The Minister approved this conservation advice and retained this species in the Endangered category, effective from 1 September 2020

Conservation Advice

Pseudomys fumeus

Smoky Mouse

Taxonomy

Conventionally accepted as *Pseudomys fumeus* (Brazenor 1934). No subspecies are recognised.

Summary of assessment

Conservation status

Endangered: Criterion 2 B2(a),(b)(iii,v),(c)(iv)

The highest category for which *Pseudomys fumeus* is eligible to be listed is Endangered.

Pseudomys fumeus has been found to be eligible for listing under the following categories:
Criterion 2: B2 (a),(b)(iii),(c)(iv): Endangered
Criterion 3: C2(b): Vulnerable

Species can be listed as threatened under state and territory legislation. For information on the listing status of this species under relevant state or territory legislation, see http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

Reason for conservation assessment by the Threatened Species Scientific Committee

The Smoky Mouse was listed as Endangered under the predecessor to the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), the *Endangered Species Protection Act 1992*, and transferred to the EPBC Act in July 2000.

This advice follows assessment of new information provided to the Committee to review the listing status of the Smoky Mouse.

Public consultation

Notice of the proposed amendment and a consultation document was made available for public comment for 32 business days between 17 May 2019 and 3 July 2019. Any comments received that were relevant to the survival of the species were considered by the Committee as part of the assessment process.

Species/subspecies information

The Smoky Mouse is a native mouse, similar in size to a small rat (Watts & Aslin 1981). It is pale grey to blue-grey to black above, with a grey to white belly (Cockburn 1995) and a ring of dark hairs around each of its large, bulging eyes. The feet are pink with white fur (Cockburn 1995). The species is distinguished by its bi-coloured tail, which is blue-grey dorsally, white ventrally and lightly furred. The species has a head and body length of 85–100 mm (average 90 mm), a tail length of 110–145 mm (average 140 mm) and weighs 45–86 g (Cockburn 1995).

Variability in size and colour has been noted between two forms found in Victoria. The western form, known only from the Grampians, is larger and darker than the eastern form (east of

Melbourne) (Cockburn 1995). Specimens found in New South Wales appear to be similar to the eastern form (Osborne & Preece 1987).

Other common names for the species include Koonoom (Wonarski et al. 2014).

Distribution

The Smoky Mouse occurs in Victoria, New South Wales (NSW) and the Australian Capital Territory (ACT), over a wide but disjunct distribution with small and fragmented populations (Menkhorst & Broome 2006). Most of the populations are in Victoria, where the species has been recorded from the greater Grampians area, the Otway Ranges, the south-east highlands area (the Central Highlands and Victorian Alps) and the East Gippsland lowland area (Menkhorst & Broome 2006). It is not certain that the species persists in all of these regions, as it has not been recorded from the Otway Ranges since the 1980s, or from East Gippsland since 1990, despite rigorous survey efforts (Menkhorst & Broome 2006; Nelson et al. 2009; Burns et al. 2015).

The species was first recorded in NSW and the ACT in the mid-1980s (Menkhorst & Broome 2006). In NSW, the Smoky Mouse has been recorded from Kosciuszko National Park (NP), Bondo State Forest (SF), Buccleugh SF, Ingbyra SF, Nullica SF and South-East Forests NP (Menkhorst & Broome 2006; Schulz & Wilks 2017). In the ACT the Smoky Mouse is known from the Brindabella Range in Namadgi NP, but it has not been recorded in the ACT since the initial sightings in the 1980s despite targeted surveys.

In 2018−19, during surveys for the Snowy 2.0 development in NSW, a substantial and significant new population (42 records from live captures and camera traps) was found north of Cabramurra in Kosciuszko NP. During 2018−19 surveys by the NSW Department of Planning, Industry and the Environment, two additional camera trap records were also obtained: one near the northern border of Kosciuszko NP, and one approximately 25 km south-west of Cabramurra (L Broome 2019. pers comm 31 July).

