Independent Review Report

Assessment of the conservation benefit provided to Leadbeater's Possum by the establishment of Timber Harvesting Exclusion Zones

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Summary

This report provides an independent assessment and review of a June 2017 report by the Department of Environment, Land, Water and Planning (DELWP) on the extent to which the establishment of a set of Timber Harvesting Exclusion Zones (THEZ) has provided a conservation benefit to the threatened Leadbeater's Possum *Gymnobelideus leadbeateri*. I conclude that the DELWP report appropriately documents the assumptions underlying its assessments, undertakes appropriate analyses and interprets its findings fairly and reasonably.

Largely as documented in the DELWP report, the main conclusions of my assessment are that:

1. A very substantial survey effort since 2014 by DELWP and the community has resulted in the discovery of far more confirmed locations for Leadbeater's Possums than previously known.
2. 436 of these locations are in State Forest and the possum colonies at these sites have now been protected by the establishment of 200 m radius (i.e. 12.6 ha) THEZs. This represents some conservation success: without such survey effort and protection, many of these possum colonies may have been destroyed unwittingly in the process of timber harvesting.
3. The total area of State Forest now protected through THEZs is ca. 40 km^2. This is an important contribution but represents only a very small proportion (ca. 2 to 4%) of the potential habitat of the species.
4. Notwithstanding the very considerable survey effort, to date only about 6-10% of the possum's potential habitat has been surveyed. Hence, most colonies probably remain undiscovered and many to most remain unprotected.
5. Notwithstanding much research and survey conducted on Leadbeater's Possum over many years, there remain some pivotal information gaps. There is notable uncertainty about the possum's total population size, and about the number of possums (or possum colonies) that are likely to occur within a single THEZ, or across the set of THEZs. This renders it particularly challenging to estimate the relative proportion of (possums protected in THEZs)/(total number of possums). Without such information on the relative proportion of the total Leadbeater's Possum population that is contained within the THEZ network (or in the broader reserve system), it is difficult to provide a robust estimate of the relative contribution of the THEZ strategy to the conservation and recovery of the species.
6. The likelihood of persistence of Leadbeater's Possums within THEZ is uncertain. While possum colonies are known (by definition) to be present in all THEZs now, they may not persist into the future as critical resource features (particularly hollow-bearing trees) decline within THEZs, and with some likelihood of episodic bushfire. Longer-term persistence of possum populations in any protected area is likely to be dependent upon the number of individual possums (or number of colonies) within the protected area, the size of the protected area, the isolation of the protected area and the extent of disturbance around the protected area. Most THEZs are small, and the set of THEZs forms a very diffuse archipelago of isolated fragments in the context of the broader landscape.

7. The DELWP report provides an explicit assessment of the contribution made by the establishment of THEZs to reducing the extinction risk of Leadbeater's Possum, through the application of the best available and most recently published Population Viability Analysis. DELWP concludes that the THEZs reduce the risk of 'quasi-extinction' by 34% relative to the risk associated with the previously established Leadbeater's Possum reserve system alone. However, (i) even with the THEZs added to the reserve system, this analysis suggests that there is still a considerable risk (45% chance) of quasi-extinction, and (ii) the figure of 34% reduction in extinction risk due to the establishment of the set of THEZs *relates solely to an implausible future scenario of 200 years without bushfire*. When a single bushfire is factored into the analysis, the population within the conservation reserve system, including THEZs, is far more likely than not to become quasi-extinct.
8. The DELWP report provides a brief qualitative assessment of the potential benefits and detriments associated with options other than the current THEZ protocol. Somewhat self-evidently, the option of reducing the buffer size (from the current 200 m radius) of THEZs will reduce the conservation value provided, and increasing the buffer size will enhance that value, mostly because larger protected areas are more likely than smaller protected areas to retain their protected possum colonies. There is some scope for more flexibility in THEZ shape, but circular THEZs will have lowest edge:area ratios and hence will be less likely to suffer from detrimental edge effects; and THEZs shaped by other criteria may be more likely to inadvertently excise part of the home range of the possum colonies that they were established to protect. Allowing more disturbance and other activities (such as roading) within THEZs is likely, in general, to reduce or subvert the conservation benefit they were established to provide. THEZs have provided protection to some Leadbeater's Possum colonies from inadvertent destruction, so abandoning the THEZ process, unless replaced by a superior conservation approach, would most likely result in future losses (that could readily otherwise be averted) of possum colonies.

