

Mountain Pygmy-possum

Burramys parvus

Action Statement No. 2

Flora and Fauna Guarantee Act 1988



Approved revision May 2020

Cover photo credit

Dean Heinze, 2017.

Acknowledgment

We acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, their unique ability to care for Country and deep spiritual connection to it. We honour Elders past and present whose knowledge and wisdom has ensured the continuation of culture and traditional practices.

We are committed to genuinely partner, and meaningfully engage, with Victoria's Traditional Owners and Aboriginal communities to support the protection of Country, the maintenance of spiritual and cultural practices and their broader aspirations in the 21st century and beyond.



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Description

The Mountain Pygmy-possum *Burramys parvus* (Broom 1896), is the largest of five species of pygmy-possum in Australia. The Mountain Pygmy-possum has grey-brown fur on the head, back and sides with pale grey-brown to cream underside. The tail is scaly, sparsely haired, prehensile and longer than the head and body combined. It can weigh between 35g and 80g (Menkhorst and Knight 2011).



Figure 1: A Mountain Pygmy-possum in the Mt Hotham boulder fields.

Source: Dean Heinze, *Ecology Links*

Distribution

The Mountain Pygmy-possum is the only Australian mammal restricted to the sub-alpine and alpine zone above 1,200 metres. Initially described from a fossil record, the first live specimen was discovered in 1966 in a ski hut at Mount Hotham. Three genetically isolated or regional populations occur at: Mt Kosciuszko area (NSW); Mt Buller (Victoria); and between Mt Bogong (this includes a small population at Mt McKay) and Mt Higginbotham (Victoria) (Osborne *et al.* 2000). It was not until 1996 that the first specimen was found at Mount Buller (Heinze and Williams 1998). The Mt Bogong to Mt Higginbotham population can be sub-divided geographically into three sub-populations (Mansergh *et al.* 1989). The Kosciuszko population range has been further extended recently by the discovery of individuals in northern Kosciuszko National Park, at elevations of 1,200 to 1,310 metres (Schulz *et al.* 2012). Fossil remains recovered from caves in Victoria and New South Wales suggest that at the height of the last Pleistocene glacial period (*ca.* 20,000 years bp) the Mountain Pygmy-possum had a much wider distribution around the snowline of south-eastern Australia. Since that time its range has been contracting with a gradually warming climate and receding snowline (Caughley 1986; Mansergh and Broome 1994).

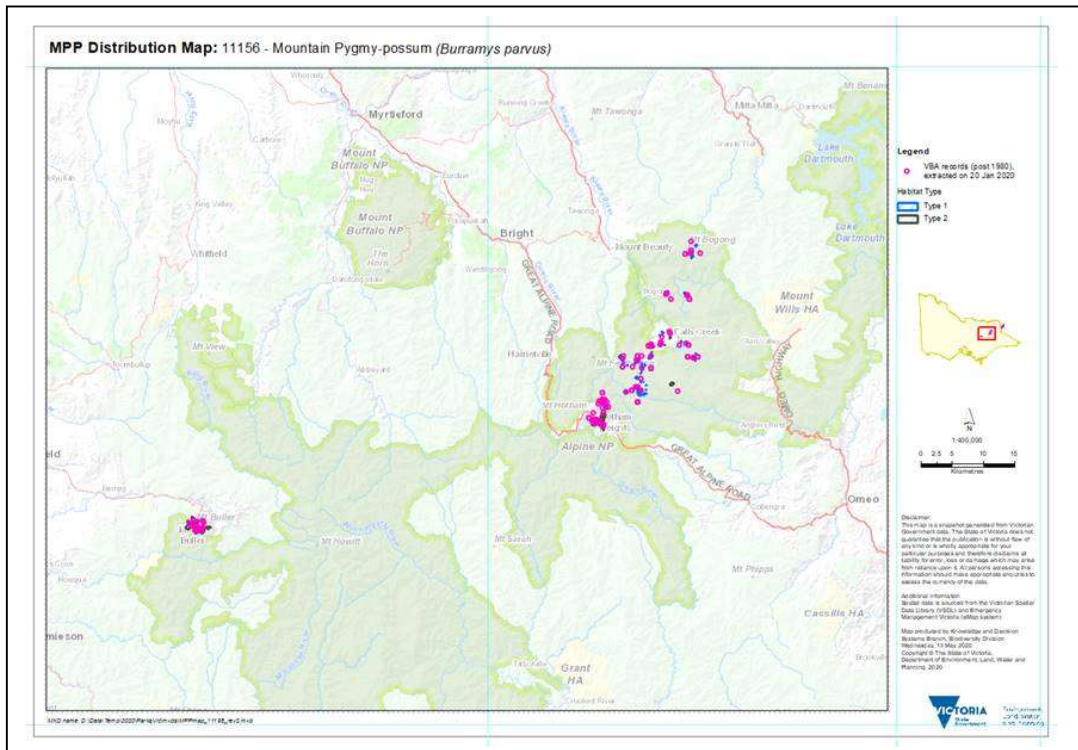


Figure 2: Victorian distribution of the Mountain Pygmy-possum *Burrmys parvus*.

Source: Victorian Biodiversity Atlas, 2020.

Habitat

The habitat of the Mountain Pygmy-possum is naturally restricted and disjunct, occurring as a series of patches of boulders with associated shrubby heath vegetation within the broader alpine and subalpine environments. The species is largely confined to naturally occurring boulderfields and rock screes in alpine and subalpine areas at altitudes above 1,400m. Individuals have occasionally been observed as low as 1,300m in the montane zone at Mt. Buller and 1,200m in northern areas of Kosciuszko National Park (Heinze unpubl. data; Schulz *et al.* 2012)

Most of these habitat patches are small (<1 ha, and few are greater than 5 ha) and are separated from each other by distances of several hundred metres to several kilometres. Densities and carrying capacities vary markedly. The Mountain Pygmy-possum is typically confined to well-defined boulderfields with associated shrubby heathland. Mountain Pygmy-possums also forage and sometimes nest in shrublands with scattered boulders adjacent to the main boulderfields (Heinze *et al.* 2004).

The Mountain Pygmy-possum has specific habitat requirements and there is habitat partitioning between the sexes. Generally, females tend to occupy the higher quality, higher elevation habitat and males move to these female habitats during the breeding season. This habitat has been described as “optimal” or “Type 1” habitat. After breeding, the males disperse to lower elevation habitats, or to habitat having a more westerly or northerly aspect. This habitat has been described as “Type 2” habitat. This habitat usually accumulates less snow, has earlier snow melt or lower densities of Bogong Moths *Agrotis infusa*, is generally lower in altitude and the boulderfields are often shallower than those in female habitats (Mansergh 1988; Mansergh and Scotts 1990; Walter 1996; Körtner and Geiser 1998; Broome 2001; Heinze *et al.* 2004). In addition to the two habitat types, the interstitial habitat connecting the two is essential for movement of males to higher elevations during the breeding season.

The boulders provide shelter, sites for hibernation and seasonal food sources. Rock crevices are used as summer aestivation sites for migratory Bogong Moths, an important food source of the Mountain Pygmy-possum (Mansergh *et al.* 1990; Smith and Broome 1992). The preferred boulderfield habitat is also strongly associated with alpine shrubby heathland (Mansergh and Walsh 1983; Gullan and Norris 1984; Caughley 1986), which supplies nectar in spring and summer, seeds and fruit in autumn and a substrate for a variety of arthropods included in the diet (Mansergh *et al.* 1990; Mansergh and Broome 1994; Broome 2001; Gibson 2007).

This heathland is characterised by the presence of Mountain Plum-pine *Podocarpus lawrencei* and can include Alpine Pepper *Tasmannia xerophila*, Dusty Daisy Bush *Olearia phlogopappa*, Alpine Rice Flower *Pimelea alpina*, Snow Beard-heath *Leucopogon montanus*, Mountain Baeckea *Baeckea utilis*, Alpine Grevillea *Grevillea australis*, Royal Grevillea *G. victoriae*, Ovate Phebalium *Nematolepsis ovatifolium* and several species of *Epacris*. Flowering forbs, some grasses (e.g. Snow Grass *Poa* spp., Ribbony Grass *Chionochoa frigida*), sedges, ferns (e.g. Mother Shield-fern *Polystichum proliferum*) and mosses occur in the intervening spaces (Gullan and Norris 1984; Caughley 1986; Broome 2001, Schulz *et al.* 2012). Some areas have an overstorey of Snow Gum (*Eucalyptus pauciflora* or *E. stellulata*). Shrublands with scattered boulders between the main boulderfields are also used for foraging and occasionally nesting (Mansergh *et al.* 1989; Broome 1992; Walter 1996; Heinze and Olejniczak 2000, Schulz *et al.* 2012).

In Victoria, the bushfires of 2003, 2006/2007 and 2013 impacted the Mt Bogong to Mt Higginbotham population, while the Mt Buller population was affected by bushfire in 2007 (e.g. Heinze 2009). Fires in 2019/20 reached Mt Bundara but did not extend into Mountain Pygmy-possum habitat.

Life history and ecology

The Mountain Pygmy-possum is the longest-lived, small, terrestrial marsupial known (females may live for 12+ years, males up to five years). They have a highly biased sex ratio, with more females than males (Mansergh and Scotts 1990; Broome 2001; Heinze *et al.* 2004). Almost all females breed in their first year, with litters usually of four young, born in October or November. Females can give birth to litters with multiple paternity (more than one father per litter; Boys 2018). The young are independent by January and most leave their natal site within a month (Mansergh and Broome 1994). A second litter in the same season is rare and usually unsuccessful. Juvenile males and most juvenile females leave the natal areas by autumn.

