Wild Otways Initiative
Project 4: Conserving threatened small mammals in the Otway Ranges, Bells Beach (Ironbark Basin) and Great Ocean Road hinterland.

Recovery management guidelines for the threatened Long-nosed Potoroo (southern), *Potorous tridactylus trisulcatus* in the Otways

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Front cover: Long-nosed Potoroo, Moggs Creek track 2022 (Images: Barbara Wilson Pty Ltd).

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1. Otway Ranges Long-nosed Potoroo Recovery Management Summary

This Species recovery management is specific to the Otways Ranges, Victoria. It is nested under the 2022 Threatened Species Scientific Committee Advice (see Extract in Appendix 1).

2. Description and taxonomy

The Long-nosed Potoroo (*Potorous tridactylus tridactylus*) is a medium sized macropod marsupial with a weight range of 660–1640 g and long hind limbs, enabling them to hop at great speeds(Johnston 2008). The forearms are short and muscular with short, strong claws, well adapted to digging. The species has small, rounded ears, large eyes.

Potorous tridactylus has three subspecies *Potorous tridactylus apicalis* occurs on the islands of Bass Strait and Tasmania. The two mainland subspecies are *Potorous tridactylus trisulcatus* the Southern Long-nosed Potoroo, which occurs south of the Sydney Basin and inhabits the Otways, and *Potorous tridactylus tridactylus* the Northern Long-nosed Potoroo which occurs north of the Sydney Basin.

3. Conservation Status and threats

Potorous tridactylus trisulcatus (Southern Long-nosed Potoroo) is currently listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) (EPBC Act) as Vulnerable (TSSC 2022). It is listed as Vulnerable due to the predicted decline of 33 percent but as high as 56 percent (80 percent confidence interval) in the next three generations as a result of the 2019-2020 bushfires compounding existing threats from habitat degradation and predation by European red fox (*Vulpes vulpes*) and cats (*Felis catus*) both feral and domestic. The species requires habitat that has been unburnt for long periods of time (>20 years). The species is unlikely to recover to pre-fire population abundance before the next bushfire event.

Threats to the long-nosed Potoroo have been identified (Woinarski *et al.* 2014) and by the Threatened Species Scientific Committee Conservation Advice 2022:

4. Conservation Threats in the Otway Ranges (not listed in order of priority)

- Inappropriate fire regimes e.g. too frequent, intense and broadscale (Severe consequence, across much of its range)
- Habitat loss, fragmentation, and small remnant refuge size (Severe consequence, but unclear of extent)
- Predation by foxes and cats (Moderate consequence, over a large extent)
- *Phytophthora* dieback Disease (Severe consequence, over a large extent)
- Climate change (Severe consequence, over a large extent)

Threats can operate synergistically and be cumulative, e.g., inappropriate fire management can result in loss of refuge habitats, loss of food resources, and increased exposure to predation. Increased foraging in open post-burnt areas can co-occur with an increase in predator activity, which may increase threats to a point where subpopulations disappear.

5. Conservation Actions in the Otway Ranges

5.1 Active mitigation of threats

Table 1: Threat mitigation actions

Action	Priority	Where	Who
Prioritise management and protection of identified refuges, consider exclusion zones during planned burning	High	All identified	**DEECA_ FFM/PV/GORCAPPA/relevant local government authorities**
Implement optimum fire regimes and fire control measures including prescriptions to maintain areas of mature dense vegetation with thick ground cover, especially refuges	High	Anglesea Carlisle Cape Otway Dune and headlands Painkalac Valley	**Forest Fire Management Vic (DEECA/PV).**
Implement management of *Phytophthora* infestation in all refuges and surrounding habitat where it is an identified risk	High	All identified risk	***DEECA_ FFM/PV/GORCAPPA/relevant local government authorities***
Implement intensive local-scale predator control programs, at and around important refuges. Ensure immediate and ongoing post-fire predator control following fires.	High	At identified high density sites	***PV/ GORCAPPA/relevant local government authorities***
Develop conservation covenants on lands with high value for this species	Low to Medium	At identified sites	***PV, Colac Otway Shire, Surfcoast Shire, CCMA***
Maintain and protect areas identified as climate change refuges; establish corridors to allow movement to modelled suitable habitat under climate change projections.	Medium-High	At identified sites	***DEECA_ FFM/PV/GORCAPPA/relevant local government authorities***
Identify high-risk subpopulations under climate change and catastrophic depletion scenarios and plan for emergency responses to translocate at-risk animals where needed.			***DEECA_ FFM/PV/GORCAPPA/relevant local government authorities***
Assess the need for, and feasibility of fenced areas to make insurance populations that are protected from feral predators, habitat degradation e.g., protect small populations in coastal habitat fragments.			***DEECA_ FFM/PV/GORCAPPA/relevant local government authorities***

5.2 Survey and monitoring priorities

Table 2: Survey and monitoring priorities

Action	Priority	Where	Who
Continue to monitor selected sites to confirm loss or recovery based on a designed integrated monitoring program across subpopulations linked to an assessment of management effectiveness.	High	**TBA – CEC**	**CEC/DEECA/PV/**
Define fine-scale distribution patterns across the subspecies' range, and the number of individuals in subpopulations	Medium	**Otways refuges sites**	**CEC**
Monitor the incidence of fire, and vegetation response, at key subpopulations	Medium – High	**Otways Refuge sites**	**FFM Vic MER Program**
Monitor the abundance of feral predators at key subpopulations, in response to management actions (e.g. with sites inside and outside the Otway Ark, program of intensive fox baiting).	Medium	**Otway Refuge sites**	**PV/DEECA**

5.3 Long nosed Potoroo Otway Refuges Spatial Data

Exact locations for Key Fauna Refuges, that includes Swamp antechinus, in the Otway Ranges is held by the Corangamite Catchment Management Authority Data Repository and Forest Fire Management Victoria, Barwon Southwest Region. The currency of the spatial data is maintained, they are available from the spatial data custodians, and they should be assessed as part of any Land Management activity in the Otway Ranges.

6. The Wild Otways Initiative Management of Long-nosed Potoroo.

The Wild Otway's Initiative (WOI) Project 4 aims are to improve the condition of the six *Environment Protection and Biodiversity Conservation* Act 1999 (EPBC) mammal species in the Otway Ranges and hinterland. These focal species are the Broad-toothed rat, New Holland mouse, Smoky mouse, Swamp antechinus, Southern brown bandicoot and Long-nosed potoroo. Field surveys of potential refuge habitat for these species is also a key deliverable of this project. A major output is to publish project outcomes that detail management prescriptions and guidelines for managers (e.g., Barwon-Otway District Forest Fire Management Victoria, DELWP Regional Biodiversity management, Parks Victoria (Pests & Disease Management and PV Fire), local government environmental and bushfire management and Corangamite Regional Catchment Authority) to support endangered native small mammal recovery in the Otways and manage the threat of species extinction so that key populations are resilient and secure in the longer-term.

Here we provide draft management guidelines for the threatened Long-nosed Potoroo (*Potorous tridactylus tridactylus*) in the Otway Ranges based on new knowledge gained though implementation of WOI projects (2020 -2023). This draft will be presented to land managers for incorporation into the development of specific, pragmatic management interventions that are considered during annual fire planning and land management activities.

7. Distribution, Biology, Ecology and Conservation Threats

7.1 Description and Distribution

The Long-nosed Potoroo (*Potorous tridactylus*) is a medium sized macropod marsupial with small, rounded ears, large eyes and a weight range of 660–1640 g (Johnston 2008). It has long hind limbs and short forearms with short, strong claws, well adapted to digging (Fig. 1).

There are three subspecies of *Potorous tridactylus: Potorous tridactylus apicalis* occurs on the islands of Bass Strait and Tasmania; *Potorous tridactylus trisulcatus* the Southern Long-nosed Potoroo, which occurs south of the Sydney Basin and inhabits the Otways; *Potorous tridactylus tridactylus* the Northern Long-nosed Potoroo which occurs north of the Sydney Basin.

