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## Mount Imlay – an island of floristic significance on the brink

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**Abstract:** Mount Imlay is an isolated summit in south-eastern New South Wales, rising to 886 m above sea level. In addition to its cultural significance and tourism value, the summit is home to three endemic plant species (*Boronia imlayensis*, *Eucalyptus imlayensis* and *Hibbertia circinata*) and several regionally rare or disjunct species. *Eucalyptus imlayensis* has been identified as one of 100 priority threatened species for conservation efforts in the coming years. Mount Imlay was burnt severely in the fire of 2019 / 20 and faces the threat of more frequent fire in the future, resulting from climate change. Many species are threatened by the introduced pathogen *Phytophthora cinnamomi*, which is now present on most of the mountain. In this paper, we outline the work done to date on protecting Mount Imlay's significant flora and identify plant species likely to be eligible for listing in threatened species legislation; currently, only two of the species are listed as threatened in NSW. Because most significant species on Mount Imlay share the same threats, the costs of future conservation work can be shared and undertaken regardless of legislative status. For instance, spraying with phosphite to reduce the threat from *Phytophthora cinnamomi* for one species will benefit many species.

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## Introduction

Mount Imlay is an isolated peak rising to 886 m a.s.l. about 20 km south-west of Eden in south-eastern New South Wales (Figure 1). The slopes of the mountain are within Mount Imlay National Park and surrounded by state forest, which is subject to harvesting of native timber. The summit area forms a narrow rocky spine with cliffs of Devonian

sedimentary rocks on all but the southern aspect. The peak is culturally significant (Department of Agriculture, Water and the Environment 2022a). Mount Imlay is considered an Asset of Intergenerational Significance for two endemic plants species, *Eucalyptus imlayensis* and *Hibbertia circinata*, under the amended NSW *National Parks and Wildlife Act 1974*.



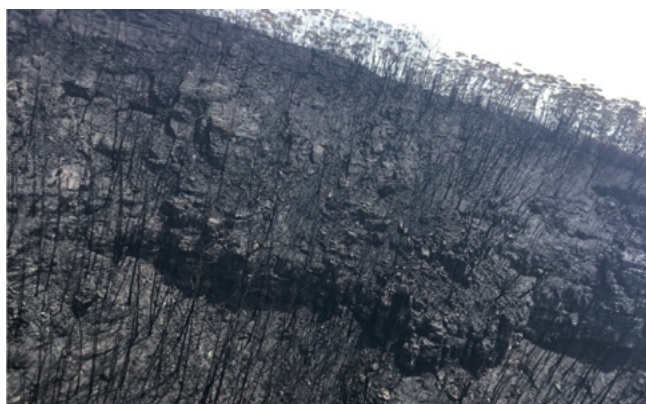
**Figure 1.** Mount Imlay is an isolated peak south-west of Eden, in Mount Imlay National Park, New South Wales. The narrow summit ridge is above 800 m a.s.l.

The lower slopes of Mount Imlay National Park are dominated by *Eucalyptus sieberi* with a shrubby understorey. Gullies typically contain *Eucalyptus cypellocarpa* and species of wet sclerophyll forest. The summit area is fringed by a forest of *Eucalyptus fraxinoides* on the eastern and northern sides, while the rocky summit itself has scattered stunted *Eucalyptus sieberi*. The steep, eastern slope below the summit features a shrubland dominated by *Leptospermum scoparium* with emergent *Eucalyptus sieberi*, *Eucalyptus fraxinoides* and *Eucalyptus imlayensis*. This highly localised shrubland appears to be restricted to the mountain. The shrubland habitat is unusually wet for this dry mountain, receiving regular dew and mist from coastal winds in summer. There is very little soil in this community but mosses (including *Sphagnum australe*) are abundant on the rocks and in crevices.