The Smoky Mouse formerly had a wider distribution. Fossil records have been collected from caves in far western Victoria and eastern Victoria, and from caves in the southern highlands, south-east Queanbeyan and south-west of Sydney in NSW (Menkhorst & Broome 2006). Its current range is likely to be highly residual, following extensive decline since the Pleistocene, with decline continuing or accelerating since European settlement (Menkhorst 1995; Bilney et al. 2010).

Adequacy of survey

Several surveys have been undertaken for the Smoky Mouse in various parts of its range. Although the results of the surveys to date are highly variable due to the ephemeral nature of populations, the surveys are considered adequate to inform an assessment of the species' listing status.

Relevant biology/ecology

Habitat and diet

The Smoky Mouse inhabits a range of vegetation communities including coastal and subalpine heath, *Eucalyptus pauciflora* (Snow Gum) woodland in the subalpine regions, and dry forest dominated by eucalypts such as *E. dives* (Broad-leaved Peppermint), *E. mannifera* (Brittle Gum), *E. dalrympleana* (Mountain Gum) or *E. delegatensis* (Alpine Ash). The species has also been trapped in fern gullies in wet forest in the Grampians (Menkhorst 1995). Capture sites range from near sea level to at least 1800 m above sea level (Broome & Menkhorst 2006).

Surveys undertaken in eastern Victoria and south-eastern NSW (Menkhorst & Seebeck 1981; Jurskis et al. 1997; Ford 1998a,b; Ford et al. 2003) indicate that the species' preferred habitat is ridge-top sclerophyll forest (Cockburn 1995) with a diverse understorey of heathy shrubs. Nearly

all captures at Nullica, NSW, have been on ridgetops or mid-upper slopes in, or immediately adjacent to, understorey heath communities; captures away from heath have been of single individuals (Ford & Broome 2005). However, a more recent study captured more individuals in damp drainage systems than on dry slopes (Burns et al. 2015), which suggests that further investigation may be needed to determine the species' habitat requirements.

A characteristic of Smoky Mouse habitat (with the exception of wet gullies) is the presence of floristically diverse heathy understorey, with members of the plant families Epacridaceae, Fabaceae and Mimosaceae well represented (Cockburn 1981a; Menkhorst & Seebeck 1981; Jurskis et al. 1997; Ford 1998a,b; Ford et al. 2003). Selection of these habitats appears to be directly linked to a dietary requirement for the diversity of food resources in these patches (Ford et al. 2003). Adequate ground cover (low heath, grass tussocks, logs, rocks or leaf-litter) and soil conditions conducive to the growth of hypogeal fungi (a major component of the diet) are also likely to be critical habitat elements (Menkhorst & Broome 2006).

The Smoky Mouse generally doesn't occur in disturbed areas. However, four individuals were caught in an artificial boulderfield in Kosciuszko NP in 2015, but were not detected in the adjacent natural vegetation or scree slopes despite extensive survey effort (Schulz & Wilks 2017). The presence of a well-defined boulderfield, which was also present at the damp gully sites of Burns et al. (2015), likely provides a refuge from feral cats (L Broome 2019. pers comm 31 July). This was the first live capture of the species in Koscuisko NP, and only the second locality where live captures have been made in NSW since 2001. No further records of Smoky Mouse have been obtained at this site since, despite annual monitoring (L Broome 2019. pers comm 31 July).

The diet of Smoky Mouse includes seeds, berries, underground fungi, flowers, and some invertebrates (Menkhorst 1995), with composition showing marked seasonal variation. Fungi is primarily consumed in winter, and seeds and invertebrates (especially *Agrotis infusa* (Bogong Moths)) in spring−summer (Cockburn 1981a; Ford et al. 2003), with potential resource bottlenecks between these periods (Cockburn 1981b). The species appears to have a preference for habitat that provide a year round source of high quality foods rich in nitrogen (Cockburn 1981a).