The Southern Long-nosed Potoroo has a broad and fragmented distribution. It occurs between the Great Dividing Range, up to 800 m above sea level and down onto the coastal plains. The species is restricted to habitats receiving an annual rainfall greater than 760 mm (Seebeck 1981; Johnston 2008). The most northern records of occurrence are at Barren Grounds Nature Reserve and Budderoo National Park in New South Wales (Norton *et al.* 2010 a, b; NSW Office of Environment and Heritage 2016). The subspecies occurs in isolated habitat patches along the coastal plains of southern New South Wales and Victoria, and inland to the slopes and foothills of the Great Dividing Range. One island population exists at French Island in Western Port Bay, Victoria.

Frankham *et al.* (2016) found evolutionary scale connectivity, though geographic isolation by distance which structured the population of Southern Long-nosed Potoroo into seven groups (Barren grounds and Buderoo in New South Wales; East Gippsland, Lake Tyers, Wilson's Promontory, French Island, Naringal and Mount Clay State Forest and west to the South Australian Border).

Areas of importance for the subspecies in Victoria were identified via consultation, literature and records available via the Victorian Biodiversity Atlas (VBA) (Victoria State Government 2021) : East

Gippsland, Grampians Bioregion, Wilson's Promontory, French Island, Central Highlands, Otway Ranges, South-west Victoria.

The southern long-nosed potoroo inhabits a range of vegetation types, including rainforest, wet and dry woodland, scrubland, coastal heathlands, and often near creeks or gullies (Martin & Temple-Smith 2012; Andren *et al.* 2013). The species is matrix-sensitive and requires wooded habitat with dense vegetation in the shrub or ground layer to provide cover; at a local scale, areas of lower vegetation density increase feeding opportunities (Bennett 1990 a,b, 1993). Accordingly, the habitat critical to the survival of the southern long-nosed potoroo includes occupied forested habitats larger than 0.1 km2 (Bennett 1990a; b; Martin & Temple -Smith 2012).

Unoccupied forested areas may also be considered critical if they are adjacent or proximal to extant subpopulations, as they can provide future habitat for the southern long-nosed potoroo as either a natural range expansion or as a translocation site for at-risk populations. Areas of habitat that supported the southern long-nosed potoroo in the past, but from which they are now absent, for example, because of high predation following a bushfire event, are also habitat critical, as the subspecies could be reintroduced to these sites in the future. One example is the reintroduction of 35 southern long-nosed potoroo to Booderee National Park in 2014–2015 translocated from New South Wales state forests) [Forestry Corporation - Helping the long-nosed potoroo bounce back.]

Figure 1. Long-nosed Potoroo, left Carlisle heath, right Moggs Creek track (Images: Barbara Wilson Pty Ltd).

7.2 Biology and Ecology

Long-nosed Potoroo become sexually mature at one year of age; produce a single pouch young at a time, and have between two and three offspring per year (Seebeck *et al.* 1989; Johnston 2008, Woinarski *et al.* 2014). Although they can reproduce throughout the year they more frequently reproduce in breeding seasons (late winter to early spring) (Johnston 2008).

Long-nosed Potoroo are omnivorous, feeding on fruits, seeds, leaves, roots and flowers as well as invertebrates (Bennett & Baxter 1989). The most significant food source (30–90 percent of the diet) is hypogeal sporocarps (fruit bodies of underground fungi) (Claridge *et al.* 1993; Claridge & Cork 1994).

The species is complexly linked to forest ecology. Their digging of the soil for food improves aeration and the consumption of the underground fungi helps to disperse fungal spores (Claridge 1993; Frankham *et al.* 2011). Most of the fungi eaten are mycorrhizal species that form relationships with plants, where the fungi colonise the root system and provide increased water, nutrients and

carbohydrates from the soil in return for carbohydrates from the plant Claridge *et al.* 1993; Johnson 1995).

Long-nosed Potoroo occur in a range of vegetation types from coastal scrub and heathy woodland, to wet sclerophyll forest and rainforest (Norton *et al.* 2010; Andren *et al.* 2013). Optimum habitat has densely vegetated ground cover that facilitates daily shelter from predators and more open areas for night foraging (Norton *et al.* 2010; Andren *et al.* 2013). Thus a mosaic of dense and open vegetation is likely best for survival.

The species has often been recorded in gullies and near creeks, which provide refuge during fire and drought (Seebeck 1981; Claridge *et al. 1*993; Martin & Temple-Smith 2012). Studies suggest that canopy cover and habitat mosaic is more important than vegetative species (Catling *et al.* 2001; Arthur *et al.* 2012).

Although Southern Long-nosed Potoroos live in fire-prone habitats, they are most abundant at sites that are long (10–25 years) unburnt and numbers decrease rapidly post fire (Catling et *al.* 2001). Recovery is slow from 10 years after fire, concurrently with the closing tree canopy (Arthur *et al.* 2012). The species is then positively associated with both tree canopy cover and rainfall and negatively with post fire presence of the red fox (Catling *et al.* 2001; Arthur *et al.* 2012).

Long-nosed Potoroos are mostly solitary and a small home range of 0.19 km^2 - 1 km^2 (Johnson 1987; Frankham et al. 2011; Woinarski et al. 2014). Males have larger home ranges than females, overlapping distributions and dispersal capabilities of six to eight km (Johnson 1987; Frankham et al. 2014). The species has small neighbourhood sizes, male biased dispersal, limited gene flow (even between geographically close populations), and strong female philopatry (Frankham *et al.* 2014).

There have not been any robust estimates of population size for any of the subspecies (Martin & Temple-Smith 2012; Woinarski et al. 2014). However, estimates ranged in abundance from 23 (Long 2001) to 25 on French Island (Frankham 2011) 180 at Naringal (Bennett 1987). The east Gippsland subpopulations have been extensively surveyed and catch rates indicate that the coastal subpopulations are more abundant than other subpopulations (Victoria State Government 2021).

The southern long-nosed potoroo is restricted to patches of wet sclerophyll forest and heathland, isolated by extensive tracts of modified and unsuitable habitat (Seebeck 1981; Andren *et al.* 2013).

Genetic diversity in the long-nosed potoroo is high but spatially structured (Frankham 2016) but habitat loss and fragmentation are likely responsible for recent reductions in gene flow, evidenced in the regional genetic sub-structuring of subpopulations (Frankham 2016, Frankham *et al* 2014).

There is evidence that fox control can have a significant positive effect on persistence, activity and colonisation of the long-nosed potoroo (Robley *et al.* 2011; Claridge *et al.* 2010; Dexter and Murray 2009).

7.3 Conservation status and Threats

Potorous tridactylus trisulcatus (Southern Long-nosed Potoroo) is currently listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) (EPBC Act) as Vulnerable (TSSC 2022); at a state level it is listed as Endangered in South Australia (National Parks and Wildlife Act 1972), Threatened in Victoria (Flora and Fauna Guarantee Act 1998), Vulnerable in New South Wales (Threatened Species Conservation Act 1995). Under EPBCA Act it is listed as Vulnerable due to the predicted decline of 33 to 56 percent in the next three generations as a result of the 2019-2020 bushfires compounding existing threats from habitat degradation and predation by red fox (*Vulpes vulpes*) and cats (*Felis catus*). The species requires habitat that has been unburnt for long periods of time (>20 years). The species is unlikely to recover to pre-fire population abundance before the next bushfire event.

It is listed as Vulnerable under two criteria:

Criterion 1 A4 ce -Populations are predicted to have declined 36 percent in the year following the 2019-2020 bushfires. In the three generations following the bushfires populations are predicted to decline by 33 percent, but potentially by as much as 56 percent. This estimate does not include the potential for future catastrophic bushfire, as may be expected under climate change (CSIRO & Bureau of Meteorology 2015 and other post-fire threatening processes (predation by European red fox). The quality of habitat is predicted to decline, and predicted population declines will likely also result in contracting EOO and AOO for the species.