In summary, the THEZ process has been effective at substantially increasing knowledge of the abundance and distribution of Leadbeater's Possum (principally through the precise determination of many new locations), and of protecting these colonies from what may well otherwise have been their inadvertent destruction. These are substantial accomplishments: the THEZ process has had some significant short-term benefits to Leadbeater's Possum. But the process is reactive, resource-hungry, has sampled only a very small proportion of the possum's range, and has further entrenched a protected area system that is highly fragmented and characterised by many small protected areas. As sketched briefly in the DELWP report, a more strategic and broader landscape-scale planning approach would be more likely to shape a comprehensive reserve system that could provide more adequately for the long-term conservation security and recovery of Leadbeater's Possum.

Introduction

This review provides an evaluation of the assumptions, analyses and interpretation of information provided by the Department of Environment, Land, Water and Planning (DELWP) on the extent to which the establishment of a set of Timber Harvesting Exclusion Zones (THEZ) has provided a conservation benefit to the threatened Leadbeater's Possum *Gymnobelideus leadbeateri*. That DELWP assessment (hereafter the 'DELWP report') is contained within a broader report – which also included an assessment by VicForests of the economic impacts of implementation of THEZs to the timber harvesting industry – to government in June 2017 (Department of Environment Land Water and Planning 2017).

Consistent with the DELWP report, there are two broad components of this review:

> (i) an account of the implementation of the THEZ mechanism and its benefit to (including its likely contribution to recovery of) Leadbeater's Possum; and
> (ii) an assessment of some proposed alternative options.

This independent report focuses solely on those sections of the DELWP report relating to benefits (or otherwise) of the THEZ process for the conservation of Leadbeater's Possum. It does not consider benefits more broadly to biodiversity or other values, and does not assess the section of the DELWP report dealing with the economic impacts of the THEZ process for the timber harvesting industry.

Constraints

There are some notable information gaps and other factors that constrain this assessment. As appropriately noted in the DELWP report, although much dedicated research conducted over many years has resulted in a very substantial evidence base about the ecology and status of Leadbeater's Possum, there are still some critical information gaps.

Previous estimates of the total population size of Leadbeater's Possum now appear to be unreliable. However no more robust estimate is yet available. This shortcoming renders it difficult to contextualise the species-level benefit arising from the set of possum colonies protected by THEZs, and challenging to evaluate the contribution that the current set of THEZs makes towards the recovery of the species.

There remains some uncertainty about the extent to which a 200 m radius (=12.6 ha) THEZ encompasses the territory of one or more colonies of Leadbeater's Possum, and provides adequately for the long-term protection of encompassed colonies. Territory size for Leadbeater's Possum is likely to vary depending on habitat quality, such that a THEZ may provide, at least currently and for the immediate future, for most likely one to three colonies. Hence the total number of possum colonies (or possum

individuals) protected by the set of THEZs is not known, further rendering it challenging to evaluate the contribution that the current set of THEZs makes towards the recovery of the species.

There is another dimension related to interpreting the reported occurrence of Leadbeater's Possum at a site, and hence to any assessment of the protective value achieved through the establishment of a THEZ at that site. Most of the recent sampling, and successful detection, of Leadbeater's Possums, has been through the use of remote cameras associated with baits – i.e. the sampling particularly targets foraging possums and habitat used for foraging. In some cases, this may mean that THEZ protection provides only for a possum colony's foraging habitat, whereas that possum colony may also be reliant on den sites (tree hollows) in a contrasting nearby habitat that may not be included within the THEZ.

Additionally, all established THEZs are currently at sites entirely or largely surrounded by forests or well-established regrowth. There is little empirical evidence available to assess whether possum populations currently present within a THEZ will persist, and for how long, in that protected area if its forest surrounds are subsequently exposed to extensive harvesting or are otherwise highly modified. However, it is unlikely that small populations (e.g. fewer than 50 individuals) of Leadbeater's Possums in small isolated protected areas (such as a 12.6 ha THEZ) will persist over periods relevant to the species' recovery (i.e. decades) (Lindenmayer *et al.* 1993b; Lindenmayer and Lacy 1995; Lindenmayer and Possingham 1996).

