Contribution

Between a rock and a hard place: preventable destruction, degradation, and fragmentation of habitats exacerbate climate impacts on the nationally endangered Mountain Skink *Liopholis montana*

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Abstract
Loss of biological diversity in Victoria mirrors global trends, and is vastly outpacing efforts to stop or recover losses. Reptile conservation is hampered by 'taxonomic chauvinism'—a tendency for society and funding bodies to favour more charismatic birds and mammals. The Mountain Skink *Liopholis montana* occurs in montane to subalpine areas on the south-eastern Australian mainland; it was recently listed as nationally Endangered. As well as 'global' threats to the Mountain Skink (such as climate change and associated impacts, for example, as increasing frequency, extent, and severity of bushfires), my team and I have observed that the species is detrimentally affected by preventable threats, including logging (which is ongoing, despite the putative cessation of commercial logging of native forests in Victoria), development (particularly in alpine resorts), planned burning in forests, damage caused by campers and recreational users of forests and subalpine areas, and undue attention from wildlife enthusiasts (particular reptile photographers). Mitigations of preventable threats to this species must include: understanding that Mountain Skinks are easily missed during pre-impact surveys, and therefore involving the most relevant experts on the species when interpreting survey results; cessation of all logging of native forests within the range of the Mountain Skink; involving the most relevant experts on the Mountain Skink during assessments for developments that affect forests or rocky areas within the species' range (or assessments for any other works that might affect the species' habitats); cessation of planned burning in Mountain Skink habitats so that forests and woodlands can mature into 'old growth' states (except where there is an immediate and obvious threat of fire to human life; in such cases seeking informed comment from the most relevant experts on the species can minimise harms from planned burning); rapid closure and rehabilitation of any new illegal campsites within the species' range; and encouraging wildlife photographers to cease harmful practises such as disturbing rocks to find and capture reptiles. To prevent further losses of colonies and populations of Mountain Skink, and to give the species its best chance of persisting despite climate change, preventable threats must be rapidly and effectively addressed. (*The Victorian Naturalist* **141** (5), 2024, 132–140)

Keywords: *Liopholis montana,* threatening processes, logging, planned burning, threat mitigation

Introduction

As the global biodiversity crisis (Ceballos et al. 2015) deepens, recognition and conservation status assessment of poorly known species is an urgent priority (Bickford et al. 2007). Biodiversity trends in Victoria mirror the global crisis (Commissioner for Environmental Sustainability Victoria 2023), and responses to biodiversity loss and decline in Victoria are inadequate (VAGO 2021). As well as displaying sobering trends of decline in Victoria, the conservation of reptiles is hampered by 'taxonomic chauvinism': a bias in funding and conservation priorities that favours popular (usually endothermic) vertebrates (Clemann 2015).

A taxonomic revision of the common scincid lizard *Liopholis whitii* (then bearing the scientific name *Egernia whitii*; Donnellan et al. 2002) resulted in the erection of two new species: *Liopholis guthega* and *L. montana*. The latter species, known by the common name Mountain Skink (Robertson and Coventry 2019), has recently been listed as nationally endangered under the Australian Environment Protection and Biodiversity Conservation Act 1999. In 2017 the species was assessed by the International Union for Conservation of Nature (IUCN) and categorised as Near Threatened (Clemann et al. 2018). While preparing assessments for Victorian reptiles and frogs for the current State threatened species list (FFG 2023), I used the same process and IUCN software that I used for the State list, to assess the status of Mountain Skink in Victoria. That assessment resulted in an indicative status of Critically Endangered in the State, but the assessment was not adopted by the Victorian government because

Mountain Skink was not included in the list of species being assessed at the time.

Our team's program on the Mountain Skink has its roots in the early 21st century. As well as supplying some of the specimens used by Donnellan et al. (2002) in the description of *L. montana*, we began assessing the status of mainland alpine reptiles and frogs, and threats to these species (including the lizard that would become *Liopholis montana*), in the early 2000s (Clemann 2002), and have had a continuous monitoring and survey program for threatened reptile and frog species in that region since 2005. In recent years the program has expanded in scope geographically, and in terms of conservation initiatives. Surveys are being conducted to determine the Mountain Skink's distribution across Victoria, New South Wales and the Australian Capital Territory, and the species' habitat preferences. Concurrently, we are conducting genetic analyses (Amor et al. in review) to refine our understanding of relationships between populations, and elucidate key population health parameters. We have established long-term monitoring sites for Mountain Skinks across the species' range in south-eastern Australia. Collectively, this work is allowing us to better understand the species' biology, ecology, detectability, and susceptibility to habitat destruction and degradation, as well as helping us to prioritise and guide conservation actions in the context of current and emerging threats.