Bogong Moths migrate from their larval lowland habitat from southern Queensland to western Victoria to aestivate, congregating in large numbers in alpine boulderfields and caves during spring and summer. The Bogong Moth is a key food resource for the Mountain Pygmy-possum in spring and summer, critical to the success of the breeding season. Low numbers of Bogong Moths during this time are believed to contribute to reduced pouch young survival (DELWP 2019). Other prey items are caterpillars, millipedes, beetles and spiders (Mansergh *et al.* 1990, Smith and Broome 1992). The Mountain Pygmy-possum also feeds on nectar from the flowers of alpine shrubs (Gibson 2007) and eats a range of seeds, drupes and berries, especially the hard-shelled seeds of the Mountain Plum Pine and Snow Beard-heath *Acrothamnus montanus*, which may be cached for the hibernation period (Mansergh *et al.* 1990).

Adult Mountain Pygmy-possums hibernate for up to seven months. They can start hibernating at any time between late summer to the start of winter and finish when there is advanced snow-melt in spring (Geiser and Broome 1991). Work by Walter (1996) and Körtner and Geiser (1998) in New South Wales revealed that shelters, used for hibernation, are often located outside the normal summer habitat in areas that are more insulated, such as in old overgrown boulderfields. At Mt Buller, radio-tracking showed that nesting locations were often closely associated with Mother Shield Fern *Polystichum proliferum* (M.Parrott pers. comm. 2020). The highly seasonal availability of nutritionally rich food items and their dearth over winter encourages behavioural and physiological adaptations such as seed caching and hibernation (Mansergh *et al.* 1990). The relative importance of seed caching is unknown.

During the non-breeding season most males live outside the female habitat (Broome and Mansergh 1989), typically at lower elevations in Victorian populations. Males have been recorded travelling up to three

kilometres in one night (Broome 2008). Mansergh (1989) and Mansergh and Scotts (1990) suggested that the social organisation of the Mountain Pygmy-possum is based on a “matriarchal resource defence polygyny”, where females become aggressive towards males and force them into less favourable habitats after mating. Female movement distances may be dependent on the availability of suitable natal nest sites and their proximity to the presence of Bogong Moths (Broome 2001). At Mt Higginbotham, some males are known to return to the same breeding area year after year (D. Heinze pers. comm. 2017).

Conservation status

National conservation status

The Mountain Pygmy-possum is listed as ‘Endangered’ under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

The species is also listed on the International Union for Conservation of Nature Red List of Threatened Species as ‘Critically Endangered’.

Victorian conservation status

The Mountain Pygmy-possum is listed as ‘threatened’ under the Victorian *Flora and Fauna Guarantee Act 1988*.

NSW conservation status

The Mountain Pygmy-possum is listed as ‘Endangered’ in NSW under the *Threatened Species Conservation Act 1995*.

Threats

Climate change and associated effects

Climate change is the greatest long-term threat to the Mountain Pygmy-possum because the species is restricted to the alpine and sub-alpine environments, does not occur below the winter snowline and is adapted to predictable, marked seasonal changes. The populations predicted to be initially impacted by global warming are those that are small, at low elevations or on westerly aspects (Broome 2001). There are also likely to be other unpredictable effects of climate change on the survival of the Mountain Pygmy-possum within the alpine habitat.

Snow ecology and effects on hibernation

Climate change is predicted to cause unprecedented reductions in the spatial extent and duration of snow cover in the Australian Alps within the next 30–70 years (Whetton *et al.* 1996; Whetton 1998). Associated increases in temperature will result in significant changes in alpine and subalpine areas, reduced snow depth and consequential changes in ecological processes (Hennessy *et al.* 2003; Hennessy *et al.* 2005, Greenville *et al.* 2018).

Time of formation, depth, duration of snow cover and time of snow melt strongly influence survival and recruitment of the Mountain Pygmy-possum in its natural environment. Survival and recruitment are substantially reduced in years of very long snow cover duration and late melt and increasingly, in years of very short snow cover duration and early melt. Preliminary modelling suggests optimal snow cover duration for Mountain Pygmy-possum survival is around 130–150 days (McDougall and Broome 2007; Broome *et al.* 2012). Survival may also be reduced when extremely low temperatures occur before the formation of

insulating snow cover in early winter or when rain causes a mid-season melt (Körtner and Geiser 1998; McDougall and Broome 2007; L. Broome unpublished data).

Food resources

Change in food availability through declines or changes in seasonality of plant production, or availability of Bogong Moths and other arthropods is likely to impact on the Mountain Pygmy-possum. Not all changes may be negative; for example, nectar and seed production of some plants may increase (McDougall and Broome 2007). However, the bio-physical effects of climate change on Bogong Moth habitat and ecology remains unclear as does the effects from land use and agricultural management practices in Bogong Moth breeding habitat. Large scale regional changes such as drought, change of land use from grazing to cropping and use of pesticides could reduce available breeding areas. The effect on the Mountain Pygmy-possum from such changes is unknown, although recent observations of a substantial drop in Bogong Moth numbers in alpine areas, is believed to have resulted in high levels of pouch young losses in the 2017/18 and 2018/19 breeding seasons (DELWP 2019).

Fire Regimes

South-east Australia faces a drier, warmer and extreme weather event-prone future with high risk of extreme fire days (Solomon *et al.* 2007; Steffen 2009; Hennessey *et al.* 2005, Greenville 2018). Extensive fires in alpine and subalpine environments generally only occur in periods of extended drought (Williams *et al.* 2009) such as Victoria's bushfires in 2003 and 2006 and the fires in 2019/20, that significantly impacted habitat in the NSW population.

Mountain Pygmy-possum adaptation

The essentially subterranean habitat of the Mountain Pygmy-possum may be able to provide some buffering protection from ambient temperature rises. However, the persistence of the species is likely to relate to its physiological and behavioural adaptive capacity in response to climate change and its indirect effects. This includes responses to bio-physical changes, such as increased temperatures, changes in rainfall, snow depth and duration (Hennessey *et al.* 2005), and their ability to tolerate any competitive advantages from potential competitors and predators, future fire regimes, weed invasion and vegetation change. The ability of the Mountain Pygmy-possum to adapt to the range of changes predicted with climate change will likely depend on how tightly the species is tied to its current highly seasonal phenology and its physical and behavioural plasticity.

Decline in numbers of Bogong Moths

As Bogong Moths provide the primary and most abundant food source during the critical breeding period in spring, any threats or actions that substantially reduce numbers of moths in the alpine and subalpine boulderfields, pose a significant threat to Mountain Pygmy-possum breeding success. Observations of high levels of pouch young loss (up to 95% in one population) in Victorian populations, is believed to be a direct result of very low number of Bogong Moths in 2017/18 and 2018/19 (DELWP 2019). Potential threats to Bogong Moths include further loss of inland native grassland larval habitat, application of agricultural chemicals in their breeding sites and environmental variation due to climate change, especially increased drought conditions and bushfires. There is also evidence that artificial UV light, building lights and storms can interfere with the moths' navigation during migration. The impact of artificial lighting on moth numbers in alpine aestivation sites, both in the vicinity of colonies and along migration paths, warrants further investigation.

Loss, degradation and fragmentation of habitat

Loss and degradation of habitat are among the greatest immediate threats to the continued viability of the Mountain Pygmy-possum populations. Approximately 80% of Victorian Mountain Pygmy-possums live in or immediately adjacent to ski resorts (Mt Hotham, Mt Buller, Falls Creek).

Habitat connectivity enables movement of individuals between the disjunct habitat patches, maintaining metapopulation structure and genetic diversity. It is essential for enabling males to migrate to the females

during the breeding season (Mansergh and Scotts 1989). Fragmentation of connective habitat increases predation risk, particularly for male movements (e.g. Mt Buller, Mt Blue Cow).

Alpine heath vegetation is susceptible to damage as it has a very short growing season; growth is slow and recovery from damage can take many years. This means that damage tends to be cumulative and recovery slow (Bell and Bliss 1973; Costin *et al.* 1979). Damage to heathland vegetation can occur from bushfire, exotic grazing animals such as European Rabbits *Oryctolagus cuniculus*, European Hares *Lepus europaeus*, deer species, horses *Equus caballus* and snow compression from snow grooming and ski activities particularly when snow cover is shallow. Summer activities can also cause damage, such as during summer slope grooming, management activities and trampling by visitors.

Erosion and sedimentation

Mountain Pygmy-possum habitat is susceptible to sedimentation. Erosion is exacerbated by loss of vegetation cover from road and track batters, fire and trampling. Sources of sediment movement include construction works and mechanical disturbance from snow-clearing on roads. Degradation of boulderfield habitat can occur from runoff from surrounding areas where soil and silt can be deposited between and under rocks into nesting and hibernation spaces.

Predation by cats and foxes

Predation by the Red Fox *Vulpes vulpes* and Feral Cat *Felis catus* are a significant threat to Mountain Pygmy-possums (Mansergh *et al.* 1989; Mansergh 1991; Broome 1992; Mansergh and Broome 1994; NPWS 2002; Heinze *et al.* 2004, Anon. 2005; Broome *et al.* 2012). These species prey on the possums and have been observed foraging amongst boulderfields. The small numbers of males in some sub-populations, such as on the Bogong High Plains, suggests that males are vulnerable to the effects of fox predation when they move between isolated patches of habitat where shrub cover is low (Mansergh 1988, Heinze *et al.* 2004).