Another constraint is that the distribution of Leadbeater's Possum remains imperfectly known. A predictive occupancy model was developed under the LPAG process (Lumsden *et al.* 2013) and this model formed the basis for ascribing a timber harvesting moratorium in areas deemed to have a high probability of occurrence (>65% likelihood) of Leadbeater's Possum (Leadbeater's Possum Advisory Group 2014a). However, subsequent sampling has indicated that Leadbeater's Possums have been recorded at similar (and high) proportions of sites for which the model predicted 30-50%, 50-65% and >65% probability of occurrence, and also that Leadbeater's Possum occurred at many sites (41% of sampled sites) for which the model predicted a low likelihood (<30%) of occurrence (Nelson *et al.* 2015; Nelson *et al.* in press). This imprecision means that it will remain difficult to predict whether Leadbeater's Possum will or will not be present at any location; and confidence about its occurrence may only be achieved through appropriate field survey at a site.

Another major challenge to any assessment of the likely persistence and recovery of Leadbeater's Possum, and the extent to which the established set of THEZs or other conservation options may make to this recovery, is that possum population trajectories in the future will be greatly influenced by disturbance regimes (principally the incidence and extent of bushfires). A relatively small reserve system, or a system bolstered by the establishment of several hundred THEZs (mostly small in size), may be adequate to achieve the persistence, and possibly also some recovery, of Leadbeater's Possum in a future unencumbered by bushfire. However, such a protective system is likely to be inadequate under the more realistic scenario of episodic extensive bushfires; and the characteristics of that bushfire regime will markedly affect the possum's probability of persistence and recovery (Todd *et al.* 2016).

The DELWP report generally acknowledges these constraints appropriately. Unfortunately, the constraints mean that the answers to the questions posed about the extent of benefit provided by THEZs must be nuanced and qualified.

The establishment of Timber Harvesting Exclusion Zones and their likely contribution to the conservation and recovery of Leadbeater's Possum

The DELWP report provides a comprehensive account of the rationale and establishment to date of THEZs and of the survey effort underlying these. The report documents a marked increase in the number of known locations of Leadbeater's Possums since 2014, and appropriately interprets this increase as being due to increased sampling effort and to markedly more effective survey protocols and technology (rather than to any overall population increase). As noted (and explained) in the report, most of this recent sampling effort has been in State Forest, with disproportionately less sampling in existing conservation reserves. While this survey focus on State Forests was purposeful and justified, a consequence of this dispersion of sampling effort is that there is little information about the current occurrence and population size of Leadbeater's Possums in the formal conservation reserve system. This makes for some challenges in comparing the conservation value to Leadbeater's Possum of the THEZs relative to that of the existing formal conservation reserve network, or of the extent to which the THEZs complement or provide a significant addition to the formal conservation reserve system.

A key parameter reported by DELWP (at section 2.1.2 of the DELWP report) is that the detections of Leadbeater's Possum has now resulted in the establishment of 436 THEZs in State Forest (and that these are assumed to provide protection, at least in the short term, to at least 436 possum colonies), with a total newly-established protective area of ca. 40 km^2 (at section 2.1.6). Of this THEZ area, ca. 31 km^2 is 'Available Resource', of which ca. 12 km^2 comprises forest otherwise suitable for current harvesting (i.e. forest originating in 1939 bushfire regrowth) (section 2.1.6).

Remarkably, 346 colonies of Leadbeater's Possum were newly detected (and hence protected) in sampling since 2014 (as given in DELWP report: section 2.1.2), a testament to the amount of survey effort (mostly by government departments and the public) and the enhanced efficacy of new survey techniques.

This represents a particularly notable advance in knowledge and contribution to the conservation of the species. However, the DELWP report appropriately contextualises this contribution by noting (at section 2.1.4), with due acknowledgement of assumptions, that only ca. 6-10% of the area and habitat likely to be inhabited by Leadbeater's Possums has been subject to recent (i.e. post 2014) survey: that is, protection has been afforded by THEZs to many and all *known* colonies (in addition to those already protected by reserves), but the location of the vast majority of colonies remains unknown and hence most colonies remain unprotected.