A popular walking track leads to the summit from the north-eastern side of the mountain but there was once a rough vehicle track (now overgrown) to the summit from the south-western side. There is a small communications tower on the summit. The pathogen *Phytophthora cinnamomi* was isolated on the summit in 1999 prior to the construction of the tower. It has transformed understorey vegetation of the forest on the lower northern slopes from a diverse shrub-dominated community to a species-poor graminoid-dominated community (McDougall and Summerell 2003). *Xanthorrhoea australis* is the most obviously affected species, with these arborescent monocots turning yellow as they succumb. Until the early 2000s they were present close to the summit itself but have gradually died out there. *Phytophthora cinnamomi* has been recovered from the roots of the following species

on Mt Imlay since 2000: *Amperea xiphioclada*, *Banksia spinulosa* var. *cunninghamii*, *Boronia imlayensis*, *Dillwynia glaberrima*, *Diplarrena moraea*, *Gonocarpus teucroides*, *Hibbertia circinata*, *Leucopogon affinis*, *Monotoca glauca*, *Philotheca virgata*, *Platysace lanceolata*, *Prostanthera walteri*, *Stylidium armeria*, *Tetratheca subaphylla* and *Xanthorrhoea australis* (McDougall and Summerell 2003, Liew and McDougall unpublished data). Species such as *Epacris impressa* and *E. microphylla* are also likely to be affected; symptomatic plants of the former have not been sampled on Mount Imlay but the species is known to be highly susceptible elsewhere (Weste 2001), while, prior to the fire of 2019 /20, the latter only grew in areas where the pathogen was likely to be absent and had perhaps not yet come into contact with it. *Phytophthora cinnamomi* may also contribute to occasional deaths of *Eucalyptus sieberi* and *Eucalyptus obliqua* on the lower slopes. Both species are known to be susceptible but, given the dominance of at least *Eucalyptus sieberi* where *Phytophthora cinnamomi* is also abundant, susceptibility is probably low. The wet summer of 2021 / 22 resulted in more deaths in more species than usual. *Leucopogon affinis* for instance was thought to be largely unaffected by *Phytophthora cinnamomi* (McDougall 2006) but was commonly seen dead and dying in early 2022, and the pathogen was recovered from the roots of symptomatic plants. Apart from the northern part of the summit ridge and isolated pockets of healthy *Xanthorrhoea australis*, most of the park is likely to be infested with *Phytophthora cinnamomi*. Sadly, in the years since the recent fire, the pathogen appears to have made its way onto the summit ridge, where most of the significant plants grow.

Most of Mount Imlay National Park was burnt in a wildfire in late December 2019 / early January 2020, which moved rapidly through the park from the south. The eastern and southern aspects, typically moist and probably somewhat resistant to burning, had become dry during the drought in the preceding years and burnt severely (Figure 2). The fire was so hot there that it melted metal markers and consumed the lignotubers of young *Eucalyptus imlayensis* planted in 2011 and 2018. The fire, coupled with the increased activity of *Phytophthora cinnamomi* in the years since and its apparent spread to previously uninfested areas, has heightened the threat to the area's flora and vegetation. Currently, two plant species are listed as threatened under the Commonwealth *Environment Protection and Biodiversity Act 1999 (EPBC Act)* and the New South Wales *Biodiversity Conservation Act 2016 (BC Act)*: *Eucalyptus imlayensis* and *Hibbertia circinata*. A few species are listed in Victoria under the *Flora and Fauna Guarantee Act 1988 (FFG Act)*, an indication of their broader conservation significance. We believe that other species warrant inclusion in NSW threatened species legislation. In this brief communication, we review the significant plant species of Mount Imlay National Park and describe the conservation work done to date by the NSW Department of Planning and Environment (DPE), Australian National Botanic Gardens (ANBG), Booderee Botanic Gardens (BBG) and the Royal Botanic Gardens Victoria, and that required in the future.



**Figure 2.** The steep eastern face of Mt Imlay on the 13<sup>th</sup> of January, 13 days after a fire, which burnt the entire *Eucalyptus imlayensis* population there. The fire burnt into the soil A horizon in places. Photo: Grant Brewer, NSW National Parks and Wildlife Service.

## Species of significance

### *Boronia imlayensis*

**Status:** EPBC Act - not listed; BC Act – not listed; FFG Act – not relevant

**Population size:** pre-fire 1000s, post-fire 10s of thousands

**Susceptibility to *Phytophthora cinnamomi*:** susceptible

**Fire response:** obligate seeder (killed by fire)

*Boronia imlayensis* is a shrub that grows to about 1.5 m tall (Figure 3a). It is endemic to Mount Imlay, where it is abundant but restricted to the northern part of the summit

ridge and adjoining slopes above the cliffs (Figure 3b), mostly where *Phytophthora cinnamomi* has until recently been absent. It is an obligate seeder, its entire population having been burnt and killed in the fire of 2019/20. Seedlings were not apparent in June 2020 six months after the fire but were numerous by November 2020; the population now undoubtedly exceeds the pre-fire number and is continuing to recruit. About 5% of the population flowered in spring 2021 but seed production was not assessed after that event. The species is susceptible to *Phytophthora cinnamomi* and may be killed by the pathogen, but appears to be much less susceptible than *Hibbertia circinata* with which it grows. The long-term effect of *Phytophthora cinnamomi* on the *Boronia imlayensis* population will depend on whether its recruitment exceeds its mortality. The species should be assumed to be at risk from this pathogen unless population monitoring assesses it as being able to persist despite occasional deaths.