Criterion 2 B2ab(ii,iii,iv,v) – The extent of occurrence (EEO) is estimated at 216 962 km^2 and the area of occupancy (AOO) is estimated at 1856 km^2 both are inferred to be contracting, state that The species has a "highly fragmented distribution" between Sydney Basin and south-west Victoria (Woinarski et al 2014). The small dispersal capabilities of the species, as well as the suitable habitat requirements result in subpopulations being isolated from each other.

The area of occupancy is limited, and the geographic distribution is precarious for the species' survival because it is severely fragmented, and a decline in extent of occurrence, area of occupancy, habitat, number of individuals and number of locations may be inferred or projected.

Threats to the long-nosed Potoroo have been identified (Woinarski *et al.* 2014) and by the Threatened Species Scientific Committee Conservation Advice (2022) and include:

1. Inappropriate fire regimes e.g too frequent, intense and broadscale (Severe consequence, across much of its range)

2. Habitat loss and fragmentation, - land clearing (from urban, residential and agricultural land development and change) (Major consequence, over parts of its range)

3. *Predation by foxes* (Major consequence, over entire range)

4. *Predation by cats* (Major consequence, over entire range)

5. *Habitat degradation due to trampling and grazing by livestock and feral herbivores* (Minor, over parts of range)

6. *Habitat degradation due to invasive weeds* (Unknown consequence, parts of range)

7. *Climate change- drier and hotter* (Major consequence, over entire range)

8. *Timber harvesting* (minor consequence, parts of range)

9. *Forest dieback – Phytophthora cinnamomi,* myrtle rust *(Austropuccinia psidii)* (Unknown consequence, parts of range)

Threats can operate synergistically and be cumulative, e.g., inappropriate fire management can result in loss of refuge habitats, loss of food resources, and increased exposure to predation. Increased foraging in open post-burnt areas can co-occur with an increase in predator activity, which may increase threats to a point where subpopulations disappear.

7.4 Conservation Actions

The Threatened Species Scientific Advisory Committee recommended priority actions to mitigate against key threats, undertake stakeholder and community engagement, survey and monitoring and research priorities (**Appendix 1**).

Primary Conservation and management priorities included:

Habitat loss, degradation, disturbance and modifications

• Avoid further loss and fragmentation of habitat and where feasible, promote the restoration and enhancement of habitat connectivity between fragmented habitat patches
• Outside of Parks promote the conservation of habitat through conservation agreements,
• Ensure adequate protection measures to protect the viability of populations in areas subjected to timber harvesting and associated management activities
• Assess the effectiveness of current and new forestry management practices in ameliorating disturbance to the habitat of the species
• Implement measures to reduce road mortality, such as underpasses, road escape ramps
• Where *P. cinnamomi* occurs within or proximal to subpopulations, implement appropriate disease management plans and hygiene protocols (O'Gara 2005).

Climate Change and fire

• Ensure that a high proportion of habitat is maintained in a long unburnt condition (>20 years).
• Ensure immediate and ongoing post-fire predator control following fires.
• If fire is essential and long unburnt patches are not possible, implement regimes to include: buffers that prevent bushfire or planned burns from impacting habitat and food sources; a post-fire predator control program, a post-fire population monitoring program.
• Provide maps of known long-nosed potoroo sites to Fire Services and seek inclusion of actions to mitigate impacts.
• Maintain and protect areas identified as climate change refuges; establish corridors to allow movement to modelled suitable habitat under climate change projections.

Invasive species threats from predation, competition

• Develop and implement strategies to control predation by the red fox and feral cats, and competition from feral pigs, as detailed in the relevant Threat Abatement Plans (TAPs)
• Implement grazing management actions with land managers and community groups; prevent further introduction of pest animals and control those that are already present
• Develop and implement strategies to manage weeds consistent with the Australian Weeds Strategy 2017-2027 (Invasive Plants and Animals Committee 2016).
• Promote the registration and responsible management of domestic cats and dogs, in urban areas adjacent to known southern long-nosed potoroo populations.

Captive breeding and other ex situ recovery actions

• Identify population thresholds to initiate captive breeding program and identify key subpopulations and suitable habitats for a future release of captively bred animals and wild-to-wild translocations.
• Assess the need for, and feasibility of fenced areas to make insurance populations that are protected from feral predators, habitat degradation e.g., protect small populations in coastal habitat fragments.
• Identify high-risk subpopulations under climate change and catastrophic depletion scenarios and plan for emergency responses to translocate at-risk animals where needed.
• Identify and translocate at-risk subpopulations from forestry tenures to suitable habitats on protected tenures.

8. Distribution and status of Long-nosed Potoroo in the Otways

8.1 Previous research and information (1975 -2020)

In Victoria the habitat of the Long-nosed Potoroo is characterised by dense vegetation in the ground and shrub layers (DEPI Victoria, 2013). They use a range of floristic associations, apparently preferring

a mosaic of open and closed patches (Bennett 1993). Most records are from heathy woodland, though they also occupy lowland and damp forest types and in the Otway Ranges there are records from wet forest to an altitude of about 650 m (Seebeck 1981, Seebeck et al. 1989). Measured population densities include 0.19 to 2.55/ha at Naringal (Bennett 1993), and 1.4/ha at Lake Tyers in East Gippsland.

Although the populations in the Great Otway National Park have been identified as important (DEDPI 2013), there has been little surveying or research undertaken. Work accomplished in similar habitats west of the Otways is however enlightening. Research was undertaken on the species (1980-82) at Naringal in forest vegetation dominated by *Eucalyptus obliqua*, with a sclerophyllous understorey including *Acacia verticillata, Banksia marginata, Leptospermum juniperinum, Lomandra longifolia, Pteridium esculentum, Tetrarrhena junca and Tetratheca ciliata*. The species was found to be locally common in forest fragments despite a land-use history of extensive disturbance and fragmentation of forests over the past century (Bennett 1990). At 3 sites one within a 10-ha forest remnant and two within narrow strips of forest vegetation on road reserves the species was captured frequently 676, 52 and 97 respectively (Bennett 1987, 1993). Whereas the distribution of P*. tridactylus* on a regional scale emphasises the importance of dense vegetative cover, this study found that on a finer spatial scale microhabitat use indicates the importance of vegetation mosaics that include both dense cover for diurnal shelter and more-open, floristically diverse vegetation for foraging (Bennett 1993).

Dietary studies of the species at Naringal using faecal remains found the species to be omnivorous: the main component of the diet was fungi, and other important items included hard-bodied arthropods, vascular plant tissues, seeds and fleshy fruits (Bennet and Baxter 1989). There was a seasonal switch in the relative proportions of the main dietary components during autumn and winter, the main components were fungi and seeds while in spring and summer, fewer fungi were eaten and the proportions of arthropods, plant tissues, fleshy fruit and flowers in the diet increased. Identification of fungal spores revealed the presence of at least 50 species in the diet, most of which have a hypogeal fruiting habit emphasised the role of this mycophagous species in the health of this forest ecosystem (Bennet and Baxter 1989).

Recent work (2009-10) investigated the ecology of the species and impacts of fire and foxes in south-west Victoria, covering over 40,000 ha of public land across five areas; Lower Glenelg and Cobboboonee National Parks, Annya, Mount Clay and Hotspur State Forests (Smith 2013). Dominant EVCs across the area included Heathy Woodland, Damp Sand Herb-rich Woodland, Lowland Forest and Wet Heathland dominated by brown stringybark (*Eucalyptus baxteri*), messmate (*Eucalyptus obliqua*), and a dense understorey dominated by austral grass trees (*Xanthorrhoea australis*), austral bracken (*Pteridium esculentum*), silver banksia (*Banksia marginata*), wiry spear grass (*Austrostipa muelleri*), tea-tree (*Leptospermum continentale* and *L. myrsinoides*) and beaked hakea (*Hakea rostrata*).