Genetic loss and small populations

Although overall genetic variability of Mountain Pygmy-possums is high compared to many other threatened marsupial populations, the disjunct nature of the distribution of the species both within and between populations makes it particularly susceptible to genetic loss. Loss of genetic variation is likely to reduce evolutionary potential and reproductive fitness, making this species susceptible to extinction at both the local and overall population level.

Winter impacts from ski resort operations and snow-sport activities

Prime areas of Mountain Pygmy-possum habitat overlap with areas used for skiing and snowboarding. Activities relating to these snow sports, if not managed correctly, are a threat to this species. Over-snow vehicles such as snow-groomers and snowmobiles can damage the underlying vegetation when snow is shallow and can increase the compaction of snow and eliminate the space between the ground layer and the underside of the winter snow pack (Sanecki *et al.* 2006). Noise and vibration from these machines may also cause more frequent arousals. These energy-expensive arousals could be fatal if they occur too often.

Bushfire and fuel hazard reduction (planned burning)

Bushfires pose a serious threat to the Mountain Pygmy-possum through loss of vegetation cover, food sources and movement corridors. In 2003, bushfires burnt through approximately 20% of the Mountain Pygmy-possum habitat in the southern region of Kosciuszko National Park and over 80% of the habitat in northern Kosciuszko. The Mt Bogong to Mt Higginbotham area in Victoria was burnt to varying degrees (Broome and Ford 2005; Heinze 2005, L. Broome unpubl. data). In 2006 and 2007 substantial areas of habitat were burnt at Mt Buller (Harvey 2007) and some habitat patches were burnt in the Mt Bogong to Mt

Higginbotham area, including some that had previously been burnt in 2003 (i.e. Mt McKay). The 2019/20 bushfires burnt to the edge of habitat at Mt Bundara, but it did not directly impact the boulderfield. NSW populations were significantly impacted by the 2019/20 fires.

Fire suppression activities and planned burning close to habitat pose a threat, including the use of retardant which affects water quality. However, as was the case at Mt Bundara in 2020, retardant can be used to prevent fire from moving into habitat.

Weed invasion and competition from introduced species

Weeds affect the quality of Mountain Pygmy-possum habitat by out-competing preferred native species and reducing biodiversity. Main problem weeds in Victoria include willows *Salix* spp. and Blackberry *Rubus fruticosus*.

Climate change may increase the potential for other exotic weed species to establish. Currently, introduced grasses and clover sown along roads and on ski runs attract rabbits and hares, which have the potential to sustain predator populations. Rabbits and hares appear to have increased in abundance in some areas at higher altitudes and this may be in response to drought conditions or climate change. These animals also cause grazing and erosion impacts in alpine and subalpine areas. Sambar Deer *Cervus unicolor* may adversely impact on Mountain Pygmy-possum habitat in some areas.

Important populations

The total breeding population of Mountain Pygmy-possum is estimated to be around 1605 adult females and 575 adult males, including the additional animals recently found in the northern Kosciuszko National Park (Table 1) (Heinze *et al.* 2004 updated by D. Heinze pers. comm. 2017, L. Broome pers. comm. 2018).

Table 1. Estimates of population and sub-population sizes of Mountain Pygmy-possum (D. Heinze pers. comm. 2017, L. Broome pers. comm. 2018)

Population		Adult females	Adult males	Sex ratio	Date of estimate
Kosciuszko		650	300	1:2	2018
Mt Bogong – Mt Higginbotham	Mt Bogong ¹	100	50	1:2	2013
	Bogong High Plains	210	30	1:7	2017
	Mt Hotham / Mt Loch	480	160	1:3	2017
Mt Buller		165	35	1:5	2017
Total		1605	575	2180	

All populations and sub-populations of the Mountain Pygmy-possum are important to the survival of the species and its adaptive potential. A significant area for the conservation and scientific study of the species in Victoria is the area between Mt Loch and Mt Higginbotham where over 50% of the entire Victorian population occurs (Weeks and Corrigan 2011). About 70% of the critical breeding area between Mt Loch and

¹ These figures include a small population at Mt McKay

Mt Higginbotham is within the Alpine National Park, managed by Parks Victoria and about 30% is within the Mt Hotham Alpine Resort, managed by Mt Hotham Alpine Resort Management Board (ARMB). The small population at Mt McKay, within Falls Creek Alpine Resorts, is managed by the Falls Creek Alpine Resort Management Board. An area of habitat (0.2ha) at Mt Hotham occurs on private land. At Mt Buller the entire population of the Mountain Pygmy-possum occurs inside the Mt Buller and Mt Stirling Alpine Resort. Detailed information on distribution including maps is available from the Department of Environment, Land, Water and Planning (DELWP).

Past management actions

While this species has a long history of past management actions previously reported (e.g. Mansergh *et al.* 1989, Mansergh and Broome 1995), the actions listed below are the period since 2000.

Survey and assessment

- Some trapping was undertaken in 1998 and 2013 to investigate the possible occurrence of Mountain Pygmy-possum in the Cobberas–Tingaringy region and Mt Buffalo (1998 only). No individuals were detected during these surveys.
- Fire severity mapping was carried out by Mt Buller–Mt Stirling ARMB for the entire Mt Buller Mountain Pygmy-possum habitat after the 2006/2007 bushfire (Harvey 2007). Threats to regeneration of burnt Mountain Pygmy-possum habitat were also identified at this time.
- Surveying (trapping) was undertaken at Mount Howitt in 2019, to investigate the possible occurrence of Mountain Pygmy-possum at this previously un-surveyed location. Traditional Owners from the Gunaikurnai Land and Waters Aboriginal Corporation and Taungurung Land and Waters Council participated in this survey work. No individuals were detected during these surveys.

Planning

- Mt Buller–Mt Stirling Resort Management first developed a Recovery Plan for the Mountain Pygmy-possum on Mt Buller in 2005. This five-year plan was implemented and included actions relating to research and annual monitoring, habitat mapping and rehabilitation projects, roads and track management, sediment control, fire protection, predator control, management of over-snow activities, Bogong Moth investigations and public interpretation activities. The Plan has a 25-year aim and five-year recovery goals. The next Mt Buller Recovery Plan is under development for the 2020 – 2025 period
- Strategic plans and documents have arisen from actions within the Mt Buller recovery plan and are used in day-to-day management including:
 - Integrated Pest Animal Control Program (Mt Buller and Mt Stirling Alpine Resort Management Board 2005a);
 - Updated Habitat Mapping Project (Heinze and Harvey 2006);
 - Snowmobile Manual Insert (Mt Buller and Mt Stirling Alpine Resort Management Board 2006) - this document includes exam questions relating to Mountain Pygmy-possum;
 - Habitat and Fire Severity Mapping Project Post 2006-2007 Fires (Harvey 2007);
 - Revegetation and Habitat Restoration Plan (MacPhee and Harvey 2007);
 - Vehicular Roads and Tracks Management Strategy (Mt Buller and Mt Stirling Alpine Resort Management Board 2007);
 - Boulderfield Habitat Feasibility Study (SMEC 2007);

- Mountains Emergency Management Plan (2018), Integrated Fire Management Plan (2018) and the Community Bushfire Emergency Management Plan (2019);
- Impact of Recycled Water on Habitat Project (Feehan Consulting 2009);
- Weed Strategy (Mt Buller and Mt Stirling Alpine Resort Management Board 2009b); and
- Bogong Moth Survey (Mt Buller and Mt Stirling Alpine Resort Management Board 2009a).
- Zoos Victoria has completed a captive management plan (Parrott *et al.* 2011) and husbandry manual (Boys 2018).
- Zoos Victoria details in situ and ex situ conservation planning and work for the Mountain Pygmy-possum in its Wildlife Conservation and Science Masterplan (2014 and 2019).
- Aligned with the DELWP Translocation Policy (DSE 2011), a translocation strategy for the Mountain Pygmy-possum Mt Buller population has been prepared by Weeks and Corrigan (2011). Consistent with this strategy, the wild to wild translocation of males from Mt Hotham and Timms Spur in the central region to Mt Buller has significantly enhanced genetic diversity and size of the Mt Buller population. Thirteen individuals (6 females and 7 males) that were specifically bred for release to Mt Buller were also released from the captive breeding program in spring 2013. All females successfully produced young following release and new genes were introduced into the population (M.Parrott pers. comm. 2020). Five males were removed the following autumn due to potentially high breeding and possible resultant confounding effects on the Mt Buller population.
- A National Recovery Plan has been published (DELWP 2016) – an electronic version is available on the Commonwealth Department of the Environment website (<http://www.environment.gov.au/>).
- Environmental Significance Overlays (ESOs) in the Alpine Resorts Planning Scheme delineate Mountain Pygmy-possum Type 1 and Type 2 habitat, with a 10-metre buffer applied around habitat.
- An Environmental Management Plan (2018) has recently been revised and a Threatened Fauna Management Plan has been drafted by the Mt Hotham ARMB.
- The Mountain Pygmy-possum Operational Contingency Plan 2019-20 (DELWP 2019) was developed as an urgent response to observed high levels of pouch young losses during the preceding two seasons.