**Figure 3.** a) The pink flowers and pinnate foliage of *Boronia imlayensis* (Photo: Andrew Morrison); b) this species grows up to 1.5 m tall with another endemic *Hibbertia circinata* (yellow flowers) on the summit ridge of Mount Imlay.

Cuttings were taken in July 2018 by staff of the ANBG for the establishment of an ex-situ conservation population. There was very limited success with propagation, and trials over a 15-year period have shown this species to be extremely difficult to propagate vegetatively. In autumn 2021, a small number of seedlings growing in places on Mount Imlay where they were unlikely to survive (e.g. along the walking track and where very dense) were removed and distributed between the ANBG and BBG to add to the small existing ex-situ populations. Future propagation of this species for translocation or ex-situ conservation will certainly be dependent on seed availability. However, at present, no seed is held in conservation seed banks, and seed storage requirements and germination cues for the species are not known.

Based on area of occupancy, extent of occurrence, fluctuations in population and threats, this species is likely to be eligible for listing as critically endangered under the EPBC Act according to guidelines for assessing the conservation status of native species (Department of Agriculture, Water and the Environment undated).

### *Eucalyptus imlayensis*

**Status:** EPBC Act – critically endangered; BC Act – critically endangered; FFG Act – not relevant

**Population size:** post fire, 48 individuals representing 17 genets

**Susceptibility to *Phytophthora cinnamomi*:** apparently not susceptible based on limited glasshouse tests and baiting of root material collected in the field

**Fire response:** resprouts from lignotuber after fire

*Eucalyptus imlayensis* is a multi-stemmed tree to 7 m tall, arising from a large lignotuber. It is endemic to Mount Imlay, where it is restricted to an area of approximately 3000 m<sup>2</sup> on the eastern face of the summit ridge. The species was identified in 2022 as one of 100 priority threatened species in Australia's Threatened Species Strategy Action Plan 2021 – 2026 (Department of Agriculture, Water and the Environment 2022b). Under this plan, in 2026, *Eucalyptus imlayensis* will be on track for improved trajectory by 2031.

At the first census of the population in 2001, there were thought to be about 80 individuals. Despite the small area in which they grow, an accurate count of the population was not possible until after the 2019 / 20 fire because of the difficult, steep terrain and dense growth of *Leptospermum scoparium*. James and McDougall (2007) found five genotypes in a sample of 27 accessible plants. The fire in 2019 / 20 allowed all plants to be easily accessed, tagged and sampled for further genetic analysis. In 2022, there were found to be 48 plants but only 17 genetic individuals (Simmons and James 2022). The clones range in size from 1 m<sup>2</sup> to about 235 m<sup>2</sup>. One of the genets identified in 2007 (represented by four plants) has since died, but the cause of death is unknown.

*Eucalyptus imlayensis* is threatened primarily because it will be many years until resprouting plants are reproductive and there was very little seed in storage prior to the fire, and so, without seed storage, any catastrophic event that destroys regenerating plants may lead to extinction. Before the fire, plants rarely produced seed although they often flowered. Plants resprouted well after the fire, with numerous shoots coming from most lignotubers (Figure 4); shoots had reached an average height of 110 cm by November 2021. Prior to the fire, the main threat to the population seemed to be competition from *Leptospermum scoparium* but an adverse effect from *Phytophthora cinnamomi*, which is present on the site, cannot be ruled out. Basal resprouts prior to the fire generally did not survive, possibly because of the intense competition. There has been considerable regeneration of *Leptospermum scoparium* since the fire but of more concern is the large number of seedlings of *Eucalyptus sieberi*, which have appeared. If they reach maturity, the structure of the community will be greatly altered.