At 240 monitoring sites Long-nosed potoroos were detected at 21 sites in each of 2009 and 2010, but at only 10 of these sites in both years (Smith 2013). Modelling found that the species is more likely to occupy Heathy Woodland and Mosaic EVC sites than those of other EVCs. At the microhabitat level Potoroos were present at sites with higher mean percentage lateral vegetation cover and higher mean vegetation density between 20 and 80 cm compared to sites where they were absent. Although it was predicted that fox control and Time-since-fire would play an important role in distinguishing between sites with and without potoroos this was not the case (Smith 2013). Any relationship between fox control and potoroo populations in the study region may become evident as the length of time since baiting began increases (Smith 2013). The lack of a clear association with fire variables was unexpected. Neither time-since fire nor fire frequency contributed strongly to macrohabitat models,

nor did they show clear trends relating to the presence of the species. The classification of large areas of land with the same fire history, which may obscure fine-scale variation in burn patterns, may have contributed to the lack of relationship between species presence and these fire variables (Smith 2013). Fire does not burn in a homogenous manner; burn intensity varies and some vegetation is bumrt entirely and other is left intact or in part (e.g. canopy remains). These differences can affect the ability of a species to remain in the area, and survive in habitat that, though long unburnt, is classified as recently burnt, blurring relationships between species and fire history.

The study found that long nosed potoroos experienced high probabilities of extinction after an experimental fire, and low probabilities of colonisation for up to one and a half years post-fire (Smith 2013). The potoroos were however able to make use of unburnt vegetation patches, with extinction and colonisation post-fire linked to their presence. The survival and behaviour of individual long nosed potoroos were also monitored immediately after an experimental fire, and then again at 16 months after fire, focussing on their use of unburnt patches compared to the burnt matrix for nesting and foraging (Smith 2013). Unburnt refuges of intact vegetation apparently provided essential post fire habitat for the species. Unburnt vegetation patches were used exclusively for nesting, at least up to16 months after fire. During active foraging times potoroos used unburnt patches more than 45% of the time. It was proposed that these unburnt patches functioned as refuges by providing key resources (e.g. appropriate nesting sites, protection from predators) to allow ongoing survival (Smith 2013).

WOI 2021

The evidence for the current distribution of the species across the Otways was limited. Under the WOI program analysis of historical and recent mammal occurrence data across the Otways employing a range of databases (Wilson et al. 2021a) found the Long-nosed Potoroo is widely distributed across the Otways with a total of 827 Long nosed Potoroo records between 1918 – 2021 (Fig. 2). The species records by decade include two records (1930-47), 51 records (1960s), 25 records (1970s), 16 records (1980s), 12records (1990s), 7 records (2000s), 569 records (2010s) 43 records (2020s). The bulk of records have arisen from intensive camera monitoring since 2010 (DELWP, University of Melbourne, Otway Ark). High records from recent camera trapping and live trapping in the 2010s indicate there are areas of suitable habitat across much of the Otways landscape and possibly strong populations. Occurrences in the eastern Otways predominantly in coastal dune vegetation and vegetation in gullies with few inland locations.

Analyses of the species distribution (1975 – 2021) in relationship to Ecological Vegetation Communities (EVCs) found that across the Otways the species has been recorded predominantly in Wet or damp forests (280), Dry forests (190), Heathy woodlands (186), Shrubby foothill Forest (159), Lowland forests (103) and Riparian scrub/swampy riparian woodland complex (37) (Wilson *et al.* 2021b).

Distribution records of the LNP in the eastern Otways the species is located predominantly in Heathy woodlands and Riparian scrub/swampy riparian woodland complex particularly Anglesea Heath, in Lowland forest, Shrubby foothill forest, Herb rich foothill forest/ Shrubby foothill forest complex between Aireys Inlet to Fairhaven and Wenslydale to Deans Marsh (Wilson *et al.* 2021b.). In the west Otways the species records are restricted to Heathy woodlands and Riparian scrub/swampy riparian woodland complex in Carlisle Heath southwest of Gellibrand and in Shrubby wet forest to the southeast of Carlisle. Across the central south Otways the LNP is located in Heathy woodlands and Riparian scrub/swampy riparian woodland complex in the Carlisle Heath southwest of Gellibrand and predominantly in Wet Forest and Shrubby wet forest southeast of Carlisle Heath between Lavers Hill and Hordern Vale. LNP occurs across the central east Otways area inland from Lorne to Wye River in

Herb rich foothill forest/ Shrubby foothill forest complex, Shrubby wet forest, Shrubby foothill forest and Wet Forest.