Control of introduced animals

- Mt Buller–Mt Stirling ARMB implement an ongoing integrated predator control program that targets foxes and cats with concurrent monitoring to measure success in reducing predator pressure on the Mountain Pygmy-possum population. Wild Dogs, rabbits and deer are also controlled wherever possible. The program incorporates baiting, trapping, poisoning, shooting and remote camera surveys. In the summer of 2018-2019, cat control activities have been significantly increased at Mount Buller, via National Landcare Program funding. This has been implemented in partnership with the Traditional Owners of Country, Taungurung Land and Waters Council.
- Parks Victoria implements the fox baiting programs at Mt Hotham, Falls Creek and the Alpine National Park with financial assistance from Mt Hotham and Falls Creek ARMBs. The baiting program is ongoing with stations located on land managed by Parks Victoria and Alpine Resort Management.
- Bait-take is recorded but little additional monitoring is undertaken and there is concern about the effectiveness of the program due to the limited area treated and likely reinvasion by foxes from adjacent un-baited areas. Feral Cats are trapped and culled opportunistically at Mt Hotham. Falls Creek ARMB is currently trialling a Feral Cat control program within the village and its surrounds.

Erosion management

- 182 sediment mitigating devices have been installed and improved as a product of the Mountain Pygmy-possum Recovery Plan for Mt Buller (Mt Buller and Mt Stirling ARMB 2005b). A plan containing measures to reduce sedimentation in Mountain Pygmy-possum habitat was produced by the Buller Ski Lifts (Buller Ski Lifts Pty. Ltd. 2006).

Prevention of habitat loss

- Mt Buller–Mt Stirling ARMB and Buller Ski Lifts snow mobile manuals list Mountain Pygmy-possum habitat as no-go zones except in emergency circumstances (Mt Buller and Mt Stirling Alpine Resort Management Board 2010, Buller Ski Lifts Pty. Ltd. 2010). Over-snow vehicles, including snow-groomers and snowmobiles (except Medivac), are excluded from Mountain Pygmy-possum habitat on Mt Buller, Mt Hotham and Bogong High Plains.

Prevent realignment or expansion of tracks, roads or other visitor facilities

- Close supervision of vehicle movements prevented inappropriate earthworks from being undertaken as part of the fire suppression activities at Mt Buller in 2006/2007 and at Mt Hotham in 2013. Preventing realignment or expansion of tracks and roads is clearly articulated within the Recovery Plan for Mt Buller (Mt Buller and Mt Stirling Alpine Resort Management Board 2005b) and Vehicular Roads and Tracks Management Strategy (Mt Buller and Mt Stirling Alpine Resort Management Board 2007).

Control of environmental weeds

- Mt Buller–Mt Stirling ARMB spray priority weeds every year in the summer months. They also run, in conjunction with Buller Ski Lifts, a joint 'Weed Week' program focusing on specific weeds each January. Resort Management also have an ongoing partnership with the Goulburn Broken Catchment Management Authority (established in 2010), which delivers weed treatment in critical habitat areas, with Taungurung Land and Waters Council works team as the preferred subcontractor. Falls Creek ARMB spray roads and waterways adjacent to Mountain Pygmy-possum habitat (Mt McKay) once every year. Opportunistic spraying is undertaken by Mt Hotham ARMB. Parks Victoria conducts extensive weed control programs within the Alpine National Park, including spraying of willows in Mountain Pygmy-possum habitat at Mt Loch.

Habitat restoration

- Recent restoration works have predominantly occurred at Mt Buller. These include:
 - Installation of six boulderfield tunnels to link previously fragmented habitat areas. These tunnels were similar in design to the one built at Mt Hotham (see Mansergh *et al.* 1989). Habitat was linked between Federation and Wombat (Mt Buller) by a successfully designed and constructed major rock corridor incorporating culverts. Other rock corridors have been installed at the Funnel, South Side, Robin's Thulke's and Whiskey Creek Trail. Two other surface corridors exist at Outer Edge.
 - Re-creation of two large boulderfield habitat areas linking previously fragmented habitat patches. Each boulder-field is 0.25 ha and comprises in excess of 2000 cubic metres of rock.
 - Ongoing revegetation of habitat consisting of around 150,000 plants. Some revegetated sites were burnt during the 2006/2007 fires and have been subsequently replanted. A further 15,000 plants were used to revegetate habitat at Mt Buller post-fire. Buller Ski Lifts planted an additional 15,000 plants.
 - Vegetation survey/assessment has occurred in an identified potential habitat linkage area at Mount Buller to inform future habitat enhancement works. Taungurung Land and Waters Council were engaged to participate in the assessments.
- A second rock boulder tunnel, including remote monitoring and camera systems, under the Great Alpine Road at Mt Little Higginbotham has recently been completed by the Mt Hotham ARMB, in conjunction with DELWP and Zoos Victoria.

Captive breeding

- A captive breeding program commenced at Healesville Sanctuary once it was identified that the Mt Buller population was under threat of extinction (see “Research” below). Animals are housed in alpine mimicking climate-controlled enclosures and large outdoor enclosures and undergo annual hibernation. Ten female and one male Mountain Pygmy-possums were collected from Mt Buller between 2006 and 2007, with 2 additional males collected in 2011. The females were paired with 10 males collected from Mt Hotham, plus 3 males removed from the wild following the first Mt Hotham to Mt Buller translocation (see below). The captive population has produced and raised over 120 young, including the first backcrossed Mt Buller-Mt Hotham animals in 2009, then over 4 generations of backcrossed animals with no issues recorded. While breeding of captive-born males and females and wild caught males was high, breeding of wild caught females was low. It was unknown whether this was due to husbandry procedures or a lack of genetic diversity and reproductive issues in the wild females. In 2017, 6 females and 4 males were collected from Mt Loch for the captive breeding program. 5/6 females successfully produced and raised young by the 2019/2020 breeding season.

Translocation

- A wild to wild translocation of Mt Hotham males to Mt Buller was triggered initially by evidence of a rapidly declining population at Mt Buller and later by evidence of dramatic genetic decline. This was the first time such a ‘gene pool mixing’ strategy has been employed in Australia to successfully genetically rescue a population *in situ* (Weeks *et al.* 2013).

Community awareness and engagement

- Mt Buller–Mt Stirling ARMB offer free self-guided walks which feature Mountain Pygmy-possum interpretation and highlight the importance of this region to Taungurung people.
- The Mt Buller–Mt Stirling ARMB have constructed two miniature habitat areas with interpretive panels (Village Centre for adults and Ski School for children).
- A Mountain Pygmy-possum brochure is available from the Resort Management office and small mammal posters are delivered annually throughout the community.
- The Mt Buller–Mt Stirling ARMB staff, in collaboration with Taungurung Land and Waters Council give talks to school students and other groups visiting the Resorts each year which feature information relating to the species. Snap traps and baits are not permitted on mountain premises; live capture traps are available for purchase.
- The Mt Buller–Mt Stirling ARMB website contains pages dedicated to the Mountain Pygmy-possum and includes links to further information.
- A children’s mascot - ‘Barry the Mountain Pygmy-possum’ - was created for Mt Buller by Buller Ski Lifts.
- Zoos Victoria website contains pages dedicated to Mountain Pygmy-possum conservation.
- Mountain Pygmy-possum feature as one of Zoos Victoria’s 27 Fighting Extinction Heroes on collector cards, banners and on a City Circle tram in Melbourne to raise awareness and encourage conservation. Mountain Pygmy-possums not required for the breeding program, are on public display in specialised enclosures at Healesville Sanctuary and Werribee Open Range Zoo.
- Healesville Sanctuary has an Australian Endangered Species school program for years 5 to 10 featuring Mountain Pygmy-possum conservation. Annual presentations by Zoos Victoria staff on Mountain Pygmy-possum conservation are given to schools and universities.
- In 2019/2020, the Mountain Pygmy-possum was featured in an awareness and fundraising campaign by Zoos Victoria. This included the ‘Lights Off for the Bogong Moth’ campaign and a citizen science program, ‘Moth Tracker’.

Monitoring

- Annual trapping has been undertaken at established sites across part of the Victorian range. Recent results indicate monitored populations are in a state of decline.
- Monitoring of foxes and cats is conducted by Mt Buller–Mt Stirling ARMB and Parks Victoria. It involves remote camera monitoring, scat transects, spotlighting and incidental observation. The scats and gut contents are analysed to determine prey items from as many cats and foxes caught as possible.
- Monitoring results are required to be submitted to the Victorian Biodiversity Atlas.
- Population monitoring is undertaken by the ARMBs at all resorts. Annual monitoring reports are provided by the ARMBs to DELWP. A dramatic decline in Mountain Pygmy-possum numbers, particularly in the Mt Buller population, was detected after 2003. The population has now recovered to beyond pre-discovery level. The Bogong High Plains was burnt a second time in January 2007; no Mountain Pygmy-possums were recorded at some severely burnt sites during subsequent monitoring.

Liaison with stakeholder groups

- Flora and Fauna Guarantee permits were obtained by Buller Ski Lifts to conduct summer grooming in consultation with resort management and DELWP.
- A five-year Vegetation Management Plan has been developed for Mt Buller by Buller Ski Lifts in consultation with Mt Buller–Mt Stirling ARMB and DELWP.
- The Falls Creek Ski Lift Company identified Mountain Pygmy-possum habitat as a no-go zone in its Summer Grooming Plan following consultation with all stakeholders.