**Figure 4.** A resprouting plant of *Eucalyptus imlayensis*, 23 months after the fire of 2019 / 20; multiple shoots arise from the large lignotuber wedged into fractured rock on the steep eastern slope.

There have been two attempts at enhancement planting in the summit area, in September 2011 and October 2018. On each occasion, 20 plants were grown from seed and planted in a range of habitats close to the summit (but not within the boundary of the existing population, where there was insufficient soil to plant seedlings). Growth was slow but 36 of the 40 plants were alive in October 2019, ranging in height from 14 cm to 170 cm tall, though none had flowered in that time. Plants were tallest where competition was least. All 36 plants were killed by the 2019 / 20 fire. The time to reproductive maturity for this species is unknown but, from seed produced plants in the wild, it is clearly more than 10 years. Three plants in the ANBG which were grown from seed in 2007 have yet to flower, so it takes more than 15 years to first flowering in cultivation.

It may be a decade or more until the resprouting plants produce seed and, if similar to pre-fire seed production, few genets will produce seed at any one time and seed production will be minimal. The development of a seed orchard at the ANBG is the goal of a current project between DPE and the ANBG. This would allow for the collection and storage of pollen from flowers of all genets when these appear, and controlled hand pollination to aid seed production. Grafting trials will be undertaken with the aim of replicating the 17 genets in an ex-situ collection. If grafting is unsuccessful, the production of plants using tissue culture techniques will be attempted as insurance against loss of the wild population.

As a last resort, some of the small quantity of seed currently in conservation storage may be used to grow plants for ex-situ seed production.

### *Hibbertia circinata*

**Status:** EPBC Act – critically endangered; BC Act – critically endangered; FFG Act – not relevant

**Population size:** pre-fire c. 200, post-fire 1000s but rapidly declining

**Susceptibility to *Phytophthora cinnamomi*:** highly susceptible

**Fire response:** obligate seeder (killed by fire)

*Hibbertia circinata* is a shrub growing to about 1.5 m tall with woolly stems and coiled hairs on its leaves (Figure 5a); it was recently separated from other taxa within *Hibbertia linearis* sens. lat. (McDougall et al. 2018). This species is endemic to the summit area of Mount Imlay, where it is co-extensive with *Boronia imlayensis*. Like *Boronia imlayensis* it is an obligate seeder and all of its mature population was killed by the fire of 2019 / 20. Seedlings were observed in May 2020, five months after the fire, and the population increased greatly compared with the pre-fire population of about 200 plants, appearing in parts of the summit where it had not been seen pre-fire. Up to 10% of the population was in flower in spring 2021. In glasshouse trials, this species was found to be highly susceptible to *Phytophthora cinnamomi* (McDougall and Liew, unpublished data), and deaths in the wild population have been numerous (Figure 5b). Indeed, no live plants were detected in some 4 m<sup>2</sup> monitoring plots within five months of the first measurement.

*Hibbertia circinata* has been successfully grown from cuttings at the ANBG and a small live population is maintained there and at BBG. There is no seed in storage, and the seed storage requirements and germination cues for the species are unknown.

The prognosis for the wild population of this species appears to be poor despite the large number of plants currently present. It might be maintained on Mount Imlay by using *Phytophthora*-free refugia and spraying with the chemical phosphite. Before the fire, plants grew most vigorously beneath the cliffs of the mountain; these may prove to be pathogen-free refugia because they don't seem to receive run-off from infested areas. Phosphite (an anionic form of phosphonic acid) has been shown to provide protection for some species and vegetation affected by *Phytophthora cinnamomi* (Barrett and Rathbone 2018) and has recently been applied in screening trials to *Hibbertia circinata* plants in the wild and in a glasshouse at the Royal Botanic Gardens Sydney. Plants in the glasshouse showed minor phytotoxicity but possible beneficial effects are still being assessed.



**Figure 5.** *Hibbertia circinata* a) grown from cuttings at ANBG, b) affected by *P. cinnamomi* on Mt. Imlay.

### *Olearia rugosa* subsp. *distalilobata*

**Status:** EPBC Act – currently being assessed for listing as endangered; BC Act – not listed; FFG Act – not listed

**Population size:** pre-fire c. 250, post-fire 85 (in August 2021)

**Susceptibility to *Phytophthora cinnamomi*:** unknown

**Fire response:** resprouted after fire (and no seedlings observed)

*Olearia rugosa* subsp. *distalilobata* is a shrub that grows to about 1.5 m tall and produces corymbs of flowers in spring (Figure 6). It has been recorded in eastern Victoria but the only population in NSW is in a north-facing gully on a western ridge of Mount Imlay. Other gullies on the mountain with similar aspect were searched in October 2019 but no further populations were located.