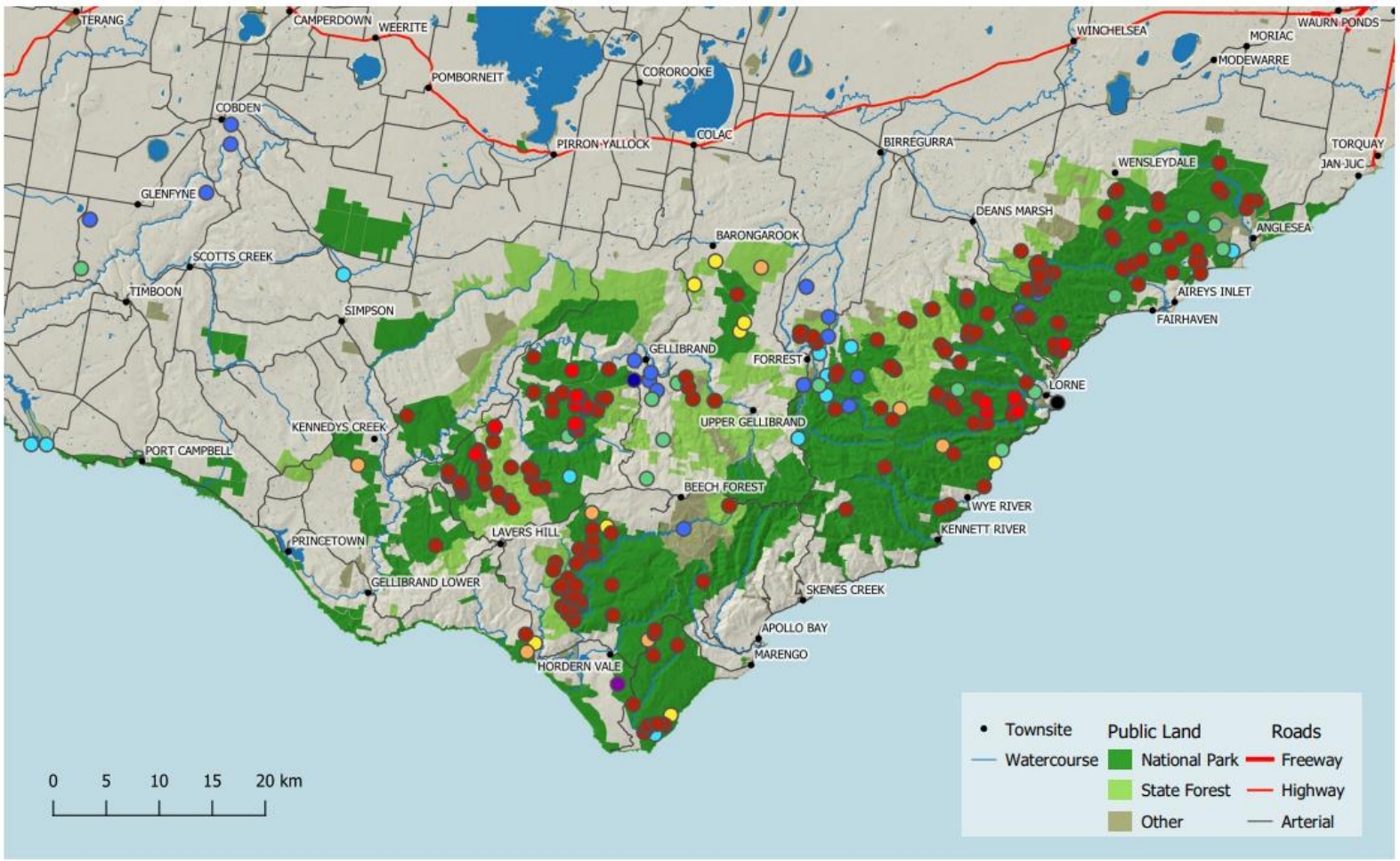

***Figure 2*. Records of long nose potoroo occurrence across the Otway Ranges 1957 – 2021 (Wilson *et al*. 2021a)**

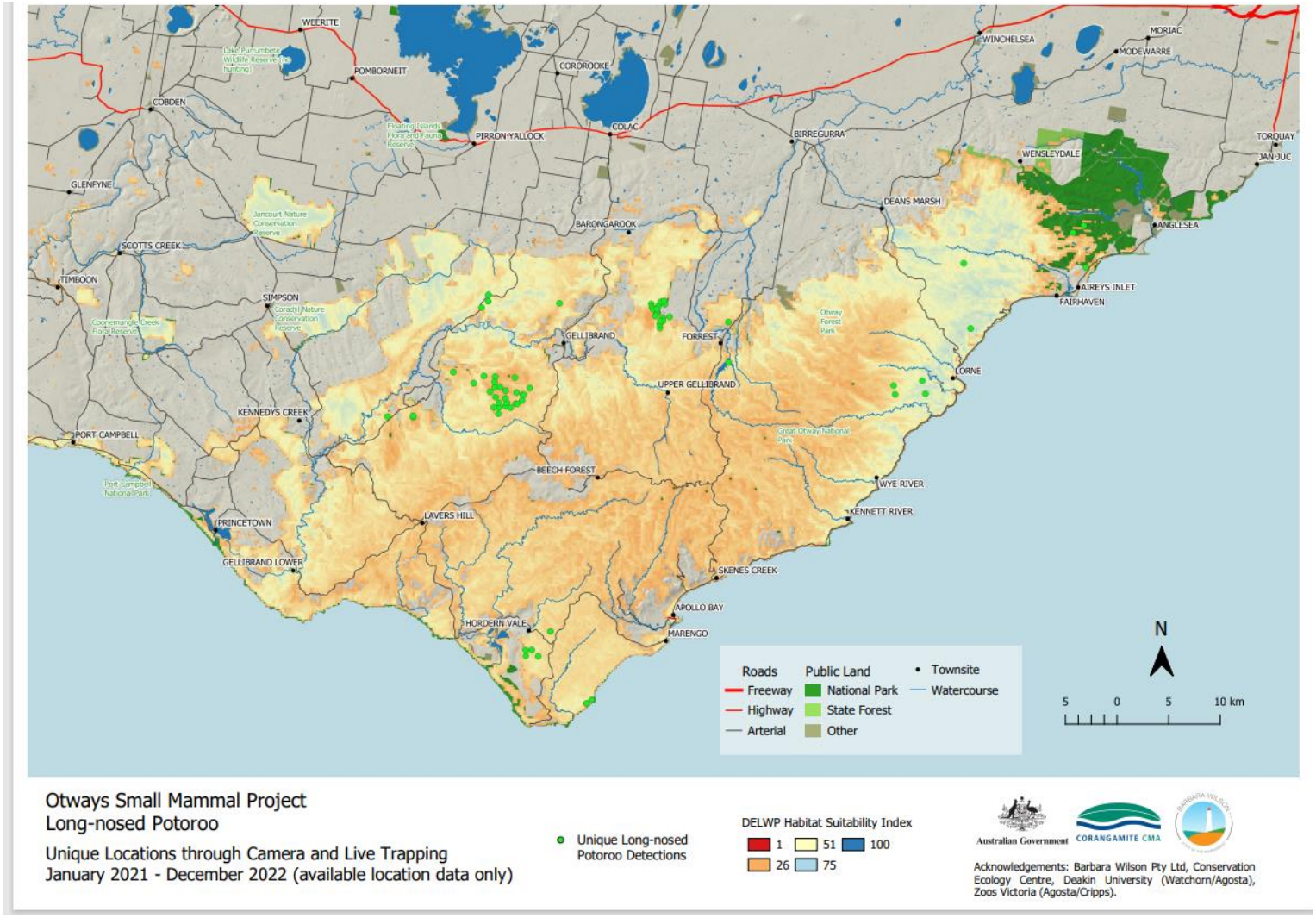

Figure 3. **Unique locations recorded for long nosed potoroo (2021-2022)**

9. Wild Otways Initiative recent surveys and current status (2021 – 2022)

9.1 Background to recent surveys

Following the analyses of records (1975 – 2021) trapping and camera trapping gap surveys were undertaken (2021 -2022). The gaps in the records guided the surveys to include the following:

1. Resurvey known sites of notable healthy populations (1975 -2007) in the eastern Otways
2. Targeted surveys in suitable habitat in the eastern Otways including small patches identified as potential refuges e.g., coastal dunes, gullies connecting dunes and inland habitat
3. Targeted surveys in the heathy woodlands of the central and western Otways including Carlisle Heathy woodland.
4. Targeted surveys in suitable habitat identified as potential refuges e.g., coastal dunes, gullies to west of Aireys Inlet to Port Campbell

9.2 Results

- Camera and live trapping identified 1777 records of Long nosed potoroo (Table 1), and the species was recorded at 74 unique camera locations (Fig. 3).

Table 3: Otway Long nosed potoroo records (1910s - 2020), January 2021 – December 2022.

Threatened Species	Years	No. of records	Databases/sources of data
Long-nosed potoroo	1918 – 2021 2020s	827 43	VBA, WD, DW (DU), CEC, OA, PB, UM (MR, ZB), DELWP FFMV VBA
	2021 -22	**166** **29** **1582** **Total 1777**	**WGPS** **DW (DU)** **CEC surveys**

VB Victorian Biodiversity Atlas, MV Museums Victoria, KR Kevin Rowe, DU Deakin University, DW D. Watchorn, CEC Conservation Ecology Centre, OA Otway Ark, ZV Zoos Victoria, PB Phoebe Burns, SK Sakib Kazi, UM University Melbourne MR M. Rees,.ZB Z. Banikos, Hawkeye (DELWP) Fire Ecology, DELWP FFMV, WD Wilson database, WGPS Wilson *et al* Gap Surveys. *2019 – data not previously available

9.2.1 Eastern Otways

- Limited occurrences inland between Batsons Track and Nos 2 Road, Moggs Creek track (high abundance in wetter habitat).

9.2.2 Central Otways

- Carlisle heathland very high occurrence (24 sites) and abundance
- Montys and Egans Track, West Barwon Reserve occurrences
- Barongarook, Hordern Vale, very high occurrences and abundance

9.2.3 Cape Otway:

- Records at Blanket Bay (very high occurrence)

9.2.4 Aire River, Johanna

- No records

9.2.5 Port Campbell:

- No records

Gap surveys appear to have improved the known distribution and abundance of species records across the Otways. Camera trapping resulted in 74 unique locations. Occurrences in heathy woodland, shrubby wet forest; shrubby foothills forest and shrubby dry forest offering complex vegetation and a limited recent fire history (Fig 4). Occurrence and capture rates are very limited in the eastern Otways and improve more broadly across the landscape towards the central and western Otways.

Figure 4: Habitat of Long Nosed Potoroo across the Otways a) Wet heath, Heathy woodlands Carlisle, b) Coastal dune scrub/dune grass mosaic Hutt Gully- Urquharts Bluff c) Moggs Creek Track refuge Shrubby foothill forest, Wet Forest, d)Parker River Inlet Shrubby wet forest, Shrubby foothill forest, Wet Forest, Coastal dune scrub

10. Key fauna refuges – Long-nosed Potoroo

Exact locations for Key Fauna Refuges, that includes Long nosed Potoroo, in the Otway Ranges is held by the Corangamite Catchment Management Authority Data Repository and Forest Fire Management Victoria, Barwon Southwest Region. The currency of the spatial data is maintained, they are available from the spatial data custodians, and they should be assessed as part of any Land Management activity in the Otway Ranges.