A medium-sized scincid species, Mountain Skinks attain a snout–vent length (SVL) of 107 mm (Z Atkins unpubl. data, 2024). They are viviparous; litter sizes of up to four have been reported (Robertson and Coventry, 2019). A gravid female I collected in the Alpine National Park in Victoria on 7 January 2006 (Fig. 1) weighed 27.4 g four days before producing a litter of four young on 25 February (Table 1). At the time of birth, the female had a snout–vent length and tail length of 92 and 133 mm respectively.

Mountain Skinks live in burrow systems in small family groups, with a colonial social structure that is probably like that of the closely-related Guthega Skink (Atkins, 2018). There is considerable phenotypic variation across the species' range (Fig. 2).

Mountain Skinks occur from the Australian Capital Territory, through the Snowy Mountains of New South Wales, into the High Country of Victoria. A population in western Victoria was discovered recently (Farquhar et al. 2021). Mountain Skinks typically occur in montane forests and woodlands, at elevations ranging from 567 to 1820 m (Z Atkins unpubl. data, 2024). Rocks and sometimes logs are conspicuous components of the species' microhabitats; Mountain Skinks mostly shelter in burrows dug beneath rocks, but may also seek shelter in fissures or hollows of logs. They

Fig. 1. A gravid adult female Mountain Skink from the Alpine National Park in Victoria (top). Newborn Mountain Skink (bottom). This female is the mother of the litter documented in Table 1; this newborn is one of her offspring.

Table 1. Details of young born to a Mountain Skink from the Alpine National Park in Victoria in February 2006.

Neonate number	Weight (g)	Snout–vent length (mm)	Tail length (mm)
1	1.4	36	51
2	1.5	38.5	50
3	1.5	38.5	48.5
4	1.7	39	48
Mean	1.5	38	49

Fig. 2. Mountain Skink plain morph (a–d) and patterned morph (e–h) phenotypes from across the species' range in Victoria, New South Wales and the Australian Capital Territory. Photos Zak Atkins.

are heliothermic (obtaining body heat by basking in the sun), and are most often observed basking on rocks, logs, or the ground, close to retreat sites. Like similarly sized scincid lizards from south-eastern Australia (Clemann et al. 2004; Atkins et al. 2018), the Mountain Skink's diet includes both invertebrates and plant matter (Z Atkins unpubl. data, 2024).

Threats to the Mountain Skink in Victoria

As well as overarching 'wicked' threats such as climate change and associated impacts including increasing frequency, extent and severity of drought and bushfires, key preventable human-driven threats to the Mountain Skink include:

Habitat destruction, degradation, and fragmentation due to logging

While traditional commercial logging of native forests ended in Victoria at the end of 2023, recent logging damaged or destroyed Mountain Skink habitat (Fig. 3), and other forms of logging continue; the reasons given for this continued logging include: fuel reduction, creating large firebreaks, 'cleaning up' trees downed by storms (a form of 'salvage logging', a practice currently being considered for listing as a threatening process in Victoria under the State's Flora and Fauna Guarantee Act 1988), and resource extraction on behalf of First Nations groups (sometimes called 'cultural thinning' or 'forest gardening') (Lindenmayer 2024). Logging, and associated activities (such as creating, widening, or maintaining tracks) can directly destroy the habitat of Mountain Skinks and kill lizards, including by disturbing, moving, and damaging rocks and logs.

Post-logging impacts on Mountain Skinks change over time with vegetation succession. Immediately after logging, the disturbance and destruction of shelter sites exposes lizards to predators and extremes of weather. The loss of vegetation strata caused by logging changes the effects of weather, initially resulting in more sunlight reaching the ground, higher wind speeds, and drier and more erosion prone soils. After some types of logging, the remaining 'slash' (vegetation debris remaining after logging) is burnt in high intensity fires intended to promote regeneration of trees; small animals that are exposed due to having shelters disturbed or destroyed by logging are susceptible to death during these fires.