Research

- The relative genetic differences between populations of Mountain Pygmy-possums have been studied (Mitrovski *et al.* 2007, 2008). Most key populations showed resilient genetic variability, however, the Mt Buller population showed a rapid decline in genetic diversity. This triggered the genetic rescue and translocation responses listed above.
- Genetic analyses of wild and captive Mountain Pygmy-possum populations have been undertaken.
- New species-specific microsatellite markers were created in 2011 by Andrew Weeks, bringing the total available to 24. This has significantly advanced the understanding of genetic diversity in Mountain Pygmy-possum populations and assisted in refining future management options (Weeks *et al.* 2017).
- Genetic analysis of the Mt Little Higginbotham population has been conducted that assessed the impacts of habitat fragmentation due to the location of the Great Alpine Road.
- Captive research including reproduction, use of mate choice, hybridisation, socialisation, diet, enrichment and hibernation studies has been completed at Healesville Sanctuary – see Boys (2018), Koch *et al.* (2011), Watson *et al.* (2010).
- Nutritionally balanced supplementary food items and feeding mechanisms were developed by Zoos Victoria, trialled in captivity and then trialled in the wild by Zoos Victoria and Parks Victoria. The food has now been used to supplement populations in NSW after bushfires – see Parrott *et al.* 2020.
- Health studies have been conducted on captive and wild Mountain Pygmy-possums by veterinarians from the Australian Wildlife Health Centre, Healesville Sanctuary (see Scheelings and Dobson 2015)
- Scicluna (2017) investigated hormone profiles and reproductive success in captive female Mountain Pygmy-possums.
- McKinnon (2009) Investigated intake of dietary energy by captive Mountain Pygmy-possums at Healesville Sanctuary.
- Cash, (2015). Completed a PhD on comparison of the behaviours of captive bred and wild caught Mountain Pygmy-possums at Healesville Sanctuary

- Fanson and Parrott (2016) and Fanson *et al.* (2017) investigated faecal glucocorticoids and reproduction in captive Mountain Pygmy-possums.
- Using citizen science to track and record Bogong Moths, and how the social programs influence community recognition and care of Mountain Pygmy-possums and Bogong Moths was undertaken by Zoos Victoria (Sherwen and Jones 2019).
- The genome of the Mountain Pygmy-possum has been sequenced and annotated by researchers at the University of Melbourne in 2016 as part of a program to understand the genetic consequences of the gene pool mixing program undertaken to enhance the Mt Buller population (Weeks *et al.* 2017).
- Green (2008) investigated levels of arsenic in Bogong Moths and concluded that they were not significant for Mountain Pygmy-possum.
- Love (2010) tested the hypothesis that arsenic found in Bogong Moths is an anthropogenic contaminant and concluded that there is no evidence that the concentration of arsenic present in Bogong Moths poses a significant risk to Mountain Pygmy-possums.
- Additional research being undertaken as part of the Mountain Pygmy-possum Operational Contingency Plan 2019-20 (DELWP 2019), includes:
 - Bogong Moth genetics to contribute to a broader understanding of population dynamics, risks and management options protecting the moths, particularly in their larval habitat; and
 - Mountain Pygmy-possum population modelling.

Conservation objectives

Long term objective

The long-term conservation objective for the Mountain Pygmy-possum is to ensure that the species persists across its range and maintains its potential for evolutionary development in the wild. However, with the severe threat to the species from climate change, alternative strategies for its long-term survival also need to be considered.

Objectives of this Action Statement

For the period of this Action Statement, the specific objectives are:

- To maintain or increase the number of Mountain Pygmy-possums in the wild;
- To maintain and enhance the extent and condition of Mountain Pygmy-possum habitat;
- To investigate key aspects of the biology and ecology of the Mountain Pygmy-possum; and
- To increase community awareness of and support for the conservation of the Mountain Pygmy-possum.

Each of the objectives above will be pursued in partnership with Traditional Owners.

Management actions

Intended management actions

Intended Management Actions	Responsibility
<p>Objective 1: To maintain or increase the number of Mountain Pygmy-possums in the wild.</p>	
<p>The actions below are designed to increase the fitness of individuals, the size of populations and the occupancy of available habitat by reducing direct mortality due to predation and by enhancing genetic variation to improve breeding success.</p>	
<p>1. Monitor and control introduced predators.</p> <ul style="list-style-type: none"> Undertake on-going integrated predator control programs (including foxes and cats) throughout all resorts and Alpine National Park areas. 	<p>DELWP, Parks Victoria, Alpine Resort Management Boards</p>
<p>2. Conduct translocations to augment populations.</p> <ul style="list-style-type: none"> Consider the feasibility and benefits of translocations within sites to increase habitat occupancy. Undertake wild to wild translocation including translocations between sites to augment the gene pool; see genetic research action for additional detail. Consider other translocation approaches to augment the gene pool as appropriate. 	<p>DELWP, Zoos Victoria, Alpine Resort Management Boards, Melbourne University</p>
<p>3. Contingency planning.</p> <ul style="list-style-type: none"> Develop and periodically revise contingency plans in response to potential threats such as food shortage (especially Bogong Moths), disease, bushfire and competition. Where necessary, undertake risk assessments and field trials of management options to determine feasibility and cost-effectiveness. 	<p>DELWP</p>
<p>Objective 2: To maintain and enhance the extent and condition of Mountain Pygmy-possum habitat.</p>	
<p>The alpine ecosystem needs to be managed in a way that will adequately protect the integrity of remaining habitat, facilitate movement and dispersal of individuals between the habitat patches and cater for future expansion of their range if populations are to remain viable, particularly under climate change scenarios. This requires that sufficient habitat is rehabilitated to sustain a viable breeding population, weeds are controlled so that there is an improvement in Mountain Pygmy-possum habitat quality, risks to habitat arising from fuel management are effectively managed and fuel management strategies other than planned burning are used, where possible. Efforts are also required to a) avoid and minimise the impacts of bushfire in Mountain Pygmy-possum habitat, while also avoiding the impacts of fire suppression activities; b) reduce sedimentation and fragmentation of habitat and c) minimise the impacts of vehicles, including snow-grooming and over-snow vehicles.</p>	
<p>4. Develop a site-specific management plan for each alpine resort for management of the Mountain Pygmy-possum.</p> <ul style="list-style-type: none"> Develop or revise management plans specific to each relevant alpine resort area in collaboration with land managers and Traditional Owners to protect important habitat and address key threats including predation, weed invasion, sedimentation, herbivores, fire management, recreation and infrastructure. 	<p>Alpine Resort Management Boards, DELWP</p>
<p>5. Determine and map important Mountain Pygmy-possum habitat.</p> <ul style="list-style-type: none"> Identify current habitat maps available and consider their current utility and any information gaps. 	<p>DELWP, Alpine Resort Management Boards, Parks Victoria</p>

Intended Management Actions	Responsibility
<ul style="list-style-type: none"> Identify and map potential movement corridors including broader dispersal areas. Identify habitat used by male and female Mountain Pygmy-possums for feeding, nesting and hibernation, movement corridors between male and female habitat, and dispersal corridors between habitat patches that constitute the minimum habitat critical to survival of the species. Identify and map habitat quality for all locations. 	
<p>6. Develop or amend planning scheme overlays or schedules for Mountain Pygmy-possum habitat and ensure currency in all planning processes.</p> <ul style="list-style-type: none"> Develop or amend Environmental Significance Overlays where required to include Mountain Pygmy-possum habitat and appropriate buffers at the alpine resorts at a scale useful for detailed planning decisions. 	DELWP
<p>7. Liaise with organisations conducting on-site management to protect habitat.</p> <ul style="list-style-type: none"> Liaise with organisations and contractors conducting on-site management to exclude damage to Type 1 and Type 2 habitat, including preclude slashing or brush cutting of vegetation within and associated buffers, unless evidence exists that selective pruning would enhance Mountain Pygmy-possum habitat. Outside of this area, works are to comply with a DELWP approved process. Raise awareness about the different vegetation understorey types and the degree of slashing that is appropriate to protect potential Mountain Pygmy-possum habitat. Liaise with CFA and land managers to ensure that risks to all Mountain Pygmy-possum habitat are avoided during planned burning, fire suppression and all fuel management activities (see Action 14). Liaise with public visitor groups to ensure minimal disturbance to Mountain Pygmy-possum habitat or populations (e.g. minimal impact bushwalking in Alpine National Park). 	DELWP, Parks Victoria, Alpine Resort Management Boards, Ski lift companies, CFA
<p>8. Restore native vegetation to create and maintain feeding areas and movement corridors between disjunct populations or populations fragmented by human actions.</p> <ul style="list-style-type: none"> Undertake revegetation of lost or previously damaged habitat caused by fire, resort development and clearing for roads and tracks. Monitor the recovery and recruitment rate of Mountain Plum-pine in burnt areas and undertake revegetation where required. Construct corridors in priority areas (for example, under the Great Alpine Road at Mt Little Higginbotham) to link upper and lower sections of boulderfield habitat and monitor these movement corridors for use by Mountain Pygmy-possums. 	DELWP, Parks Victoria, Alpine Resort Management Boards, Zoos Victoria
<p>9. Monitor and manage the impacts of introduced herbivores on Mountain Pygmy-possum habitat.</p> <ul style="list-style-type: none"> Continue rabbit monitoring and control programs. Assess whether deer browsing and trampling is having an adverse effect on habitat and implement mitigation strategies wherever appropriate. 	Parks Victoria, Alpine Resort Management Boards
<p>10. Reduce pressures and risks from ski slope activities.</p> <ul style="list-style-type: none"> Develop protocols with ski industry stakeholders with the aim to reduce impacts and increase protection of habitat from infrastructure and activities such as snow 	DELWP, Parks Victoria, Alpine Resort Management Boards, Ski Lift Companies