The key threatening processes that need to be considered or managed within each of these refuges are provided in Table 2 and a generic map showing spatial distribution of these refuges is shown in Figure 5.

10.1 Eastern Otways

10.1.1 Moggs Creek Track

The Moggs Creek Track to Seaview Road refuge area is at the confluence of Grassy, Spout, Coalmine, Moggs (and adjacent Painkalac Creek) and is approximately 1 km diameter (~300 ha). Recording of long nosed potoroo is of high significance.

10.1.2 Between Nos 2 Road, Denhams and Batson Tracks

Long nosed Potoroo was recorded at three sites, sparsely distributed.

10.2 Central, western Otways

10.2.1 Reedy and Sheoak Creek, Sharps Road

Long nosed Potoroo was recorded in 2021 at five sites, sparsely distributed.

10.2.2 Cape Otway

Records at Blanket Bay at 4 sites and very high occurrence

10.2.3 Forrest-Yaugher

One site

10.2.4 Carlisle Heath, Egans Track, Montys Track

Long nosed Potoroo was recorded at 30 sites, widely distributed, this area represents a strong macro refuge for the species.

10.2.5 Porcupine Creek

Long nosed Potoroo was recorded at many sites, widely distributed, this area represents a strong macro refuge for the species.

10.2.6 West Barwon Reserve, Barongarook, Hordern Vale,

Very high occurrences and abundance

Table 4. Significant refuges across the Otways for Long nosed potoroo 2021 -2022

Vegetation communities: HW, heathy woodland; SH, sandy heathland; HLF, heathy lowland forest; EW, estuarine woodland; CHS, coastal headland scrub; CS, coastal scrub; SWF, shrubby wet forest; SFF shrubby foothills forest; SDF shrubby dry forest; DHS, damp heath scrub. Ecological vegetation class is the standard unit for classifying vegetation types in Victoria, based on floristics, lifeforms and ecological characteristics. *Erosion vulnerability (Vic Coastal Hazard Assessment/ and associated risk rating (CoastKit (marineandcoasts.vic.gov.au)), VH, Very High; H, High; M, Medium; na, not applicable, *Phytophthora* risk: VH, Very High; H, High; M, Medium; L Low; na, not applicable

Region	Location description	Area ha	EVC	*Erosion vulnerability	*Phytophthora* risk
Eastern Otways					
Moggs Creek Track	Forest gully complex associated with headwaters near Moggs Creek, Coalmine Creek, Spout Creek, Grassy Creek and (to the west) Reedy Creek. Increased moisture resilience.	942	SWF, SFF, SDF	na	L
Between Nos 2 Road, Denhams and Batson Tracks	Inland heathland, wet gully	3	HW	na	H
Central – western Otways					
Reedy Creek, Sharps Road, Sheoak Creek	Inland Forest gully complex, wet gully	100	SWF, SFF, SDF	na	M
Forrest-Yaugher	Inland heathland, wet gully	200	HW	na	VH
Cape Otway, Blanket Bay	Wet forest gully, dunes	200	SWF, SFF, SDF	na	H
Carlisle, Egans, Montys Tracks	Inland heathland, wet heath	> 1000	HW	na	VH
Porcupine Creek	Inland heathland, wet heath	922	HW	na	VH
West Barwon Reserve, Barongarook, Hordern Vale	Inland heathland, Forest gully complex wet heath	NN	HW	na	VH

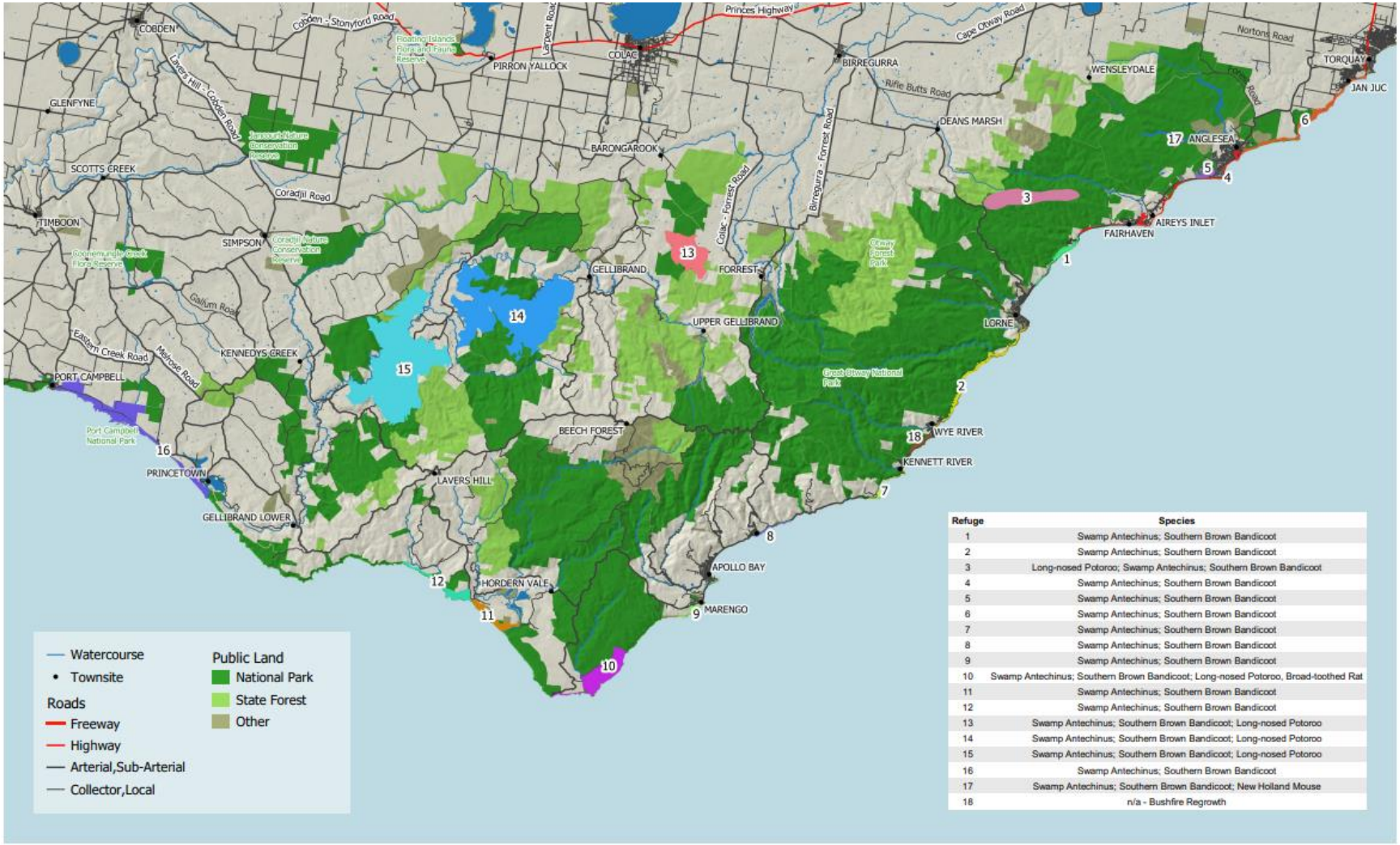

Figure 5. Spatial distribution of Key Fauna Refuges in the Otway Ranges. Accurate spatial data to be accessed from the Corangamite Catchment Management Authority or Forest Fire Management Victoria, Barwon Southwest Region.

11. Long-nosed Potoroo ecology, populations, interactions with fire and predators – WOI Conservation Ecology Centre Projects

An intensive study of Long-nosed Potoroo ecology, populations and the species interactions with fire and predators has been led by the Conservation Ecology Centre as part of the Wild Otways Initiative. Pre and post fire tracking of Potoroos has been conducted in Carlisle heath (Le Pla 2021, 2022). In 2020 of 6 of animals radio tracked all died within 2 weeks of burn, evidence that they showed strong site fidelity to pre fire ranges. In 2021 2 of 7 potoroos died with evidence of fox predation (Le Pla 2022). This time deaths occurred over a 5-week period, again reluctance to move home ranges. The results are indicative of long period of vulnerability to predation in the post fire period. A question remains as to whether survival can improve with patchier burns.

