelling, in all land tenures across the full range of the species.
- Undertake landscape scale land-use planning that provides options for conservation of suitable habitat now and in the future to ensure an acceptably high likelihood of persistence (i.e. at least 99% over 100 year period) for Leadbeater's Possum.
- Expand the dedicated reserve system to incorporate sufficient areas of current and future suitable habitat to ensure that it is adequate to maintain and enhance the long-term population viability of Leadbeater's Possum.
- Assess the feasibility, risks and cost-effectiveness of fire management options that seek to deliver long-term, strategic and landscape scale enhancement of the extent, quality and connectivity of current and future suitable habitat.
- Develop and implement fire management that effectively secures and promotes long-term, strategic and effective protection of known colonies and suitable habitat.
- Develop a priority suite of responsive actions designed to maintain or recover populations as rapidly as possible after extensive bushfire.
- Where research on habitat augmentation (including the provision of nest boxes, artificially excavated hollows, and manipulation of mid-storey) demonstrates that benefits can be obtained effectively, strategically implement these mechanisms to enhance the current and future extent of suitable habitat in the Central Highlands.
- Enhance current and future habitat suitability and extent of swamp forest habitat for the lowland subpopulation.
- Identify priority areas within the known range to which translocations may provide benefit to the possum's population viability. Assess the risks, potential impacts upon existing subpopulations, benefits, likelihood of success, and cost-effectiveness of translocation options. Develop appropriate protocols for translocation.
- Assess the risks, benefits, practicality, cost-effectiveness and consequences of 'gene pool mixing' to increase the viability of the lowland subpopulation.
- Where actions indicate likelihood of net benefit, undertake carefully monitored trial translocations, and – if successful – extend translocations to other priority areas.
- Maintain a captive breeding population for the lowland swamp forest subpopulation to act as insurance and potential source for local translocations.
- Using recently developed survey approaches, survey potentially suitable areas (in Victoria) outside the currently known range, including in areas predicted by habitat modelling to provide suitable habitat and/or where there are previous verified and plausible unverified records.
- If such surveys locate 'new' existing populations (beyond the Central Highlands), assess their status, population size, genetic affinities, habitat relationships, extent of suitable and future habitat and management requirements; and implement appropriate management actions and prescriptions.
- If such surveys fail to locate existing populations, identify the most suitable candidate areas (in Victoria) for potential translocation.
- Assess the welfare risks, likelihood of success, cost-effectiveness, and potential impacts upon existing populations of translocations to those areas outside the current range considered most practical and likely to result in the establishment of new viable subpopulations. If considered to have significant benefits, implement such translocations.
- Establish appropriate governance and protocols to be able to respond to emergency events, such as significant losses of possums to extensive bushfire.

Stakeholder Engagement

- Establish (or build from existing mechanisms) and maintain an effective and fit-for-purpose recovery team or similar governance model with clear, explicit and practical terms of reference to oversee coordination and implementation.
- Enhance the community's involvement in Leadbeater's Possum recovery.
- Provide enhanced opportunities for the participation of Indigenous groups in research, monitoring and management.
- Raise awareness of Leadbeater's Possum and its conservation among the general public.
- Promote and publicise conservation effort for Leadbeater's Possum.

Survey and Monitoring priorities

- Maintain, enhance or develop new monitoring programs to ensure an integrated monitoring and survey program across all tenures and management zones and develop an effective public reporting of monitoring results.
- Collate existing monitoring data and programs that assess trends in abundance and incidence of Leadbeater's Possum, extent and suitability of habitat (including key habitat attributes, such as the abundance of hollow-bearing trees), and management effectiveness.
- Identify key trigger events (e.g. future widespread fires) or thresholds in monitoring results that would catalyse priority emergency response (and identify such emergency response options).
- Where translocations are proposed, design translocation trials in a manner that allows for reporting on success or failure, and those factors that contribute to this fate. Monitor those trials, and use results to refine the efficacy of translocation protocols, or to assess critically whether they are of net benefit.
- Monitor the extent of success (including cost-effectiveness and collateral benefits) of management actions individually and collectively, and use such information as appropriate to refine actions.