Intended Management Actions	Responsibility
<p>grooming, snow farming, snow fencing, snow-making and summer slope grooming.</p> <ul style="list-style-type: none"> Identify the limiting depth of snow cover to determine areas where the activities above should not occur under any circumstance. Develop and implement protocols to protect Mountain Pygmy-possum populations and habitat. 	
<p>11. Reduce sedimentation impacts on habitat.</p> <ul style="list-style-type: none"> Develop the most appropriate sediment mitigation design to exclude sediment from Mountain Pygmy-possum habitat. Ensure appropriate drainage works and sediment traps are constructed before disturbance occurs. Ensure sediment pits are appropriately designed, constructed and cleared regularly with the sediment transported away from the catchment and all areas of exposed soil are stabilised. 	Parks Victoria, Alpine Resort Management Boards, Ski Lift Companies
<p>12. Monitor and control weeds if they threaten habitat.</p> <ul style="list-style-type: none"> Control woody weeds including willows and blackberry where they threaten habitat. Monitor and control the spread of exotic grasses and perennials such as <i>Mimulus mochatatus</i>, <i>Hypericum perforatum</i> and <i>Juncus</i> spp. 	Parks Victoria, Alpine Resort Management Boards, Ski Lift Companies
<p>13. Manage walking tracks and roads to avoid impact on habitat.</p> <ul style="list-style-type: none"> Investigate and implement mechanisms to prevent widening, modification or realignment of roads negatively impacting on Mountain Pygmy-possum habitat. Realign walking and vehicle tracks away from the edges of boulderfields. 	Parks Victoria, Alpine Resort Management Boards
<p>14. Protect habitat from planned burning and fire suppression activities.</p> <ul style="list-style-type: none"> Develop and implement protocols that restrict all fire suppression activities to outside areas of important habitat, including boulderfields, surrounding heathland, linking corridors and potential dispersal habitat. Liaise with resort management, ski lift company and local CFA to facilitate fire suppression using available infrastructure, such as water storage reservoirs and snow making equipment. 	DELWP, Parks Victoria, Alpine Resort Management Boards, CFA
<p>15. Create new boulderfield habitat.</p> <ul style="list-style-type: none"> Undertake priority works at specific locations to create or enhance boulderfields and crossings to assist breeding and movement near developments. Monitor boulderfield augmentation sites for Mountain Pygmy-possum and Bogong Moth use. 	DELWP, Parks Victoria, Alpine Resort Management Boards
<p>Objective 3: To investigate key aspects of Mountain Pygmy-possum biology and ecology.</p> <p>The actions below seek to achieve a demonstrable increase in the knowledge of the biology, ecology and threats to Mountain Pygmy-possum so that implemented management actions are based on the most up-to-date scientific data. They will provide sound understanding of the state and trends in distribution, abundance, habitat extent and condition. They will also deliver better understanding of the effects of climate change on the population to inform the development of mitigation/adaptation strategies.</p>	
<p>16. Undertake surveys across potential habitat areas to determine any extant yet undiscovered populations.</p>	DELWP, Parks Victoria, Zoos Victoria

Intended Management Actions	Responsibility
<ul style="list-style-type: none"> Assess and survey other potential habitat sites in Victoria. Review surveys to determine whether future periodic trapping of these sites is warranted. 	
<p>17. Undertake detailed population monitoring and collect demographic information.</p> <ul style="list-style-type: none"> Conduct annual population monitoring in November/December for all populations at appropriate sites. Determine adequacy of current monitoring programs and adjust if necessary. Review data to estimate and detect changes in population sizes and demographics. Estimate the optimum carrying capacity of all sites. Evaluate any new and emerging threats. 	DELWP, Alpine Resort Management Boards, Parks Victoria, Zoos Victoria
<p>18. Investigate genetic composition, relatedness and undertake regular genetic monitoring of populations.</p> <ul style="list-style-type: none"> Assess future annual monitoring results of the key Victorian population and sub-populations (every five years) against Victorian genetic baseline work to date. Collect genetic material for study in any monitoring or translocations to be conducted in situ (either wild to wild or captive colony to wild translocations). Accurately determine the genetic relatedness and health within sub-populations and overall genetic robustness of each regional population. Investigate gene flow between populations after habitat rehabilitation or other disturbances. Monitor the ecological fitness of the wild bred cross-breeds at Mt Buller. Assess the population to determine genetic composition, relative survival, fecundity and key demographic parameters (abundance, sex ratios etc.). Review success, risks and any impacts to the Mt. Buller population to enable the development of mitigating measures into the revision of the Mt Buller Recovery Plan. 	DELWP, Alpine Resort Management Boards, Zoos Victoria
<p>19. Monitor habitat extent and condition.</p> <ul style="list-style-type: none"> Develop a habitat condition index for Type 1 and Type 2 habitat incorporating habitat structure, connectivity and species composition. Conduct periodic monitoring to determine trends. Maintain spatial data on habitat extent. 	DELWP
<p>20. Monitor Mountain Pygmy-possum diet and key food resources.</p> <ul style="list-style-type: none"> Collect and analyse scat samples from all annual monitoring sites. Monitor Bogong Moth seasonal arrival and relative abundance in Mountain Pygmy-possum habitat at ski resorts and wherever possible at other key sites in the Alps. Investigate Bogong Moth ecology with a focus on factors affecting timing and abundance of annual migration. Develop and refine an empirical model to assist in predicting likely future timing and abundance. Investigate the risks of transfer of organic pesticides via fat accumulation in Bogong Moths to summer aestivation sites. 	DELWP, Parks Victoria, Melbourne University, Alpine Resort Management Boards, Zoos Victoria

Intended Management Actions	Responsibility
<ul style="list-style-type: none"> • Monitor Mountain Plum-pine seeds and fruits. • Assess the importance of seed caching. • Trial supplementary feeding as an option for emergency response to significant food resource shortages. 	
<p>21. Monitor snow duration at each long-term monitoring site.</p> <ul style="list-style-type: none"> • Monitor the presence of snow cover and, if possible, measure snow depth at long-term population monitoring sites, and sites enhanced by snow making or snow farming. • Investigate and review the appropriateness of snow ski slope maintenance activities over and adjacent to areas of Mountain Pygmy-possum habitat. 	Alpine Resort Management Boards, Parks Victoria, Ski Lift Companies
<p>22. Monitor microclimate and develop population, snow dynamics and climate change models.</p> <ul style="list-style-type: none"> • Measure the microclimate within possum habitat. • Develop population, snow dynamics and climate change models to better predict the likely persistence of Mountain Pygmy-possums. Using this information, identify sites most at risk from climate change and sites likely to be refugia under predicted environmental conditions. • Use models to identify the most appropriate management strategies to mitigate adverse effects. 	DELWP, research partners
<p>23. Manage the captive population.</p> <ul style="list-style-type: none"> • Maintain a captive breeding and research population at Healesville Sanctuary • Assess and periodically review the role of the captive population. • Maintain a management plan for the captive population specifying research opportunities and emergency response strategies linked to relevant contingency plans (see action 3). 	DELWP, Zoos Victoria
<p>Objective 4: To increase community awareness of, and support for, Mountain Pygmy-possum conservation.</p>	
<p>The actions below raise awareness of key stakeholders during planning and implementation of management activities to ensure consideration of the Mountain Pygmy-possum and to increase participation in community programs and activities so that the community understands and supports conservation measures undertaken for the Mountain Pygmy-possum.</p>	
<p>24. Develop, publish and distribute informative material on the conservation status of Mountain Pygmy-possum and its habitat protection to a range of audiences.</p> <ul style="list-style-type: none"> • Produce information brochures and other material on the Alps and Mountain Pygmy-possum conservation issues and distribute or display at the Alpine Resorts, National Park Offices, at field days, at schools and tertiary institutions and on the web. • Highlight the Mountain Pygmy-possum in social and mainstream media • Run campaigns to raise awareness and funds for Mountain-Pygmy-possum conservation • Report progress on the recovery of the Mountain Pygmy-possum. 	DELWP, Zoos Victoria, Parks Victoria, Alpine Resort Management Boards
<p>25. Encourage Traditional Owner and broader community engagement in the conservation of the Mountain Pygmy-possum.</p>	DELWP, Zoos Victoria, Parks Victoria, Alpine Resort Management Boards,

Intended Management Actions	Responsibility
<ul style="list-style-type: none"> • Provide opportunities for Traditional Owner groups to contribute to decisions relating to Mountain Pygmy-possum conservation and to actively participate in surveys, monitoring and habitat rehabilitation work. • Provide opportunities for Victorian community to participate in survey, monitoring and habitat rehabilitation work in recovery activities for the Mountain Pygmy-possum. • Encourage the reporting of sightings of Mountain Pygmy-possums and of feral animals. • Document skier incursions into restricted habitat areas of ski resorts. 	Traditional Owner organisations

Interests of Aboriginal Victorians and Traditional Owners

The Mountain Pygmy-possum's habitat is distributed across the lands of a number of Traditional Owner groups. Advice was sought from DELWP Aboriginal Inclusion Officers to identify the relevant Traditional Owners who must be engaged in decision making across the Mountain Pygmy-possum range. Taungurung Land and Waters Council (TLWC) and Gunaikurnai Land and Waters Aboriginal Corporation (GLaWAC) were contacted and invited to review and provide comment on the draft action statement, participate in an on-Country visit to discuss the species and its recovery, including concerns regarding Bogong Moth decline and/or meet to discuss the action statement and how they would like to participate. The overall aim of the consultation was to respect the Traditional Owners as Custodians of the land, seek any recent or traditional knowledge of Mountain Pygmy-possums and discuss any concerns they may have with the proposed management actions in their areas.