Life history

Life history studies in the Grampians, Victoria (Cockburn 1981a,b) and Eden, NSW (Ford 1998b, Ford et al. 2003) indicate that the species occurs in small discrete colonies, with each colony occupying a burrow system up to a metre in length (Woods & Ford 2000; Ford et al. 2003). Transient males may move between colonies in search of mates (Ford 1998a), suggesting that the species exists in an area as a metapopulation, the long-term survival of which would be contingent on recruitment and immigration between subpopulations and the regional dynamics of resources availability in patches of habitat (Menkhorst 2003).

Breeding is seasonal, with females producing one–two litters of three–four young per year, and most births occurring in the period October to January (Cockburn 1981b; Menkhorst 1995). Breeding may be communal, with several females cohabiting in burrows (Woods & Ford 2000; Ford et al. 2003). Males and females breed in their first year, and many survive to breed in a second year (Cockburn 1981b), so generation length is taken to be one–two years (Woinarski et al. 2014).

The population undergoes large annual fluctuations in abundance, with a rapid decline in numbers just before the breeding season (Cockburn 1981b). This is due to the death or dispersal of young, which are forced to vacate their natal territory during autumn as food resources dwindle, with only those finding high quality food likely to survive the winter (Cockburn

1981b). Consequently, the decline in abundance principally affects individuals resident in non-preferred habitats (Cockburn 1981b).

The Smoky Mouse displays both long-term range contractions and short-term boom-bust population cycles. Individual populations may at times show 'booms' of high detection rates (5–19 percent trap success) and busts where no, or very few, detections are made. Population pulses are generally in response to changes in resource availability (Menkhorst 2003). However, true variation in population density may be confounded with variability in capture/detectability, making it difficult to accurately determine when a true decline or range contraction has occurred. The species is "extremely difficult to monitor…and disappears rapidly from most known sites" (Ford & Broome 2005). Failing to detect the species when it is present is a key problem for surveys of species such as the Smoky Mouse (Nelson et al. 2009; Burns et al. 2015). Trapping rates are usually low, at around 4 percent or less (Menkhorst & Seebeck 1981; Ford 1998b); however, they can be quite high in quality habitat when conditions are good (Menkhorst 2003).

There are multiple methods available for detection of Smoky Mouse including Elliott traps, hair tubes and camera traps. None are optimal, and at times one may get better results than another (Nelson et al. 2009). The sampling duration and number of traps per night that are required to detect the species during periods of low abundance may be much greater (Burns et al. 2015). Methods based on motion-sensitive cameras may improve understanding of both persistence and population cycles as date stamping of photos, and multi-day deployment of cameras, allows detection histories to be developed that enable estimation of detection probabilities. Sampling in the Central Highlands of Victoria had estimated detection probabilities of 89 percent or higher for two models of camera, and detected Smoky Mice at 21 of 120 sites (18 percent) (Lumsden et al. 2013).

Persistence of Smoky Mouse populations over a period of 40 years has been demonstrated in the Grampians (Victoria), despite drought, invasive predators and significant fire (Burns et al. 2015). There was evidence of a possible range contraction but there were insufficient data to determine when this occurred (within a 39 year period) nor whether the larger earlier distribution was due to a single dispersing individual (Burns et al. 2015). Similarly, there were suggestions that shorter term fluctuations were associated with rainfall/drought cycles but insufficient statistical power to assess them effectively. Smoky mice persisted within an area severely burned by wildfire for at least 21 months post-fire (Burns et al. 2015).

Threats

The Smoky Mouse has undergone a contraction in range post-European settlement, due to loss of habitat as a result of vegetation clearance (Lee 1995). Since the 1980s the species may have been extirpated from the Otway Ranges, East Gippsland and the ACT, and the apparent instability of populations is of concern. The primary threats to the species are predation by feral cats and foxes (impacts of predation may be magnified where too frequent or high-intensity burns occur, and during drought periods), and habitat destruction from land clearance, logging and development activities.