Information and Research priorities

- Establish an ongoing research forum to enhance existing collaboration among researchers, and between researchers, managers and other interested parties, to make the most effective use of research actions and to identify and address any further key knowledge gaps.
- Undertake research that provides more robust knowledge of key demographic and other ecological characteristics of Leadbeater's Possum relevant to conservation management, specifically including population size, subpopulation structuring, dispersal characteristics, social systems, and home range size. This should include research
 - aimed at increasing the likelihood of success of translocations, such as to establish the number, age, provenance (e.g. wild-caught or captive-bred) and social relationships of animals that can be used to maximise success and enhance site fidelity post-release in order to reduce dispersal-related mortality.
- Investigate key aspects of the post-fire ecology of Leadbeater's Possum, especially in relation to the 2009 bushfires. This research should include at least
 - (i) assessment of current hollow availability and the importance of large dead and any live hollow-bearing trees in the burnt landscape;
 - (ii) investigation of hollow development within trees that were 1939 regrowth before being burnt, to determine their potential to provide denning sites into the future;
 - (iii) investigation of the persistence of colonies within fire refuges surrounded by burnt areas, to determine if they will be effective sources for natural recolonisation or

if translocations will be required to accelerate recolonisation of the regenerated burnt areas; and

- (iv) monitoring of rates of natural recolonisation of forest regrowing after fire
- Design and implement clearly-defined experimental trials that rigorously assess the relative benefits of forest management prescriptions, actions and other options, in a manner that allows results to inform ongoing refinement of those prescriptions and recommended conservation actions. Such research should explicitly include an assessment of the conservation effectiveness and resilience of buffers of various sizes around colonies, and retained large and hollow-bearing trees.
- Assess the practicality and effectiveness of habitat augmentation actions including the provision of nest boxes, artificially excavated hollows, and manipulation of mid-storey to accelerate the development of key habitat features.

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Collective list of questions – your views

1. In published papers, variable estimates of the probability of Leadbeater's Possum occurrence (ranging from $p=0.3$ to $p=0.5$) to have been used to define 'suitable habitat'. Can you provide comment or data to determine an appropriate level of probability of occurrence to define suitable habitat? Please provide justification for your suggestion.
2. Throughout the draft conservation advice, the decline in the abundance of hollow-bearing trees is modelled on the basis that this is a critical limiting resource. The assumption is that the possum population will track the availability of hollow bearing trees. Do you believe this to be appropriate? Are you able to provide comment or data on matters such as non-linearity, threshold effects etc.? For example, is there a minimum density (above zero) at the landscape scale at which Leadbeater's Possum cannot persist?
3. Do you accept the approach of modelling hollow-bearing tree decline used in the document? If not, can you offer suggestions on how it can be improved/refined? If you cannot, is there an alternative approach that can be used?
4. Do you accept the estimates of future timber harvesting used (in Criteria 1A3 and 1A4)? If not, can you provide additional or alternative information?
5. Do you accept the estimates of future fire used (in Criterion 1A3)? If not, can you provide additional or alternative information?
6. Do you accept the estimated past decline in Leadbeater's Possum in the 3 generation period 2000-2018 under Criterion 1A2? If not, please suggest whether you believe it to be an overestimate or underestimate and give your reasoning.
7. Do you accept the estimated future decline in Leadbeater's Possum in the 3 generation period 2000-2018 under Criteria 1A3 and 1A4? If not, please suggest whether you believe it to be an overestimate or underestimate and give your reasoning.
8. Are you able to provide an estimate of the additional effects of landscape context and/or climate change on the rate of tree collapse within the time period relevant to Criterion 1A3?
9. Do you accept the broad estimate of Leadbeater's Possum population as outlined in Criterion 3? If not, please suggest whether you believe it to be an overestimate or underestimate and give your reasoning.
10. Do you have data on Leadbeater's Possum distribution outside accepted range limits of the Central Highlands. If so, can you quantify the extent of that area and/or the density of possums in that area? Please also describe the methods used in collecting those data.