All plants on Mount Imlay were burnt in the 2019 / 20 fire but resprouting was noted five months afterwards. The population is confined to an area of about 500 m<sup>2</sup>. Although there are no obvious threats to the species on the mountain, numbers have declined since it was first documented there in 2015. The subspecies has also been recorded at seven sites in Victoria but only four of those were located during searches in 2007 (Andre Messina, Royal Botanic Gardens, pers. comm.). The total population size for all known sites was thought to be less than 500 plants prior to the 2019 / 20 fires, which also burnt much of its habitat in Victoria. The susceptibility of this taxon to *Phytophthora cinnamomi* is unknown but few daisies are known to be highly susceptible (Weste 2001); glasshouse testing of its susceptibility is recommended. *Olearia rugosa* subsp. *distalilobata* will probably be eligible for listing as endangered under the criteria used for the EPBC Act (area of occupancy, population size and fluctuations in populations) and is currently being considered for such a listing (<https://www.dccew.gov.au/environment/biodiversity/threatened/assessments/fpal>).

Cuttings were taken from plants in 2016 and 2019 and have been grown at the ANBG. The subspecies can reliably be propagated from cuttings but no seed is held in conservation seed banks, and the requirements for seed storage and germination are not known. Given the very small area in which

the subspecies grows on Mount Imlay, the establishment of more populations elsewhere on the mountain will be useful to spread the risk of local extinction.



**Figure 6.** *Olearia rugosa* subsp. *distalilobata* on Mount Imlay in October 2015.

### ***Persoonia brevifolia***

*Status:* EPBC Act - not listed; BC Act – not listed; FFG Act - critically endangered

*Population size:* few plants, but possibly overlooked when not in flower

*Susceptibility to Phytophthora cinnamomi:* unknown

*Fire response:* unknown

This shrub, which may grow up to 1.8 m tall, has only been seen twice by the authors in the past 23 years on Mount Imlay, and then only as plants no more than 20 cm tall. From herbarium collections, there appear to be just three populations: Mt Imlay, Nalbaugh Plateau (both in NSW) and near Yambulla Creek in the Genoa River catchment in Victoria. There have only been two collections this Century (both on Mount Imlay). Collection notes for the Imlay and Yambulla populations indicate that the species is uncommon. On the Nalbaugh Plateau it is described as occasional or common. All three locations were burnt in the 2019 / 20 fires. The current population size is unknown but clearly small on Mount Imlay. Further survey of known locations (especially in early summer when the species is in flower) is

urgently needed to assess post-fire recruitment and allow an assessment of conservation status.

The susceptibility of this species to *Phytophthora cinnamomi* is unknown but some species of *Persoonia* are highly susceptible (McDougall 2006). The rarity on Mount Imlay and the lack of tall individuals is suspicious of a species that is readily killed by this pathogen but that recruits occasionally from soil-stored seed. Like other *Persoonia* species, *Persoonia brevifolia* is extremely difficult to propagate from cuttings or from seed. No seed is held in conservation seed banks, and seed storage and germination requirements are not understood.

### ***Philotheca virgata***

*Status:* EPBC Act - not listed; BC Act – not listed; FFG Act - endangered

*Population size:* < 1000 plants pre-fire and post-fire

*Susceptibility to Phytophthora cinnamomi:* susceptible

*Fire response:* obligate seeder (killed by fire)

In NSW, *Philotheca virgata* is known only from Mount Imlay and the Nullica area to the north, where it is apparently rare. There are several hundred plants on Mount Imlay in two sub-populations, both of which are mostly *Phytophthora*-free. There may be more plants post-fire but the increase has not been as dramatic as with species such as *Hibbertia circinata*. Plants grow to about 1.5 m tall (and occasionally to 2m tall in the *Leptospermum scoparium* shrubland on the eastern slope). In Victoria, the species is found at only two sites in East Gippsland. It is widespread and common in western Tasmania and unlikely to be eligible for listing as threatened throughout Australia. However, Rozeffelds (2001) notes morphological differences between populations and so it is possible that the mainland and Tasmanian populations will ultimately be separated taxonomically. As genetic and geographic outliers, the mainland populations are undoubtedly significant regardless, and worthy of protection. *Phytophthora cinnamomi* was recovered from the roots of symptomatic plants on Mount Imlay in early 2022; many plants were symptomatic at that time and so the species is possibly highly susceptible and at risk on Mount Imlay.