Opportunities to involve Traditional Owners during the implementation of the action statement include:

- Surveying, monitoring and habitat rehabilitation assessments and actions, such as monitoring key food resources;
- Development and implementation of specific habitat management projects that can provide opportunities for direct engagement and employment for Traditional Owner groups on their lands;
- Opportunities to increase land management capacity and understanding of Country through sharing of cultural and scientific knowledge; and
- Participation in education and training relevant to threatened species management.

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References

- Bell, K.L. and Bliss, L.C., 1973. Alpine disturbance studies: Olympic national park, USA. *Biological Conservation*, 5(1), pp.25-32.
- Boys, N., 2018. Mountain Pygmy-possum *Burramys parvus*. Husbandry Manual, Healesville Sanctuary, Zoos Victoria.
- Broom, R., 1896. On a small fossil marsupial with large grooved premolars. *Proceedings of the Linnean Society of New South Wales* **10**, 563.
- Broome, L. S. (2001). Density, home range, seasonal movements and habitat use of the Mountain Pygmy-possum *Burramys parvus* (Marsupialia: Burramyidae) at Mt Blue Cow, Kosciuszko National Park. *Austral Ecology* **26**, 275-292.
- Broome L. S., 2008. Mountain Pygmy-possum. In 'The Mammals of Australia 3rd edition'. (Eds. S.Van Dyke and R.Strahan) pp.210-212. Reed New Holland: Australia.
- Broome, L. and Ford, F., 2005. Post fire recovery of Mountain Pygmy-possum and Smoky mice in Kosciuszko National Park. In *Fire Biodiversity in the Australian Alps National Parks*. Workshop proceedings Albury NSW (pp. 31-38).
- Broome, L. S. and Geiser, F., 1995. Hibernation in free living Mountain Pygmy-possums, *Burramys parvus* (Marsupialia: Burramyidae). *Australian Journal of Zoology* **43**, 373-379.
- Broome, L. S. and Mansergh, I. M., 1989. The mountain pygmy-possum *Burramys parvus* (Broom): an alpine endemic. In *The scientific significance of the Australian Alps*. (Ed. R.Good) pp. 241-265. Australian Alps National Parks Liaison Committee in association with the Australian Academy of Science, Canberra.
- Broome, L., Archer, M., Bates, H., Shi, H., Geiser, F., McAllan, B., Heinze, D., Hand, S., Evans, T. and Jackson, S., 2012. A brief review of the life history of, and threats to, *Burramys parvus* with a prehistory-based proposal for ensuring that it has a future. *Wildlife and Climate Change: Towards Robust Conservation Strategies for Australian Fauna*. (Eds. D.Lunney, P.Hutchings), pp.114-126.
- Buller Ski Lifts Pty. Ltd. 2006. *Habitat sedimentation reduction plan for Mountain Pygmy-possum habitat*. Mt Buller Alpine Resort, Victoria July 2006.
- Buller Ski Lifts Pty. Ltd. 2010. Mt Buller Grooming Manual. Unpublished report.
- Cash, E., 2015. A Comparison of the Behaviours of Captive bred and Wild Caught *Burramys parvus* (Marsupialia: Burramyidae). PhD Thesis, La Trobe University.
- Caughley, J., 1986. Distribution and Abundance of the Mountain Pygmy-Possum, *Burramys parvus* Broom in Kosciuszko National Park. *Wildlife Research*, 13(4), 507-516.
- Costin, A.B., Gray, M., Totterdell, C.J. and Wimbush, D.J., 1979. Kosciusko alpine flora. *Brunonia*, 2(2), pp.321-322.
- DELWP 2016. *National Recovery Plan for the Mountain Pygmy-possum Burramys parvus*. Australian Government, Canberra.
- DELWP 2019. Mountain Pygmy-possum Operational Contingency Plan 2019-20. Department of Environment, Land, Water and Planning, East Melbourne.
- DSE 2011. Policy and procedure statement for translocation of threatened native vertebrate fauna in Victoria. Department of Sustainability and Environment, Melbourne.
- Fanson, K. V. and Parrott M. L., 2016. The value of eutherian–marsupial comparisons for understanding the function of glucocorticoids in female mammal reproduction. *Hormones and Behaviour*. **76**: 41-47.
- Fanson, K.V. Best, E.C., Bunce, A., Fanson, B. G., Hogan, L. A., Keeley, T., Narayan, E. J., Palme, R., Parrott, M. L., Sharp, T. M., Skogvold, K. Tuthill, L., Webster, K. N. & Bashaw, M., 2017. One size does

not fit all: Monitoring faecal glucocorticoid metabolites in marsupials. *General and Comparative Endocrinology*. **244**, 146-156.

Feehan Consulting 2009. *Mountain Pygmy-possum and Class A Recycled Water*. Report commissioned by the Mount Buller and Mount Stirling Alpine Resort Management Board.

Geiser, F. and Broome, L.S., 1991. Hibernation in the Mountain Pygmy-possum *Burramys parvus* (Marsupialia). *Journal of Zoology London* **223**, 593-602.

Geiser, F. and Broome, L.S., 1993. The effects of temperature on the pattern of torpor in a marsupial hibernator. *Journal of Comparative Physiology Series B* **163**: 133-137.

Green, K., 2008. Migratory Bogong Moths (*Agrotis infusa*) transport arsenic and concentrate it to lethal effect by estivating gregariously in alpine regions of the Snowy Mountains of Australia. *Arctic, Antarctic, and Alpine Research* **40** (1): 74–80.

Gibson, R., 2007. The role of diet in driving population dynamics of the Mountain Pygmy-possum, *Burramys parvus*, in Kosciuszko National Park, NSW. Honours Thesis, Division of Botany and Zoology, Australian National University, Canberra.

Greenville, A.C., Burns, E., Dickman, C.R., Keith, D.A., Lindenmayer, D.B., Morgan, J.W., Heinze, D., Mansergh, I., Gillespie, G.R., Einoder, L., Fisher, A., Russell-Smith, J., Metcalfe, D.J., Green, P.T., Hoffmann, A.A. and Wardle, G.M., 2018. Biodiversity responds to increasing climatic extremes in a biome-specific manner. *Science of the Total Environment* **634**: 382-393.

Gullan, P. and Norris, K., 1984. The habitat of *Burramys parvus* (Broom) in Victoria. In *Possums and gliders* (Eds. A.Smith & I.D.Hume) pp.417-421. Surrey Beatty & Sons, Chipping Norton.

Harvey, A., 2007. *Fire Severity Mapping of Mountain Pygmy-possum Burramys parvus Habitat at Mount Buller, Victoria*. Final Report to the Mount Buller and Mount Stirling Alpine Resort Management Board. Project No. 6249, Biosis Research Pty. Ltd, Melbourne.

Heinze, D. A., 2005. *Mountain pygmy-possum Burramys parvus in Victoria two years after the 2003 Alpine Wildfires*. Report to Victorian Government Department of Sustainability and Environment. Melbourne.

Heinze, D. A., 2009. Monitoring of the Central Population of the Mountain Pygmy-possum *Burramys parvus* in Victoria, 2008-2009. Unpublished report for the Department of Sustainability and Environment, Victoria, Melbourne.

Heinze, D. and Harvey, A., 2006. *Habitat mapping for the Mountain Pygmy-possum Burramys parvus at Mount Buller, Victoria*. Report to Buller Ski Lifts and the Mount Buller and Mount Stirling Alpine Resort Management Board. Project No. 5507, Biosis Research Pty. Ltd, Melbourne.

Heinze, D. A., & Olejniczak, A. M., 2000. First observations of the mountain pygmy-possum *Burramys parvus* nesting in the wild. *Australian Mammalogy*. **22**(1), 65-67.

Heinze, D. A. and Williams, L., 1998. The discovery of the Mountain Pygmy-possum *Burramys parvus* on Mount Buller, Victoria. *Victorian Naturalist* **115**: 132-4.

Heinze, D., Broome, L. and Mansergh I., 2004. A review of the ecology and conservation of the Mountain Pygmy-possum *Burramys parvus*. In: *The Biology of Australian Possums and Gliders* (Ed. R.L.Goldingay and S.M.Jackson) pp 254-267. Surrey Beatty & Sons, Chipping Norton.

Hennessy K., Lucas C., Nicholls N., Bathols J., Suppiah R. and Ricketts J., 2005. *Climate Change Impacts on Fire-Weather in South-East Australia*. CSIRO Marine and Atmospheric Research, Bushfire CRC and Australian Bureau of Meteorology.

Hennessy, K., Whetton, P., Smith, I., Bathols, J., Hutchinson, M. and Sharples, J., 2003. *The impact of climate change on snow conditions in mainland Australia*. CSIRO Atmospheric Research, Aspendale.

Koch, J., Parrott, M. L., Watson, P. & West, M., 2011. Maintaining Behavioral Competence in Captive Mountain Pygmy-possums (*Burramys parvus*) at Healesville Sanctuary. *Thylacinus* **35**.