Table 1 − Threats impacting the Smoky Mouse in approximate order of severity of risk, based on available evidence

Number	Threat factor	Threat type and status	Evidence base
1.0	Invasive species		
1.1	Predation by feral cats (*Felis catus*)	Known current	Predation by feral cats has been implicated in the decline and extinction of many terrestrial mammals in Australia (Woinarski et al. 2014; Radford et al. 2018). In an analysis of mammal traits associated with the relative likelihood of cat

			predation, Woolley et al. (2019) ranked the Smoky Mouse in the top 40 non-volant terrestrial native mammal species most likely to be threatened, with a likelihood of 0.578 (95% CI 0.384−0.751) of being killed by feral cats. The Smoky Mouse is particularly vulnerable to predation because it has a relatively low reproductive rate, often inhabits vegetation with an open ground layer, and uses shallow communal burrows with well-defined entrances that can be staked out by 'sit and wait' predators such as feral cats (Menkhorst & Broome 2006). In 1998, three Smoky Mouse individuals were found dead at Yarrangobilly, most likely due to feral cat predation (Ford 1998b). Feral cats have the potential to eliminate small breeding populations within a very short time (Risby et al. 2000) and have been linked to a population crash at a site in the Nullica area in 1997 (Ford et al. 2003). Since 2013, the Smoky Mouse has not been detected in the area of Nullica containing the South-East Forests NP, however feral cats have (L Broome 2019. pers comm 31 July). Fire can amplify the impacts of predation on small mammals by reducing ground cover, particularly following high-intensity burns (Leahy et al. 2015). Fire in a forest in south-eastern Australia reduced understorey cover by more than 80 percent and resulted in a 5-fold increase in the occurrence of feral cats and foxes (Hradsky et al. 2017). The impacts of feral cats on small mammals appear to be mitigated by the maintenance of a dense understorey (McGregor et al. 2014; Davies et al. 2017), with the occurrence of most small-medium sized mammals positively associated with understorey cover (Hradsky et al. 2017). Droughts, which may become more severe under climate change, can intensify the impact of predation by restricting the reproductive output of Smoky Mouse populations (Short 2016).
1.2	Predation by foxes (*Vulpes vulpes*)	Known current	Predation by foxes has been implicated in the decline and extinction of many terrestrial mammals in Australia (Radford et al. 2018). Unlike feral cats, foxes are known to engage in surplus killing, where they kill more prey than required to meet their immediate needs (Short et al. 2002; McGregor et al. 2015). Fox predation can be significant for small isolated populations, and for communal nesting species such as the Smoky Mouse (Woinarski et al. 2014). Smoky Mouse remains have been detected in fox and wild dog scats (May & Norton 1995; Broome & McDonald 1997).

			There is some concern that control efforts focussed solely on foxes may lead to an increase in rabbits (*Oryctolagus cuniculus*) and stimulate an increase in predators such as feral cats (Risby et al. 2000), leading to a detrimental effect on Smoky Mouse populations. As with feral cats, fire can amplify the impacts of fox predation on small and medium-sized mammals (Leahy et al. 2015; Hradsky et al. 2017).
1.3	Predation by wild dogs (*Canis familiaris*)	Known current	Smoky Mouse remains have been detected in fox and wild dog scats (May & Norton 1995; Broome & McDonald 1997). An increase in dingo activity has been observed immediately following fire (Leahy et al. 2015). However, the level of impact of dog predation on the species is unclear. Dingoes appear not to have had the dire impact on native mammals that feral cats and foxes have (Short et al. 2002), and there is some evidence that wild dogs suppress populations of cats and foxes (Ritchie et al. 2014).
2.0	Habitat loss and degradation		
2.1	Vegetation clearance/ Habitat fragmentation	Known current	Approximately 20% of the species' AOO within National Parks and State Forests in NSW has been logged since 1990 (DPIE 2010). Since the species was first discovered at Nullica in 1994, around 35% of its State Forest habitat has been logged and the population there has experienced severe declines (Ford & Broome 2005). Logging at Nullica SF, including habitats identified as core Smoky Mouse habitat, occurs on a 25 year rotation; however, preliminary research indicates that forest with heathy understories preferred by the species cannot recover within a 25 year timeframe (Ford & Broome 2005). The species' habitat has also been cleared and fragmented on freehold land and for the construction of roads (Menkhorst & Broome 2006). The recently-discovered population in Kosciuszko NP is potentially threatened by the Snowy 2.0 development in NSW. Smoky Mouse populations (colonies) fit a metapopulation model, whereby populations are largely isolated from one another and reestablishment of a locally extirpated population depends on immigration from other populations. The discrete and ephemeral nature of Smoky Mouse colonies, together with their apparent low persistence at sites, means that Smoky Mouse populations are likely to be profoundly affected by habitat clearing and fragmentation.