The total area of newly established THEZs is ca. 40 km^2 (at section 2.1.6). Figure 1 below compares this area with the extent of other protected areas, and of the total potential habitat, within the Leadbeater's Possum distribution (as defined in Leadbeater's Possum Advisory Group (2014b)). The small total area of THEZs relative to other tenures is notable, but again interpretation of this information is also nuanced because all THEZs are known to contain Leadbeater's Possums, whereas the extent of occupancy of possums in all other tenures is unknown, and a reasonable proportion of these other tenures is unlikely to contain Leadbeater's Possum because bushfire in 2009 renders their habitat currently unsuitable.

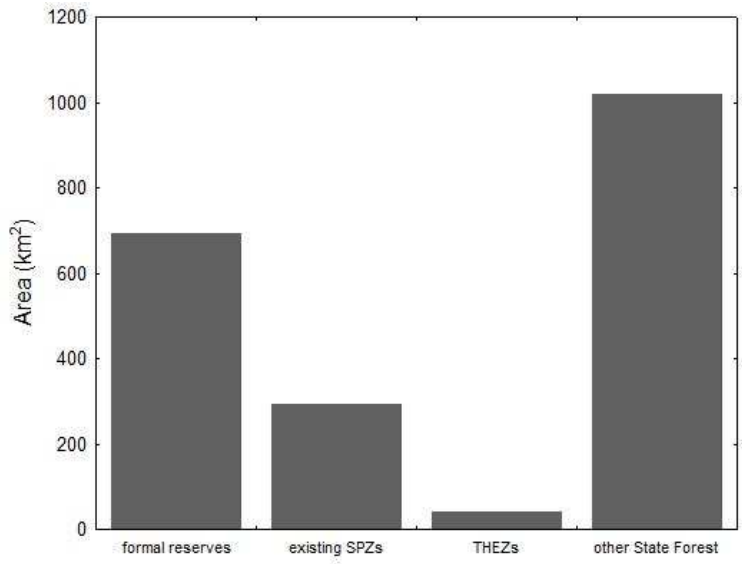

Figure 1. The combined area of THEZs relative to other existing tenures within the 'potential habitat' of Leadbeater's Possum. 'Formal reserves' comprise dedicated reserves (national parks and other permanent formal reserves), 'existing SPZs' comprise informal reserves in state forest; 'other State Forest' includes areas available for timber harvesting and areas in state forest protected by prescriptions. The total area of 'potential habitat' and categories and their areas are taken from Leadbeater's Possum Advisory Group (2014b), other than for the removal of THEZs from the 'other State Forest' category, and with area as given in Department of Environment Land Water and Planning (2017).

The DELWP report describes (at section 2.2.3) that the THEZs (and other components of the reserve system) now have reasonably good representation across the range of the species: i.e. there is some and steadily increasing level of protection afforded to samples of all Leadbeater's Possum metapopulations and management units. The report appropriately concludes that such dispersion will help to spread and constrain the risk of complete population loss associated with catastrophic bushfire.

The DELWP report (at section 2.2.4) notes the approach taken to attempt to bolster the extent of protection offered to known Leadbeater's Possum colonies through aggregating THEZs to incorporate 'clusters' of colonies, and that this has achieved some progress (e.g. by increasing the extent of protected area around population clusters). This approach is sound, as there are well-established relationships between the size of protected areas (and/or the numbers of individuals within a protected

area) and the likelihood of persistence or recovery of species' populations in those protected areas. However, many THEZs remain as single units, isolated, and provide protection to only small numbers of possums, rendering unstable the longer-term security of the possum populations within them. The small extent of individual THEZs, and of the set of all established THEZs, relative to the landscape as a whole is well illustrated in maps in the DELWP report (notably, at section 2.1.2), which show that the THEZs are figuratively fly specks on the map of Leadbeater's Possum distribution.