Starting soon after logging (and/or fire – see below), very dense plant regrowth occurs. This dense vegetation shades most of the ground, degrading opportunities for basking, which is critical for all other activities for heliothermic reptiles such as the Mountain Skink. This dense vegetation is also likely to impede the lizards' ability to see and capture prey.

Mountain Skink habitat (habitat also occupied by the threatened Alpine Tree Frog *Litoria verreauxii alpina*) has recently been logged

Fig. 3. Destruction of Mountain Skink habitat (and Alpine Tree Frog habitat; Rakali 2021) south of the Dargo High Plains. Note disturbed rocks in the foreground of the photograph on the right.

south of the Dargo High Plains in the Victorian High Country (Rakali 2021; Fig. 3); and logging remains a threat to populations on the margin of the species' distribution (Wombat State Forest), and parts of the Victorian High Country.

Some of the methods recommended for survey of reptiles during pre-logging surveys in Victoria, such as 'rolling rocks and logs' and 'active' searches that can also 'involve some destructive habitat searching' (FPSP 2023, p. 4), damage and degrade microhabitats for small fauna ranging from invertebrates to frogs and reptiles, even if attempts are made to reinstate the disturbed shelters in their original position (which is recommended in FPSP 2023). Although the latest version of these survey guidelines (FPSP 2023) still allows for this destructive practice during reptile surveys, the guidelines now contain specific directions for surveying for Mountain Skinks, telling surveyors to not disturb rocks in Mountain Skink habitat. However, reliably detecting Mountain Skinks, identifying likely habitat even if the species is not detected, and interpreting non-detections during surveys, is a highly nuanced practice; our team is still learning about Mountain Skink habitat and microhabitat use more than 20 years after commencing work on the species. Given how poorly known this species and its habitats are to most ecologists, inadvertent damage to Mountain Skink habitat caused by people disturbing rocks and logs is still possible, if not likely, during pre-logging surveys, or surveys in preparation for other disturbances in forests. Once the rock over a Mountain Skink burrow system has been disturbed, the shelter is likely to be abandoned by the lizards (Clemann, pers. obs. (2023); Z Atkins pers. comm. 2023, 2024).

Habitat destruction, degradation, and fragmentation due to development

The geographic range and habitat of the Mountain Skink overlap with some alpine resorts, including Mt Hotham, where Mountain Skinks join other threatened reptiles (Alpine She-oak Skink *Cyclodomorphus praealtus*, Alpine Bog Skink *Pseudemoia cryodroma*, Tussock Skink *Pseudemoia pagenstecheri*) and the threatened Alpine Tree Frog *Litoria verreauxii alpina* in having had remnant habitat cleared for car parks, ski lodges, and associated infrastructure. These impacts commenced as soon as Mt Hotham began to be developed for recreational activities. Disappointingly, substantial destruction and damage to threatened reptile and frog habitats on and near Mt Hotham continue; in the 21st century alone we have witnessed ever-increasing destruction of these threatened species' habitats at Mt Hotham (Fig. 4).

Habitat destruction and degradation caused by planned burning

Mountain Skinks occur in colonies of varying size, and shelter in burrow systems. Entrances to these burrows are used for basking and ambushing invertebrate prey. It is probable that most Mountain Skinks survive fire by sheltering in these burrows, as does the closely related Guthega Skink *L. guthega* (Atkins et al. 2015). Like Guthega Skinks, Mountain Skinks require a canopy open enough to allow effective thermoregulation by basking to warm up, and sheltering in burrows when temperatures are too hot or cold (Senior et al. 2019; Z. Atkins unpubl. data 2024). An immediate post-fire landscape not only compromises the species' pre-fire inconspicuousness by creating a contrasting blackened landscape, the lack of vegetation immediately after a fire means that lizards are more visible to predators. Conversely, the dense post-fire regrowth months-to-years after fire can overshadow burrow systems, lessening the time available for effective thermoregulation and degrading the effectiveness of thermoregulation; dense regrowth can also make it more difficult for Mountain Skinks to detect and capture invertebrate prey.