2.2	Habitat loss caused by Cinnamon Fungus (*Phytophthora cinnamomi*)	Known current	Up to 60% of understorey plant species are eliminated in heathlands and heathy woodlands infected by Cinnamon Fungus (Kennedy & Weste 1986). The percentage of affected vegetation is a significant variable affecting small mammal diversity and density (Wilson et al. 1994). Many of the plant families and genera characteristic of Smoky Mouse habitat are particularly susceptible to the fungus. Smoky Mouse habitat in some areas of infestation has been degraded or eliminated in both Victoria (e.g. East Gippsland and the Grampians; Menkhorst 2003) and NSW (e.g. Nullica) (Menkhorst & Broome 2006). Cinnamon Fungus has the potential to have a large impact on populations of the Smoky Mouse.
3.0	Fire		
3.1	Too frequent burning	Suspected current	Too frequent fires, such as repeated prescribed burns, are likely to simplify the heath understorey in dry forests towards early successional species, depleting floristic diversity and abundance of the Smoky Mouse's preferred heath species, and encouraging ingress of predators (Catling 1986, 1991). Frequent burning is also likely to result in a low abundance and diversity of fungi (Claridge & Cork 1997). Although the Smoky Mouse has been trapped in vegetation ranging from early to senescent seral stages following fire (2−40 years) and can persist within an area severely burned by wildfire for at least 21 months post-fire (Burns et al. 2015), it appears to be most abundant in relatively stable habitats (Menkhorst 2003). Insufficient data exist to determine the fire-dependent vegetation states that are compatible with persistence of Smoky Mouse populations. It has been suggested that the understorey floristics and density at most Smoky Mouse sites in heath and dry forests can be maintained by fire regimes of moderate frequency (15–20, but up to 40, year intervals) and moderate intensity (Lane 1997; Ford et al. 2003). Fire-free intervals which are too long may result in senescence in heathland plants (Menkhorst 2003).
4.0	Climate change		
4.1	Increased fire frequency/ intensity due to climate change	Suspected future	Current climate change predictions suggest that wildfires will become more frequent and intense. Whether such 'unplanned' fire regimes *per se* will be unfavourable for the Smoky Mouse and its habitat is uncertain. However, the effect of higher-severity wildfire events could result in a greater probability of local extinctions of Smoky Mouse

			populations. More frequent fuel reduction burns (in response to perceived greater fire threat) could also present a threat to the Smoky Mouse if the resulting fire regime promotes habitat characteristics that are less suitable for the species (ACT Government 2013). Periods of drought following fire are also likely to increase under climate change, compounding impacts to habitat and populations of Smoky Mouse. This was exemplified in the recent 2019-20 bushfires. Following years of drought (DPI 2020), catastrophic wildfire conditions culminated in fires that engulfed eastern Australia, covering an unusually large area and, in many places, burnt with an unusually high intensity. The full impact of the 2019-20 bushfires has yet to be determined. The bushfires will not have impacted all areas equally, with the pattern and intensity varying within the fire grounds. Some areas will have burnt at very high intensity whilst other areas may not have burnt at all. However, initial indications are that an estimated 10–30 per cent of the Smoky Mouse's distribution range was impacted. The extent of potential habitat loss, together with the Smoky Mouse's vulnerability to fire and post-fire conditions, has led to it being identified as one of the highest priority species for urgent management intervention (DAWE 2020).