- Körtner, G., and Geiser, F., 1998. Ecology of natural hibernation in the marsupial Mountain Pygmy-possum (*Burramys parvus*). *Oecologia* **113**: 170-178.
- Love, P., 2010. Spatial and temporal characteristics of arsenic in the Bogong Moth (*Agrotis infusa*). PhD thesis, La Trobe University, Bundoora, Victoria.
- MacPhee, L. and Harvey A., 2007. Revegetation and Habitat Restoration Plan for the Mountain Pygmy-possum *Burramys parvus* on Mount Buller, Victoria. Biosis Research Pty. Ltd., Melbourne.
- Mansergh, I. M., 1988. The ecology and conservation of the Mountain Pygmy-possum (*Burramys parvus*), (Marsupialia: Burramyidae) in Victoria; with comparisons to populations in New South Wales, Australia. (in 2 vols). PhD thesis, La Trobe University, Bundoora, Victoria.
- Mansergh, I., Baxter, B., Scotts, D., Brady, T. and Jolly, T., 1990. Diet of the Mountain Pygmy-possum, *Burramys parvus* (Marsupialia: Burramyidae) and other mammals in the alpine environment at Mt Higginbotham, Victoria. *Australian Mammalogy* **13**: 167-177.
- Mansergh, I., Heinze, D. and Weeks, A., 2010. A new alternative to assist with the conservation of the Mountain Pygmy-possum *Burramys parvus* population on Mt Buller: facilitating and strengthening genetic diversity through cross-breeding in the wild. Proposal submitted to the *Burramys parvus* State Recovery Team.
- Mansergh, I., Kelly, P. and Scotts, D., 1989. Management strategy and guidelines for the conservation of the Mountain Pygmy-possum, (*Burramys parvus*) in Victoria. Arthur Rylah Institute Environmental Research Technical Report No. 66.
- Mansergh, I. M., & Broome, L. S., 1994. *The mountain pygmy-possum of the Australian Alps*. New South Wales University Press.
- Mansergh, I. and Scotts, D., 1990. Aspects of the life history and breeding biology of the Mountain Pygmy-possum, (*Burramys parvus*) (Marsupialia: Burramyidae) in alpine Victoria. *Australian Mammalogy* **13**: 179-191.
- Mansergh, I. M., & Walsh, N. G., 1983. Observations on the Mountain Pygmy-possum, *Burramys parvus*, on Mt Higginbotham, Victoria. *Victorian Naturalist*, 100, 106-15.
- McDougall, K. L. and Broome, L. S., 2007. Challenges facing protected area planning in the Australian Alps in a changing climate, pp 73-84. In: *Protected Areas: buffering nature against climate change*. Proceedings of a WWF and IUCN World Commission on Protected Areas Symposium, 18-19 June 2007, Canberra. (Eds M. Taylor and P. Figgis) WWF-Australia, Sydney.
- McKinnon, J., 2009. Intake of dietary energy by captive Mountain Pygmy-possums *Burramys parvus*, at Healesville sanctuary. Honours thesis, The University of Melbourne.
- Menkhorst, P and Knight, F., 2001. *A field guide to the mammals of Australia*. Oxford University Press, Australia.
- Mitrovski, P., Heinze, D., Broome, L., Hoffmann, A. A. and Weeks, A. R., 2007. High levels of variation despite genetic fragmentation in populations of the endangered Mountain Pygmy-possum *Burramys parvus*, in alpine Australia. *Molecular Ecology* **16**: 75-87.
- Mitrovski, P., Hoffman, A.A., Heinze, D.A. and Weeks, A.R., 2008. Rapid loss of genetic variation in an endangered possum. *Biology Letters* **4**: 134-138.
- Mt Buller and Mt Stirling Alpine Resort Management Board, 2005a. Integrated Pest Animal Control Program. Internal unpublished report.
- Mt Buller and Mt Stirling Alpine Resort Management Board, 2005b. Recovery Plan for the Mountain Pygmy-Possum *Burramys parvus* on Mt Buller, Victoria. Internal unpublished report.
- Mt Buller and Mt Stirling Alpine Resort Management Board, 2006. Snowmobile Manual Insert. Unpublished report.

- Mt Buller and Mt Stirling Alpine Resort Management, 2007. Vehicular Roads and Tracks Management Strategy. Unpublished report.
- Mt Buller and Mt Stirling Alpine Resort Management Board, 2008. Wildfire Management Plan. Unpublished report.
- Mt Buller and Mt Stirling Alpine Resort Management Board, 2009a. Trap Design and surveys of Bogong Moths (*Agrotis infusa*) at Mount Buller. Unpublished report.
- Mt Buller and Mt Stirling Alpine Resort Management Board, 2009b. Weed Strategy Mount Buller and Mount Stirling Alpine Resorts, Victoria. Unpublished report.
- Osborne, M. J., Norman, J. A., Chistidis, L. and Murray, N. D., 2000. Genetic distinctness of isolated populations of an endangered marsupial, the Mountain Pygmy-possum *Burramys parvus*. *Molecular Biology* **9**: 609-613.
- Parrott, M., Harley, D. and Traher, R., 2011. Zoos Victoria Threatened Species Draft Captive Management Plan: Mountain Pygmy-possum (*Burramys parvus*).
- Parrott M., Davies, N., Wicker, L., Broome, L. and Miller K., 2020. Looks like an ANZAC biscuit, tastes like a protein bar: Bogong Bikkies help mountain pygmy-possums after fire. *The Conversation*, February 6, 2020.
- Sanecki, G. M., Green, K., Wood, H. and Lindenmayer, D., 2006. The implications of snow-based recreation for small mammals in the subnivean space in south-east Australia. *Biological Conservation* **129**: 511–518.
- Schulz, M., Wilks, G. and Broome, L., 2012. An uncharacteristic new population of the Mountain Pygmy-possum *Burramys parvus* in New South Wales. *Australian Zoologist* **36**: 22-28.
- Scheelings, T. F. and Dobson, E. C., 2015. Retrospective analysis of causes of death in mountain pygmy-possums (*Burramys parvus*) at Healesville Sanctuary, Victoria, Australia. *Aust Vet J.* **93**: 424-9.
- Scicluna, E., 2017. The reproductive endocrinology of female Mountain Pygmy-possums *Burramys parvus* (Marsupialia: Burramyidae); a comparison of successful and unsuccessful breeding females. Honours Thesis, Deakin University.
- Sherwen S. and Jones T., 2019. You can help track 4 billion Bogong moths with your smartphone – and save pygmy possums from extinction. *The Conversation*, September 16, 2019.
- Smith, A. P. and Broome, L. S., 1992. The effect of season, sex and habitat on the diet of the Mountain Pygmy-possum. *Wildlife Research* **19**: 755-768.
- SMEC, 2007. Feasibility and planning study for major boulderfield habitat re-creation at Mount Buller. Report commissioned by the Mount Buller and Mount Stirling Alpine Resort Management Board.
- Solomon, S., Qin, D., Manning, M., Averyt, K. and Marquis, M., Eds., 2007. Climate change 2007 - the physical science basis: Working group I contribution to the fourth assessment report of the Intergovernmental Panel on Climate Change (Vol. 4). Cambridge University Press.
- Steffen, W., 2009. *Australia's biodiversity and climate change*. CSIRO Publishing.
- Walter, M., 1996. The ecology of hibernating Mountain Pygmy-possum *Burramys parvus* in Kosciuszko National Park. Honours thesis, University of Canberra.
- Watson, P., Parrott, M. L. and West, M., 2010. Healesville Sanctuary's role in the conservation of Australia's only hibernating marsupial, the Mountain Pygmy-possum (*Burramys parvus*). *Thylacinus* **34**.
- Weeks, A. R. and Corrigan, T., 2011. Translocation strategy for the Mount Buller population of the Mountain Pygmy-possum: 2011 - 2015. A report prepared for the Department of Sustainability and Environment, East Melbourne.
- Weeks, A. R., Heinze, D., Kelly, T. and Mansergh, I., 2013. Annual spring monitoring of the Mountain Pygmy-possum at Mt Buller Alpine Resort, 2012. A report prepared for the Department of Sustainability and Environment, East Melbourne.

Weeks, A. R., Heinze, D., Perrin, L., Stoklosa, J., Hoffmann, A. A., van Rooyen, A., Kelly, T. and Mansergh, I., 2017. Genetic rescue increases fitness and aids rapid recovery of an endangered marsupial population. *Nature Communications* 8.

Whetton, P.H., 1998. Climate change impacts on the spatial extent of snow-cover in the Australian Alps. *Snow: a natural history; an uncertain future*, pp.195-206.

Whetton, P.H., Haylock, M.R. and Galloway, R., 1996. Climate change and snow-cover duration in the Australian Alps. *Climatic Change*, 32(4), pp.447-479.

Williams, R. J., Bradstock, R. A., Cary, G. J., Enright, N. J., Gill, A. M., Liedloff, A. C., Lucas, C., Whelan, R. J., Andersen, A. N., Bowman, D. M. J. S., Clark, P. J., Cook, G. D., Hennessy, K. J. and York, A., 2009. *Interactions between climate change, fire regimes and biodiversity in Australia – a preliminary assessment*. Report to the Department of Climate Change and Department of the Environment, Water, Heritage and the Arts, Canberra.

Zoos Victoria 2014. *Wildlife Conservation Masterplan 2014-2019*. Zoological Parks and Gardens Board, Victoria.

Zoos Victoria 2019. *Wildlife Conservation Masterplan 2019-2024*. Zoological Parks and Gardens Board, Victoria.