The DELWP approach appropriately sought to cluster THEZs to increase their resilience, to create neighbourhoods of possum colonies, to increase the numbers of possums contained within any protected area, and hence to increase the likelihood of persistence of possums within THEZs. However, most THEZs are small. The actual size distribution is difficult to determine from the DELWP report because THEZ sizes are conflated (i.e. in some cases, spatially overlap to some extent) with pre-existing protection mechanisms such as SPZs (at section 2.1.6), but the average extent of previously unprotected state forest now protected across the 436 established THEZs is only 9.3 ha (at section 2.1.6). The consequent highly fragmented set of small protected areas (THEZs) will produce considerable conservation challenges in terms of persistence of protected colonies, the ability of possums to disperse among protected areas, and practical management. Although the previously established Leadbeater's Possum reserve system was also characterised by fragmentation and often small reserve size (it comprised 30,500 ha spread among 127 patches: Leadbeater's Possum Advisory Group (2014b)), at least it recognised the desirability of a minimum reserve patch size of 50 ha (Leadbeater's Possum Advisory Group 2014b).

The long-term security of protection afforded by individual THEZs, and of the set of all THEZs, is further considered in the DELWP report (at section 2.2.6) through consideration of vegetation dynamics and assessment of the likelihood that habitat currently within THEZs will maintain suitability for possums in the future. One important point recognised by DELWP (at section 2.1.6) is that the THEZs span a considerable range of forest ages and disturbance history. This heterogeneity is likely to be of considerable conservation benefit, as it will mean that THEZs will retain habitat suitability for varying lengths of time, or provide optimum suitability to possums at different times. There is well established evidence describing the ongoing and severe reduction in hollow-bearing trees (and the total number of tree hollows) in this environment, with consequent ongoing reduction in habitat suitability for Leadbeater's Possum (Lindenmayer and Wood 2010; Lindenmayer *et al.* 2012). This process of declining abundance of required denning resource will also be evident in the established THEZs: the DELWP report predicts that THEZ sites will have substantially fewer hollow-bearing trees (particularly so for dead hollow-bearing trees) in 2030 than they have now, and hence will generally become less suitable for Leadbeater's Possums than they are currently (at section 2.2.6). This may generally reflect trends across the montane ash forest as a whole, but it also indicates that possum recovery based on THEZ sites is unlikely, at least over the next few decades, as possum abundance at THEZ sites may decline in association with their decline in hollow availability. The outlook for trends in *Acacia* density – the other main resource attribute determining habitat suitability for Leadbeater's Possum – at THEZ sites is less clear (at section 2.2.6); at some THEZ sites, the abundance of wattle mid-storey is likely to decline in the near future, whereas at others, suitable mid-storey vegetation will persist over at least several decades.

The relative contribution of the THEZs (and the reserve system in total) to the recovery of Leadbeater's Possum could, in principle, be evaluated by reference to the proportion of Leadbeater's Possums in conservation reserves (including THEZs) relative to the total possum population, or by the number of possums in reserves (including THEZs) relative to a minimum viable population size. However, the DELWP report (at section 2.2.1) notes that it is not yet feasible to provide a reliable estimate of the number of Leadbeater's Possums encompassed within the set of THEZs or of the proportion that this may constitute of the total population of the species. This is because (i) the total number of possums (or of colonies of possums) within THEZs or within the reserve system has not yet been estimated with any appropriate level of precision, and (ii) previous estimates of the total population of Leadbeater's Possum (Leadbeater's Possum Advisory Group 2014b; Woinarski *et al.* 2014; Threatened Species Scientific Committee 2015) now appear to be generally implausible. [Note that the reasonably high number of new possum colonies discovered, and the high proportion of survey sites at which Leadbeater's Possums were detected, indicate that the total possum population is probably higher than these previous estimates, with this difference largely attributable to more reliable and effective sampling techniques. However, it does not necessarily follow that any estimate of higher population size implies appreciably more conservation security. The overall population trajectory is still likely to be declining; critical components of its habitat (notably the abundance of hollow-bearing trees) are continuing to decline; and the population is likely to be further subverted by future episodes of severe bushfire.]