Habitat destruction, degradation, and fragmentation due to recreational activities

A Mountain Skink population in Victoria's Alpine National Park that we visit frequently because it is adjacent to some of our long-term monitoring sites for other threatened species has, in recent years, been transformed from an intact area with infrequent human visitors and a single vehicle pull-in with one campfire scar, to an area with more than a dozen camp sites. It is now an area of consistently high human visitation, vehicle use, and camping; as a result, many of the trees have been cut down,

Fig. 4. Destruction of the habitat of Mountain Skink, several other threatened reptiles and the Alpine Tree Frog at Mt Hotham in 2006 (top left), 2008 (top right), 2018 (bottom left), and 2023 (bottom right).

rubbish left by campers is accumulating, and rocks—some that formed the ceilings of Mountain Skink burrows—have been ripped up and used to surround the many new camp fire scars (up to four scars per newly created camp site; Fig. 5).

Sometimes the response of land management agencies to new illegal campsites is to formalise the camp site(s), and try to contain its spread. Where these sites occur in the habitat of threatened reptiles, a failure to close the new campsites and prevent others from forming can lock-in long-term harm to populations of the reptiles.

Habitat destruction, degradation, and fragmentation caused by wildlife enthusiasts

Rare and threatened reptiles are 'high value targets' for reptile enthusiasts, wildlife photographers, and even poachers (Masroor et al. 2020), and interest, competition, and sharing of location information has increased commensurately with the growth of the internet. As a rare and threatened species with specialised habitat requirements, Mountain Skinks are at substantial risk from undue attention from wildlife enthusiasts. Inexpert capture of Mountain Skinks during these pursuits is likely to involve damage to rocky habitats and burrow systems; we have witnessed analogous damage caused to colonies of the also-threatened congeneric Guthega Skinks—some of this damage was even caused by professional ecologists!

Mitigation of threats to Mountain Skinks

Habitat destruction, degradation, and fragmentation due to logging

Given the damage caused to Mountain Skink habitat by logging (Fig. 3), the cessation of traditional logging of native forests in Victoria is a step in the right direction for the conservation of the species. However, some forms of logging are continuing (Lindenmayer 2024), including in forest occupied by Mountain Skinks,

Fig. 5. Damage to Mountain Skink habitat due to the creation of new camp sites by tourists in an area of the Victorian Alpine National Park that was infrequently visited by people until a few years ago. Snow Gums *Eucalyptus pauciflora* cut down by campers (left). Four new campfire scars at a recently created camp site (centre). Rocks, some previously forming ceilings of Mountain Skink burrows, ripped up to create a campfire surround (right).

such as Wombat State Forest. Cessation of all logging of native forests in Victoria is an attainable standard that will remove an obvious and highly destructive threat from the habitats of the Mountain Skink (and other threatened species; Rakali 2021; Lindenmayer 2024). It would also allow previously logged and/or burnt habitat to begin maturing to the age and structure required by Mountain Skinks, although in recently logged areas this will take many decades.

As with many rare and cryptic reptiles, one of the most important factors in surveys is who conducts the survey (i.e. the experience and species-specific and method-specific knowledge of the people doing the work), and who interprets survey results in general, and non-detection at a location in particular. Our team's experience with Mountain Skinks suggests that detection is highly variable within and between sites (even at some of our most productive monitoring sites), and within and between surveys. At some sites it has taken multiple surveys to detect the species, while at other sites detection is rapid. At some of our monitoring sites, we do not detect individuals even where we have detected them previously, and/or detect them later. Similarly, there have been times when we detect them later in the day in locations where they were not visible earlier in the day (or vice versa). Often a sign of the species' presence (sometimes the only sign) is burrow entrances; however, these entrances can be very inconspicuous, and similar burrows may be used by other species, such as White's Skink *Liopholis whitii* or Southern Water Skinks *Eulamprus tympanum tympanum*.

Because of this, great care must be taken when interpreting results from surveys where Mountain Skinks were not detected, especially where non-detection may have implications for the habitat in the area (e.g. where non-detection during surveys may result in logging, clearing, or other impacts to habitat). The FPSP (2023) survey guidelines for reptiles stipulates (p. 2) that

> observers must be familiar, via first-hand experience, with identification features and habitat preferences of all the reptile species likely, or possibly present, in the program area, including shelter locations and behaviour.