Whilst *Philotheca virgata* can be propagated with moderate success from cuttings, any conservation efforts will be impacted by the lack of any seed in conservation seed banks and information on how to store or germinate seed.

### ***Prostanthera walteri***

*Status:* EPBC Act - not listed; BC Act – not listed; FFG Act - endangered

*Population size:* pre-fire < 100, post-fire < 1000

*Susceptibility to Phytophthora cinnamomi:* highly susceptible

*Fire response:* obligate seeder (killed by fire)

This sprawling shrub is, like *Persoonia brevifolia*, known in NSW only from Mount Imlay and the Nalbaugh Plateau. In Victoria it has been recorded at several sites in East Gippsland.

On Mount Imlay it occurs mostly in the *Leptospermum scoparium* shrubland of the eastern slope below the summit ridge. The species was rarely seen pre-fire but more common after the fire. It appears to be highly susceptible to *Phytophthora cinnamomi* with many symptomatic plants observed in early 2022, and the pathogen was readily recovered from roots. The fact that this species was largely present in areas containing the pathogen before the fire and that it is susceptible, suggests that some susceptible species like this may be able to persist in low numbers despite the pathogen. Disease escapes are not unexpected in the rocky habitat where there is little soil and run-off is unlikely to reach all parts of the slope. Periodic seed production and long soil seed storage could enable some susceptible species to survive in this habitat. Given that this species is regarded as endangered in Victoria, where it occurs at more locations, it may be eligible for listing under the EPBC Act as endangered in Australia. Much of its habitat was burnt in the 2019 / 20 fires.

Whilst this species can be reliably propagated from cuttings, like other threatened species on the mountain its conservation is impacted by the lack of stored seed in seed banks, and knowledge about how to successfully store or germinate seed.

### *Tetratheca subaphylla*

**Status:** EPBC Act - not listed; BC Act – not listed; FFG Act - vulnerable

**Population size:** < 1000

**Susceptibility to *Phytophthora cinnamomi*:** highly susceptible

**Fire response:** unknown

*Tetratheca subaphylla* is cryptic when not in flower, with its leaves reduced to small scales on narrow stems, making the plant look grass-like (Figure 7). This species was one of the first to disappear from the northern slopes of Mount Imlay after the arrival of *Phytophthora cinnamomi*. It is highly susceptible to infection, rapidly killed and apparently did not recolonise infested areas. The species has been recorded at several sites in the hinterland of the south coast of NSW (though, has not been relocated in post-fire surveys by the Royal Botanic Gardens Victoria), the western side of Kosciuszko National Park (where rare) and East Gippsland. It is regarded as vulnerable in Victoria and may be eligible for such a listing nationally if adequate data were available for its assessment. On Mount Imlay at least, while the species has re-appeared post-fire, there seems a chance that it will approach extinction in the coming decades.



**Figure 7.** Though cryptic when sterile because of its grass-like leaves, *Tetratheca subaphylla* is unmistakable when in flower. Photo: Andre Messina, CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>).

The species can be reliably propagated from cuttings, but again lacks any stored seed in conservation seed banks and information about the storage or germination of seed.

### Other species of note

There is a record of *Calotis glandulosa* (vulnerable under the BC Act and EPBC Act) in the Atlas of Living Australia, which we suspect is a data entry mistake. There is no vouchered specimen that can be checked and, based on where this species typically grows (i.e. grasslands and open woodlands of the southern and central tablelands), it is improbable in Mount Imlay National Park where there is no suitable habitat.

A few species are at or close to the edge of their range (e.g. *Leptospermum scoparium* and *Pseuderanthemum variabile*) on Mount Imlay and so their populations may have genetic significance for the species. *Pultenaea gunnii* was collected by von Mueller in 1860 from ‘Barren ranges near Mount Imlay’ (Corrick 1993) and may occur there. There are numerous records of this species in Victoria close to the NSW border. It is regarded as being highly susceptible to *Phytophthora cinnamomi* (Weste 2001) and might be listed as critically endangered in NSW if relocated.