It is difficult to contextualise the contribution to Leadbeater's Possum conservation of the set of THEZs (with a combined area of only ca 40 km^2, but with each THEZ known to currently harbour possums) relative to other components of the reserve system or of State Forests (which are much larger, but which may contain many areas without possums). A recently published new spatially-explicit habitat suitability model for Leadbeater's Possum (Taylor *et al.* 2017) may have provided some insight into the relative conservation value to Leadbeater's Possum of the set of THEZs. That study concluded that the formal Leadbeater's Possum reserve system encompassed only 7.6% of the cumulative habitat suitability of the species, with other previously-established reserves encompassing only another 29.6% of the cumulative habitat suitability, implying that the majority of the most suitable habitat for the species was unprotected by the existing reserve system. It would have been relevant to the assessment here to quantify the extent of cumulative habitat suitability encompassed within the set of THEZs, and hence to assess the extent to which the THEZs progressed the adequacy of reservation for the species, but I understand that the new distributional model was not able to be provided to DELWP in time for such analysis.

The DELWP report (at section 2.2.2) attempts to assess the extent to which the establishment of the set of THEZs has reduced the extinction risk for Leadbeater's Possum, through the application of a previously developed population viability model specifically developed for Leadbeater's Possum (Todd *et al.* 2016). This is an appropriate analysis using the best available model, and it can provide an explicit numerical assessment of changed extinction risk. However, the model is complex, rests on many assumptions, and (appropriately) provides markedly different answers depending upon future disturbance scenarios. As an example of the assumptions underlying the published model, it excised –

as entirely unsuitable for Leadbeater's Possum – all forest areas that have been clear-cut since 1978; and considered that post-fire understorey recovery would not be suitable for use by Leadbeater's Possum until it was 30 years old. However, the DELWP report (at section 2.1.6) shows clearly that Leadbeater's Possums are using some sites with regrowth (from fire or timber harvesting) younger than 30 years. Nonetheless, the validity or otherwise of these assumptions is of relatively minor consequence, as the model applies them consistently when evaluating extinction risk for the current formal reserve system relative to that for that system augmented by the set of THEZs.

The Todd *et al.* (2016) model uses a 'quasi-extinction' threshold, defined as a 5% or more chance of the population falling to fewer than 500 mature females over a 40 generation (=200 year) period. This threshold is reasonable. For a future scenario with no further disturbance, the model predicted the probability of quasi-extinction of Leadbeater's Possum in the formal reserve system (i.e. the previously established 305 km^2 dedicated Leadbeater's Possum reserve system) was 0.73. The DELWP report (at section 2.2.2) demonstrates that when the set of established THEZs (with total area of 40.6 km^2) was added to this reserve system, the model predicted that the probability of quasi-extinction (in this scenario of no future disturbance) was substantially reduced, to 0.45. This indicates that the THEZs somewhat reduce the risk of quasi-extinction of Leadbeater's Possum from that associated with the dedicated reserve system alone, but that a substantial risk of quasi-extinction remains. This is consistent with the findings reported in the original model (Todd *et al.* 2016) that demonstrated that an appreciably larger reserved area (an additional 370 km^2) would be required to reduce the risk of quasi-extinction to the acceptable 0.05 probability threshold, under a scenario of no further disturbance.

However, disturbance through episodic bushfire is almost inevitable in this environment. When such disturbance is factored into the PVA model the probability of quasi-extinction increases very substantially such that *even with the establishment of the set of THEZs* quasi-extinction becomes likely. For example, the modelling presented in the DELWP report (at section 2.2.2) indicates that, for the combined dedicated reserve system and set of THEZs, there is a probability of ca. 0.65 of quasi-extinction of possums in a scenario of a single future bushfire that burns 12.5% of the reserve system; and that the probability of quasi-extinction across the combined dedicated reserve system and set of THEZs increases to ca. 0.9 with a single future bushfire that burns 25% of that area.

It is beyond the detail and scope of the analyses and interpretation presented in the DELWP report, but the primary and immediate value of the THEZ procedure is that it prevents, reasonably effectively, the otherwise unwitting destruction by timber harvesting of colonies of a critically endangered species. As demonstrated in the DELWP report, the procedure has been successful in maintaining (saving) at least 436 colonies of Leadbeater's Possum that otherwise may have been destroyed. This is no small boon, but it remains a reactive and time-consuming process that focuses mostly on the protection of individual colonies and not on the conservation of the species as a whole. An ultimate objective of threatened species management is recovery (e.g. Secretariat of the Convention on Biological Diversity (2010)), preferably by creating or managing conditions that allow for the species' population to stabilise or increase. Given the demonstrated ongoing and projected broad-scale decline of one of the most critical resources (hollow-bearing trees) required by Leadbeater's Possum (Lindenmayer and Wood 2010;