Trapping in the Carlisle Heath June – July 2022 resulted in 247 captures, 80 individuals across 3 sites (2 burnt in 2021, 1 control unburnt site), indicating that the population of long nosed potoroos at Carlisle is high (Stylli 2022).

12. Threats to Long-nosed Potoroo across the Otways

Threats to the Long-nosed potoroo across the Otways are a reflection of those that have been identified for the species within its full distribution (Woinarski *et al.,* 2014; TSSC 2022). However, the priorities are somewhat different and are specific to the Otways.

Here we have not ranked these threats but assessed the current consequences and extent of each. It is highly likely that these threats will have interactive or cumulative impacts on the species (note – as Land Managers adopt this plan for the Otway Ranges, changes in relation to the management of existing or newly emerging threats should become apparent through an Adaptive Management framework).

12.1 Inappropriate fire regimes e.g. too frequent, intense and broadscale (Severe consequence, across much of its range)

Long-nosed Potoroos are most abundant at sites that are long (10–25 years) unburnt and numbers decrease rapidly post fire (Catling et *al.* 2001). Recovery is slow from 10 years after fire, concurrently with the closing tree canopy (Arthur *et al.* 2012).

In western Victoria long nosed potoroos experienced high probabilities of extinction after an experimental fire, and low probabilities of colonisation for up to one and a half years post-fire (Smith 2013). The potoroos were however able to make use of unburnt vegetation patches. They were used exclusively for nesting, at least up to16 months after fire and for foraging. It was proposed that these unburnt patches functioned as refuges by providing key resources (e.g. appropriate nesting sites, protection from predators) to allow ongoing survival (Smith 2013).

There is recent evidence that the species is highly vulnerable to burns in Carlisle Heath where the species has been heavily predated by foxes up to 4 weeks post burn (La Pla, Stylli 2021, 2022 2023). Susceptibility is related to the high site fidelity of the species.

12.2 *Predation by foxes and cats* (Moderate consequence, over a large extent)

There is evidence that fox control can have a significant positive effect on persistence, activity and colonisation of the long-nosed potoroo (Robley *et al.* 2011; Claridge et al. 2010; Dexter and Murray 2009). Predation by foxes has been demonstrated for this species in the Otways (Hradsky 2020, Hradsky *et al.* 2017, Le Pla 2021, 2022), and population-level risks are assumed to be substantial. Risks may be magnified where *Phytophthora* dieback, fire or grazing has reduced ground cover (Hradsky 2020, Hradsky *et al.* 2017; Le Pla 2021, 2022; Wilson *et al.* 2020).

12.3 Habitat loss, fragmentation, and small remnant refuge size (Severe consequence, but unclear of extent)

Across its range the long-nosed potoroo is restricted to patches of wet sclerophyll forest and heathland, isolated by extensive tracts of modified and unsuitable habitat (Seebeck 1981; Andren *et al.* 2013). In the Otways the species' habitat has been cleared for agriculture, recreation, housing and these effects continue to be a threat in the Otways.

12.4 Reduced genetic diversity (Unclear)

Genetic diversity in the long-nosed potoroo is high but spatially structured (Frankham 2016). Habitat loss and fragmentation are likely responsible for recent reductions in gene flow, evidenced in the regional genetic sub-structuring of subpopulations (Frankham 2016, Frankham *et al.* 2014). Evidence of reduced genetic diversity is unclear in the Otways.

*12.5 Phytophthora dieback Disease (*Severe consequence, over a large extent*)*

Phytophthora cinnamomi infestation has been identified as a major threat at sites where the species has been recorded historically but is no longer present in the eastern Otways (Harvey St, Bald Hills Road). Long -term (26 years) studies have found substantial disease progression, significant declines in plant species richness and susceptible species; and increases in cover of resistant sedges and grasses in post-disease areas (Laidlaw and Wilson 2003; Wilson *et al.* 2020). Declines in numbers of mammal species and captures in post-disease areas were highly significant (Laidlaw and Wilson 2006). Threatened mammals such as Long nosed potoroo are at significant risk due to loss of susceptible keystone plant species e.g., *Xanthorrhoea australis* that contribute to complex vegetation structure, nesting and resting sites, and associated food resources (invertebrates, fungi).

*12.6 Climate change (*Severe consequence, over a large extent*)*

Drier conditions under *El Nino* will substantially change the characteristics of the species' preferred habitat, exacerbated by the small size of remaining habitat patches and the species' limited dispersal ability. It is unclear how *La Nina* conditions of increased rainfall and flooding as experienced 2021- 22 will impact on the species.

13. Management prescriptions and guidelines to support recovery of Long nosed potoroo in the Otways Ranges

Conservation Actions

Table 5. Active mitigation of threats

Action	Priority	Where	Who
Prioritise management and protection of identified refuges, consider exclusion zones during planned burning	High	All identified	**DEECA_ FFM/PV/GORCAPPA/relevant local government authorities**
Implement optimum fire regimes and fire control measures including prescriptions to maintain areas of mature dense vegetation with thick ground cover, especially refuges	High	Anglesea Carlisle Cape Otway Dune and headlands Painkalac Valley	**Forest Fire Management Vic (DEECA/PV).**
Implement management of *Phytophthora* infestation in all refuges and surrounding habitat where it is an identified risk	High	All identified risk	***DEECA_ FFM/PV/GORCAPPA/relevant local government authorities***
Implement intensive local-scale predator control programs, at and around important refuges. Ensure immediate and ongoing post-fire predator control following fires.	High	At identified high density sites	***PV/ GORCAPPA/relevant local government authorities***
Develop conservation covenants on lands with high value for this species	Low to Medium	At identified sites	***PV, Colac Otway Shire, Surfcoast Shire, CCMA***
Maintain and protect areas identified as climate change refuges; establish corridors to allow movement to modelled suitable habitat under climate change projections.	Medium-High	At identified sites	***DEECA_ FFM/PV/GORCAPPA/relevant local government authorities***
Identify high-risk subpopulations under climate change and catastrophic depletion scenarios and plan for emergency responses to translocate at-risk animals where needed.		At identified sites	***DEECA_ FFM/PV/GORCAPPA/relevant local government authorities***
Assess the need for, and feasibility of fenced areas to make insurance populations that are protected from feral predators, habitat degradation e.g., protect small populations in coastal habitat fragments.		At identified sites	***DEECA_ FFM/PV/GORCAPPA/relevant local government authorities***

Table 6. Survey and monitoring priorities

Action	Priority	Where	Who
Continue to monitor selected sites to confirm loss or recovery based on a designed integrated monitoring program across subpopulations linked to an assessment of management effectiveness.	High	**TBA – CEC**	**CEC/DEECA/PV/**
Define fine-scale distribution patterns across the subspecies' range, and the number of individuals in subpopulations	Medium	**Otways refuges sites**	**CEC**
Monitor the incidence of fire, and vegetation response, at key subpopulations	Medium – High	**Otways Refuge sites**	**FFM Vic MER Program**
Monitor the abundance of feral predators at key subpopulations, in response to management actions (e.g. with sites inside and outside the Otway Ark, program of intensive fox baiting).	Medium	**Otway Refuge sites**	**PV/DEECA**

Table 7. Information and research priorities

Action	Priority	Where	Who
Assess the spatial fire history information in the subspecies' habitat to determine optimum fire regimes	High	**Otways Refuge Sites**	***FFM Vic MER***
Assess population-level responses to a range of fire regimes, and model population viability across fire scenarios, and habitat fragmentation and isolation	Medium	**Otways Refuge Sites**	***FFM Vic MER***
Assess the efficacy and impacts of management options to reduce the incidence, extent and intensity of fires, and promote appropriate heterogeneity of a fire mosaic	High	**Otways Refuge Sites**	***FFM Vic MER***
Determine the abundance of feral cats, dogs and foxes across the range, and the impact of predation on population viability	Medium - High	**Otways Refuge Sites**	***PV – Otway Ark***
Trial predator-proof enclosures at selected sites, for reintroductions and to provide refugia and aid in population recovery	Medium	**Otways Refuge Sites**	***CEC***