Further taxonomic discoveries are possible on Mount Imlay, which may increase the conservation significance of the area. Until recently, *Boronia imlayensis* and *Hibbertia circinata* were included with more widespread taxa (*Boronia muelleri* and *Hibbertia linearis*). The same may be true for populations of *Epacris microphylla* and *Oxylobium ellipticum* on the summit ridge of Mount Imlay, which are superficially dissimilar to typical plants of these species. Shrubs of *Epacris microphylla* on Mount Imlay were up to 3 m tall but were all killed by the fire. This species is typically less than 1 m tall elsewhere in south-eastern Australia. The population of *Oxylobium ellipticum* on Mount Imlay has dense terminal floral racemes and leathery foliage unlike its low growing Alps form of the same name. Both are worth further taxonomic investigation.

## Conclusion

Curiously, many species growing in the summit area of Mount Imlay are obligate seeders, including the dominant tree of the sheltered eastern slopes, *Eucalyptus fraxinoides*. This suggests that fire is an infrequent visitor to the mountain or at least to the sheltered parts of the mountain that are normally moist in summer. If fire frequency increases greatly because of climate change then local extinction seems inevitable for many of the significant species found there. That said, rare fire may well be important for *Eucalyptus imlayensis* by reducing competition from the dominant shrub *Leptospermum scoparium*. *Phytophthora cinnamomi* has increased pressure on some species, which are likely to be pushed into small refugia on the mountain in the coming years. It is perhaps unsurprising that most of the species we discuss above are restricted to areas where *Phytophthora cinnamomi* is apparently absent (based on soil sampling and the presence of the highly susceptible *Xanthorrhoea australis*).

Many of the significant species of Mount Imlay are likely to be eligible for listing as threatened under State and Commonwealth legislation, and the area itself will warrant listing as an Area of Outstanding Biodiversity Value under Part 3 of the *NSW Biodiversity Conservation Act 2016*, having multiple threatened species, including three species of global significance, and irreplaceable biological distinctiveness (Department of Planning, Industry and Environment 2021). However, the listing process can be time-consuming and for a species like *Persoonia brevifolia*, will require additional survey to assess population size at sites where it occurs. In addition, funding is not guaranteed even when species and areas are listed in legislation. On Mount Imlay, it may not be essential to have all species listed in order to undertake effective recovery measures because action on the main threat, *Phytophthora cinnamomi*, for one species will benefit many species. Similarly, the effort required to obtain seed or cuttings for germplasm storage for one species will not be greatly different to that for all species. The highest priority actions are seed collection and *Phytophthora* mitigation. The latter action is likely to involve spraying of the summit ridge with phosphite, which will probably be most cost-effective if applied by helicopter. Surveys are also needed to assess the

significance of other life forms on Mount Imlay (e.g. fungi, insects, vertebrates) – it would be surprising if endemism and disjunction were a feature of only vascular plants.

Is Mount Imlay unusual in its number of endemics and share of locally rare species? Perhaps not; the region has many highly localised endemic plant species, some on mountain tops (e.g. *Nematolepis rhytidophylla* on Nalbaugh Plateau, *Acacia constablei* on Narrabarba Hill) and others on localised geological features (e.g. *Olearia astroloba* on limestone in East Gippsland and *Zieria buxijugum* on a rhyolite outcrop near Pambula). Indeed, the closest relative to *Eucalyptus imlayensis*, *Eucalyptus elaeophloia*, occurs only on Brumby Point, part of the high elevation Nunniong Plateau in East Gippsland, with many other highly localised plant species (Department of Sustainability, Environment, Water, Population and Communities 2011). Isolated plant populations may occur through speciation where long periods of isolation promote genetic change, rare dispersal events leading to disjunction, or fragmentation where habitat for a species was once widespread but becomes isolated through broad-scale environmental change (e.g. Raven 1972, Muellner-Riehl et al. 2019). At almost 900 m a.s.l., Mount Imlay is palpably isolated from other mountains; the nearest summit above 800 m being Egans Peak, almost 20 km to the north. Mount Imlay and many other peaks in south-eastern Australia have clearly been isolated for a long time, potentially facilitating speciation. However, climatic fragmentation may have contributed to species disjunctions in some cases. The Nunniong Plateau for instance shares several of its cool climate rare species with the Kosciuszko area.

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