Lindenmayer *et al.* 2011), and the likelihood of future episodes of extensive bushfire, recovery of Leadbeater's Possum will be extremely challenging. The establishment of the set of THEZs has retained many colonies that may otherwise have been lost, and (relative to not having any THEZs) may have reduced the likelihood of extinction for Leadbeater's Possum by a measurable and perhaps significant extent, but – as demonstrated by previous modelling (Todd *et al.* 2016) and its application in the DELWP report – the current set of protected areas (including THEZs) is likely to be substantially inadequate to achieve the recovery of the species.

Consideration of alternative options for protection of detected Leadbeater's Possum colonies

The DELWP report (at section 6, and informed by information presented in section 3) includes some consideration of options other than the current THEZ protocols and approach, and provides some qualitative assessments of the relative costs and benefits of these options for the conservation of Leadbeater's Possum and for timber harvesting. Many of these options were also considered, sometimes in more detail, previously in the LPAG deliberations (Leadbeater's Possum Advisory Group 2014b).

Six broad options were considered in the DELWP report:

- size of exclusion zones;
- shape of exclusion zones;
- activities permitted within exclusion zones;
- location of exclusion zones in relation to existing protected areas;
- discontinuation of exclusion zones; and
- strategic options.

THEZ size. The consequences to the conservation effectiveness for Leadbeater's Possum of varying the size of THEZs are appropriately described in the DELWP report, and have been considered extensively elsewhere (Lindenmayer *et al.* 2013a; Leadbeater's Possum Advisory Group 2014b). THEZs that are smaller than 200 m radius may be inadequate to encompass even one Leadbeater's Possum colony, and any colony protected in a smaller THEZ will be less likely to persist over time (and hence will be largely a waste of conservation investment). This is because smaller retained area will be more susceptible to detrimental edge effects, and because very small possum populations may be highly susceptible to stochastic effects and may lack genetic diversity and may rapidly become inbred. Conversely, increasing the THEZ size would likely result in protection of larger neighbourhoods of possums (and hence more possums) with increased genetic diversity, would be more likely to provide a wider range of resources, and would be more resilient to edge effects: hence possum populations would be far more likely to persist in larger than in smaller THEZs. A set of larger-sized reserves (including larger THEZs) would help redress one of the shortcomings in the current reserve system – most notably its characterisation by

many isolated and small protected forest fragments. Lindenmayer *et al.* (2013a) proposed that a buffer size of 1 km radius was required around known Leadbeater's Possum colonies based on evidence relating to the possum's susceptibility to disturbance (Lindenmayer *et al.* 1993a; Lindenmayer *et al.* 2013b). The case presented in the DELWP report and elsewhere is compelling: reducing the THEZ buffer size will render these protected areas significantly less effective for the conservation of Leadbeater's Possums and increasing the buffer size will enhance their conservation effectiveness.

THEZ shape. The DELWP report again provides a reasonable qualitative assessment of the potential benefits and costs of changing the protocol from a simple 200 m radius THEZ to a comparably sized area that is tailored to local conditions. There may be some benefits to Leadbeater's Possums if such flexibility allows for avoidance of disturbed areas (such as roads) and areas unlikely to be accessible or used by Leadbeater's Possum (e.g. habitat fragments beyond a road barrier), and allows for encompassing a higher proportion of better quality habitat. However, without a detailed knowledge of an individual Leadbeater's Possum colony's actual home range dimensions and shape, any adjustment of buffer shape based on an observer's perception of optimal or unsuitable habitat will be conjectural and inexact. Furthermore, circles (such as the current THEZ prescription) provide the minimum edge:area ratio for any polygon of specified area, so any change from this shape will increase the relative extent of edge in the protected area, rendering possum colonies in an irregularly-shaped protected area more susceptible to edge effects. My assessment of the information presented in the DELWP report is that change in THEZ shape (albeit retaining the current prescribed THEZ area) may in some instances provide some benefit to Leadbeater's Possum colonies, but that this benefit will not always occur and may be marginal. As noted in the DELWP report, it may also require considerably more planning considerations.