How judged by the Committee in relation to the EPBC Act criteria and regulations

Criterion 1. Population size reduction (reduction in total numbers)
Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4

	Critically Endangered Very severe reduction	Endangered Severe reduction	Vulnerable Substantial reduction
A1	**≥ 90%**	**≥ 70%**	**≥ 50%**
A2, A3, A4	**≥ 80%**	**≥ 50%**	**≥ 30%**

A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.

A2 Population reduction observed, estimated, inferred or suspected in the past where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible.

A3 Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [*(a) cannot be used for A3*]

A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

based on any of the following:

(a) direct observation [*except A3*]

(b) an index of abundance appropriate to the taxon

(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat

(d) actual or potential levels of exploitation

(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites

Evidence:

Insufficient data to determine eligibility

The results of Smoky Mouse surveys undertaken to date are highly variable, with detections often followed by extended absences before being detected again at that site or nearby. For example, in the Grampians a Smoky Mouse population persisted for 40 years, despite extended periods of (probable) low abundance when it was undetected (Burns et al. 2015). There is evidence suggestive of regional extinctions, with Smoky Mouse not detected in the Otway Ranges, East Gippsland or Namadgi NP for two decades (Menkhorst & Broome 2006; Nelson et al. 2010; Belcher 2011). However, the live trapping of several individuals in Kosciuszko NP in 2015, after unsuccessful efforts to do so over a 70 year period (Schulz & Wilks 2017), demonstrates the difficulty in concluding that local extinction has occurred.

In Victoria, the population in the Central Highlands is by far the largest and occurs in the largest extent of habitat. Trends in the population are unclear. Sampling in the Central Highlands of Victoria in 2012 detected the Smoky Mouse at 21 of 120 sites (Lumsden et al. 2013). Surveys in 2018−19 by Zoos Victoria and the Museum Victoria at 150 sites across the Central Highlands failed to detect Smoky Mouse at two thirds of the sites from which Lumsden et al. (2013) found them at in 2012, but individuals were detected at 27 new sites (DELWP 2019. pers comm 15 October). In the Victorian Alps, only two records have been found post-2000 (DEWLP 2019. pers comm 15 October).

Previously, a large population existed at Mt William in the Grampians; Cockburn (1981a) reported 701 captures from 9600 trap-nights over the period 1976 to 1979. However, the population has declined substantially since (Menkhorst 1995; Nelson et al. 2009). Since the late 1970s some sites in the Grampians have been sampled intermittently (Cockburn 1981a,b; Homan 2008; Nelson et al. 2009), and some surveys have had relatively high detection rates, partly due to the introduction of a new survey technique (Nelson et al. 2009). Populations at Victoria Range in the Grampians may be declining; the population at one of the survey sites declined from 27 individuals in November 2012, to nine in 2013 and three in 2014 (Burns et al. 2015). However, due to natural fluctuations in population numbers, the trend is unclear.
In NSW, the population at Nullica has declined over the last two decades, with an estimated decline of greater than 50 percent over the last 10 years. During a six month study undertaken during 1997−98, the Smoky Mouse was one of the most commonly trapped rodents in the area, with 32 individuals captured (Ford et al. 2003). However, site occupancy rates have declined from 85 percent (20 sites sampled) in 1997−2004, to 31 percent (29 sites sampled) in 2005−2013 and 24 percent (29 sites sampled) in 2014−2018, and the population apears to have contracted to the centre/east region of the study area (L Broome 2019. pers comm 21 August). The population trend in Kosciuszko NP is undetermined (L Broome 2019. pers comm 31 July).