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APPENDIX 1 - Long-nosed Potoroo Conservation Advice

THREATENED SPECIES SCIENTIFIC COMMITTEE 2022
Conservation Advice
Long-nosed Potoroo (southern), Potorous tridactylus trisulcatus

Conservation and management priorities

Habitat loss, degradation, disturbance and modifications

• Avoid further loss and fragmentation of habitat, including loss of vegetation connecting areas of habitat for the species or the creation or increase of barriers to movement between subpopulations.
• Where feasible, promote the restoration and enhancement of habitat connectivity between fragmented habitat patches to allow safe movement of individuals.
• Outside of National Parks and other managed conservation areas, promote the conservation and management of the species' habitat through the establishment of voluntary conservation agreements, Council open space habitat areas and covenanted areas.
• Continue to ensure that adequate protection measures are in place to protect the viability of populations in areas subjected to timber harvesting and associated management activities (this includes logging, road construction, coupe burning).
• Assess the effectiveness of current and new forestry management practices in ameliorating disturbance to the habitat of the species, and revise management practices if necessary. Given the suspected impacts of logging on the species, stringent protection measures should be adopted or ongoing where they are already in place.
• At sites where road mortality of the species is highly likely, consider the implementation of measures to reduce road mortality, such as underpasses (with appropriate substrate and shelter within, see Lewis 2015), road escape ramps and slowing vehicle movement. Ensure underpasses have appropriate vegetation cover for the species on either side of the road.
• Where P. cinnamomi occurs within or proximal to the southern long-nosed potoroo subpopulations, implement an appropriate disease management plan to protect forest health and structure. Ensure appropriate hygiene protocols are adhered to when entering or exiting areas infected with P. cinnamomi, such as those outlined in Podger et al. (2001) and O'Gara (2005).

Climate Change and fire
• Ensure that a high proportion of the southern long-nosed potoroo habitat is maintained in a long unburnt condition (>20 years).

• Ensure immediate and ongoing post-fire predator control within the habitat of the species following fires.

• If a fire is essential and long unburnt patches are not possible, then develop and implement a fire management strategy that optimises the survival of the species during planned and unplanned fires. These regimes should include buffers that prevent bushfire or planned burns from impacting habitat and food sources, a post-fire introduced predator control program, a post-fire population monitoring program, and sufficient funding to facilitate these projects.

• Provide maps of known long-nosed potoroo sites to local and state Rural Fire Services and seek inclusion of actions to mitigate impact to the southern Long-Nosed Potoroo. Where prescribed fire is necessary for reducing the risk of wildfire, maintain and document habitat structure and fire frequency, ensuring some patches are fire-free for at least 20 years.

• Maintain and protect areas identified as climate change refuges; establish corridors to allow movement to modelled suitable habitat under climate change projections.

Invasive species (including threats from predation, competition)

• Develop and implement strategies to control predation by the European red fox and feral cats and, where relevant, competition from feral pigs, as detailed in the relevant Threat Abatement Plans (TAPs) or management strategies.

• Implement grazing management actions in consultation with land managers and community groups; prevent further introduction of pest animals and control those that are already present, as detailed in the relevant threat abatement plan (DOEE 2016). Develop and implement strategies to control introduced herbivores consistent with the relevant TAP.

• Develop and implement strategies to manage weeds where they are impacting the species, consistent with the Australian Weeds Strategy 2017-2027 (Invasive Plants and Animals Committee 2016) and other relevant management strategies. Develop appropriate prioritisation of which weed species to control based on those which specifically affect the southern long-nosed potoroo.

• Promote the registration and responsible management of domestic cats and dogs, targeting urban areas adjacent to known southern long-nosed potoroo populations. Consider cat containment and prohibition options for suburbs next to important populations of the southern long-nosed potoroo.

Captive breeding and other ex situ recovery actions

• Identify population thresholds that may initiate a captive breeding program for the species.

• Identify key subpopulations and suitable habitats for a future release of captively bred animals and/or wild-to-wild translocations, and ensure habitats are managed for future suitability.

• Assess the need for, and feasibility of, one or more large, fenced areas to create insurance populations that are protected from feral predators and habitat degradation from livestock. For example, this approach may be a viable management option to protect small populations in coastal habitat fragments.

• Identify high-risk subpopulations under climate change and catastrophic depletion scenarios and plan for emergency responses to translocate at-risk animals where needed.

• Identify and translocate at-risk subpopulations from forestry tenures to suitable habitats on protected tenures (e.g. National Park), integrating learnings from existing programs (e.g. the reintroduction of the southern long-nosed potoroo to Booderee National Park, translocated from New South Wales state forests).

Stakeholder engagement/community engagement

• Engage and involve Traditional Owners in conservation actions, including the implementation of Indigenous fire management and other surveys, monitoring and management actions.

• Identify and engage partners including the Local Councils, NRM regions, state agencies, Indigenous communities, landholders, community-based organisations and conservation management organisations that can assist with conservation actions.

• Contribute to impact assessment and planning processes on measures to protect the species and its habitat.

• Ensure information and data on long-nosed potoroo and their habitat are shared between land managers, environmental managers and landholders.

• Where research identifies potential habitat for the species in areas that are privatelyowned, liaise with landholders to provide information on the species and its habitat requirements and encourage reporting of any sightings.

• Increase the recognition and support for the species' recovery by disseminating information on the species and its conservation status to the public.

Survey and monitoring priorities

• Monitor the subspecies at representative sites across its range to track changes in the overall population size, the effects of varying levels of threats, and the effectiveness of management of those threats.

• Continue to gather information on the impact of the 2019–2020 bushfires on the species.

• Survey the spatial and temporal behavioural, occurrence, abundance and predation patterns of European red foxes, feral cats and wild dogs in important southern long-nosed potoroo habitats.

• Monitor abundance and responses of the southern long-nosed potoroo before and after a fire and invasive species control measures.

• Assess the efficacy of existing threat management actions.

Information and research priorities

• Determine the key environmental variables and thresholds for habitat critical in both coastal and mountain areas where are extant potoroo subpopulations. Assess the risk of extinction and causes in coastal versus mountain populations.

• Determine variability in food availability between different habitat types for important populations, and determine which environmental drivers are responsible for changes in food abundance and nutrient levels.

• Determine natural and anthropogenic fluctuations in the key ecological attributes responsible for species survival (e.g., food resources, predator abundance, environmental parameters and responses to fire and drought). Use the information to prioritise management responses at a location/subpopulation level.

• Undertake research into the ecology of hypogeous fungi, particularly the impacts of timber harvesting, bushfire, drought, and prescribed burning. Determine the spatial variability in mycophagous species and where the most intense competition for this food source with other species occurs.

• Model habitat loss and projected habitat loss and fragmentation under different climate scenarios.

• Determine thresholds for viable subpopulations and viability under future climate change scenarios.

• Determine the prevalence and impact of both *Phytophthora cinnamomi* and Bell Miner related dieback on important habitats for the southern long-nosed potoroo.

• Determine the current distribution and abundance of the species.

• Identify individual risks for each subpopulation.

• Develop standard protocols for the detection of the southern long-nosed potoroo in the field using remote camera and trap survey methods.

• Determine the need for captive breeding or reintroduction programs in key areas where isolated populations have declined or severe impacts on the subpopulations have occurred due to stochastic events such as fire.

• Undertake connectivity analysis to prioritise important areas for conservation and restoration and the location of critical habitat linkages and barriers to the movement of individuals and gene flow (McRae et al. 2008).

• Determine the efficacy of predator control programs (especially for European red fox) in reducing predator caused mortality of the southern long-nosed potoroo. Include scale, intensity and interacting factors in the control programs in the experimental design.