The DELWP report also considers another very specific variation as a rationale for an irregularly-shaped THEZ, for the case where a circular THEZ may include in part a recently harvested area in which appropriate regeneration management has not yet occurred. This variant relates also to another set of options relating to what management activities may occur in THEZs (at section 6.1.3). As noted in the DELWP report (at section 6.1.2.3), this issue has arisen rarely to date and affects only small areas (mostly <1 ha). Nonetheless, the argument seems valid that if a circular THEZ had the consequence of impeding appropriate regeneration in some portion of its area, then it would be a conservation benefit to re-draw the THEZ boundaries to excise such portions but extend the THEZ boundary elsewhere to retain the 12.6 ha size.

Allowed activities within THEZs. The DELWP report considers two variants relating to allowed activities within established THEZs – (i) roading, existing infrastructure and regeneration activities, and (ii) timber harvesting. These potential variants may require changes in the protective layer under which THEZs are regulated (from SPZs to SMZs). The DELWP report appropriately indicates no established benefit (but probable detriment) to Leadbeater's Possum from either option, although it speculates (at section 6.1.3) that judicious thinning may result in higher growth rates of remaining unharvested trees, and hence may provide future benefits to Leadbeater's Possums. Any such putative potential benefit is likely to be substantially outweighed by immediate detriment to Leadbeater's Possums from habitat loss and disturbance associated with such activity. Because of their small size in relation to Leadbeater's Possum

conservation needs, THEZs provide a relatively precarious security for the conservation of possum colonies within them. This security is likely to be increasingly compromised if any habitat loss and more disturbance (such as the establishment of new tracks, ongoing use of infrastructure and selective harvesting) is allowed within them.

Coalescing THEZs with existing nearby protected areas. The DELWP report recognises that, in some instances, there may be benefit to a detected Leadbeater's Possum colony if the consequential imposed THEZ was shaped such that it joins up with other protected areas. This may help to consolidate the connectivity and size of a protected area, and hence the population size of the possums encompassed within it. However, an attribute of the current THEZ establishment is that the THEZ is largely centred on a record of a possum, such that it maximises the likelihood that the possum's entire home range is encompassed within the imposed THEZ. A re-shaping to fit or abut the THEZ instead to pre-existing protected areas may result in parts of the home range being excised from protection. Any such advantage or disadvantage will be a case-by-case proposition, which may be resolved through detailed field assessment: however, this may be laborious and time-consuming, and hence an ineffective use of resources. To some extent, this issue is already being addressed sufficiently through consolidation of THEZs with already existing protected areas (e.g. section 2.2.4).

Discontinue protection of colonies. Given that surveys to date have investigated only a very small proportion of Leadbeater's Possum's distribution, the location of most possum colonies remains unknown and hence many to most are unprotected. It is almost certain that cessation now of the THEZ process, without instigation of other measures, would result in future timber harvesting activities destroying colonies of Leadbeater's Possum. Given the current protected area system is unlikely to be adequate to prevent the species' extinction (and especially so if future bushfires occur) (Todd *et al.* 2016), such ongoing loss from unprotected areas will subvert the likelihood of recovery.

Strategic options. The DELWP report notes that landscape-scale proactive approaches are beyond the scope of this assessment, and hence it provides little relevant discussion of this issue. As noted in my comments above, the THEZ process has been effective at substantially increasing knowledge of the abundance and distribution of Leadbeater's Possum (principally through the precise determination of many new locations), and of protecting these colonies from what may well otherwise have been their inadvertent destruction. These are substantial accomplishments. But the process is reactive, resource-hungry, has sampled only a very small proportion of the possum's range, and has further entrenched a protected area system that is best characterised as a complex and unstable archipelago of mostly small isolated protected areas that individually and collectively provide inadequate long-term security for the possums that they were painstakingly established to protect. In terms of the objective for the recovery of Leadbeater's Possum, the THEZ process has been necessary (to prevent the inadvertent destruction of possum colonies), but is likely to be insufficient. As sketched briefly in the DELWP report, a more strategic and broader landscape-scale planning approach would be more likely to shape a comprehensive reserve system that could provide more adequately for the conservation and recovery of Leadbeater's Possum.

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