However, given the rarity of Mountain Skinks, it is probable that few people have such 'first-hand experience' with Mountain Skinks, and, of those that do, most will have observed the species in only one or perhaps a couple of general areas; these areas may not be representative of other habitats occupied by the species.

It is therefore critical that non-detections in potential habitat are interpreted in the context of these challenges, and that failure to detect the species after modest amounts of survey

effort, often by people with little or no experience with the species across its range, does not lead to assumptions of absence, particularly when survey results will affect land management (e.g. Burns et al. 2020).

Habitat destruction, degradation, and fragmentation due to development

Clemann (2015) documented how destruction and degradation of threatened reptile habitats in Victoria is often facilitated by some ecological consultants promoting dubious 'mitigations' that facilitate agency approval of actions that destroy or damage habitats. Irreversible harm to the habitats of threatened species such as Mountain Skink can be avoided, minimised, and/or better understood via objective peer review by independent experts of the ecological advice that is currently facilitating this destruction. Similarly, if land management agencies are diligent in seeking informed reviews from the most relevant and experienced experts on specific threatened species, the real consequences of habitat impacts on populations of threatened species of habitat impacts can be understood by those agencies and used to make more informed decisions. Agencies may still choose to allow logging and development that destroys, degrades, and/or fragments these habitats, but it is essential that the agencies make their decisions based on advice from the best available experts on the species (preferably while being transparent with government and the public about the known or probable impacts to threatened species that will result from the actions being planned).

Habitat destruction and degradation caused by planned burning

The rationale underpinning most planned burning regimes in forest ecosystems in southern Australia is in question, and there is a growing understanding that old growth forests are less flammable than young forests (Zylstra 2018; Lindenmayer et al. 2021; Lindenmayer et al. 2022; Zylstra et al. 2022). Compared to dense regrowth after fires (and/or logging), old forests and woodlands provide microhabitats favoured by Mountain Skinks. Mountain Skinks (and other small reptiles) have limited capacity for dispersal, and Mountain Skinks occupy long-term shelter sites and exhibit high microhabitat philopatry; so, if survivors of fires are subsequently lost due to post-fire conditions in the months and years after fire, recolonisation of these areas may take a very long time, or not be possible. Where possible, planned fires should be excluded from Mountain Skink habitats.

Habitat destruction, degradation, and fragmentation due to recreational activities

Rapid and effective responses to illegal tracks and camp sites from land management agencies will maximise protection of Mountain Skink habitats where they intersect with human recreational pursuits. Where new illicit tracks and camp sites are created by the public in Mountain Skink habitats, rapid closure of these sites, education, and (if necessary) punitive action will help to minimise impacts. Interpretive signs explaining the natural values of the area may help, but we caution that signs that explicitly mention that threatened reptiles occur in the immediate area can exacerbate impacts from wildlife enthusiasts (see below).

Habitat destruction, degradation, and fragmentation caused by wildlife enthusiasts

Parks Victoria rangers, and compliance and enforcement staff from Victoria's Conservation Regulator do an admirable job in trying to prevent habitat damage caused by wildlife enthusiasts. But the geographic and temporal scope of wildlife enthusiasts' impacts makes policing of all activities prohibitive. Increasingly, enthusiasts interested in birds and mammals are exploring ethical wildlife interactions, and encouraging self-policing amongst enthusiasts (Fennell and Yazdan panah 2020; Jafarpour and Ramkissoon 2023). I sense that my herpetological colleagues are trending in a similar way, but believe that more awareness and self-control is needed to stem harm caused by reptile enthusiasts. Prevention is preferable to compliance of offenders and needing to restore damaged habitats. I encourage wildlife enthusiasts to prioritise the conservation of threatened species over their own interests, and to foster a culture of avoiding disturbances to wildlife and their habitats.

In the short time since the Mountain Skink was listed as nationally Endangered, our team

has witnessed destruction and degradation of the species' habitat in Victoria that adds to historic impacts. As the climate crisis deepens, species such as the Mountain Skink will struggle; if the species is to persist into the future, it is imperative that the preventable impacts detailed here are effectively mitigated (or cease altogether!).

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