In the ACT, the only confirmed records are two individuals trapped in Namadgi NP in the 1980s. Subsequent surveys have failed to detect the species, including a large targeted survey undertaken in Namadgi NP in 1994. Most recently, a baited camera survey was undertaken in Namadgi NP in 2013−14, with 50 sites of potential habitat surveyed over a total of 500 trap-nights (Evans 2018). Sites were located in four main vegetation types, and included some of the most remote and difficult to access areas (these were accessed by helicopter), and the two sites where the species was previously trapped. No individuals were found. A range of other mammals, reptiles and birds were detected, including feral cats (12 percent of sites) and foxes (8 percent of sites) that were found even in the most remote locations. The surveys indicate that the Smoky Mouse is now absent in Namadgi NP, or if present is extremely rare.

Overall, a decline in population size over the past 10 years is suspected, due to declines reported at Nullica and ongoing threats facing the species. However, there are insufficient data to quantify trends in population size.

The Committee considers that there is insufficient information to determine the eligibility of the species for listing in any category under this criterion.

Criterion 2.	Geographic distribution as indicators for either extent of occurrence AND/OR area of occupancy			
		Critically Endangered Very restricted	**Endangered Restricted**	**Vulnerable Limited**
B1.	Extent of occurrence (EOO)	**< 100 km²**	**< 5,000 km²**	**< 20,000 km²**
B2.	Area of occupancy (AOO)	**< 10 km²**	**< 500 km²**	**< 2,000 km²**
AND at least 2 of the following 3 conditions:				
(a)	Severely fragmented OR Number of locations	**= 1**	**≤ 5**	**≤ 10**
(b)	Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals			
(c)	Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals			

Evidence:

Eligible under Criterion 2 B2(a),(b)(iii,v),(c)(iv) for listing as Endangered

There is no robust estimate for the Area of Occupancy (AOO). However, available data indicates that the AOO is likely to be less than 500 km^2.

Based on the mapping of point records from the last 20 years (1999 to 2019) obtained from state governments and museums, the Extent of Occurrence (EOO) is estimated to be 102 270 km^2, and the Area of Occupancy (AOO) estimated to be 264 km^2. The EOO was calculated using a minimum convex hull, and the AOO calculated using a 2x2 km grid cell method, based on the IUCN Red List Guidelines 2014 (DotE 2018). Using records from the last 40 years (going back to 1979), the estimated AOO is 604 km^2. However, this includes records from the Otways, East Gippsland and the ACT, where the species may no longer be extant.

The Victorian Department of Environment, Land, Water and Planning estimated the AOO to be 480 km^2 in Victoria, based on records from the past 50 years (post-1970) but excluding records from East Gippsland, the Otways, Teran and Lower Glenelg. They considered this a generous estimate given that population numbers and localities of the species fluctuate (DEWLP 2019. pers comm 15 October).

The ephemeral nature of populations makes a robust estimate of AOO difficult. A lack of detection may indicate that a population no longer occurs, or that it is persisting at very low levels. The above data indicates that the AOO is probably around 500 km^2, but it could be less if populations previously detected are no longer extant, or greater given there has been limited sampling throughout the species' range. Here we take a risk-based and precautionary approach and, given that the population appears to be declining, argue that the AOO is likely to be less than 500 km^2, which meets the threshold for Endangered under subcriterion B2.

The Smoky Mouse is subject to long acting, landscape scale threats that impact on individuals of the taxon sequentially or randomly over time. There are four discrete areas where the majority of individuals are potentially at risk of being impacted by these threats (notably feral predators and increased fires): the Grampians (Victoria), Central Highlands (Victoria), Eden/Nullica region (south-eastern NSW), and the Snowy Mountains (from Cabramurra to the Brindabellas, NSW). Therefore, the species is considered to occur at no more than five locations, which meets subcriterion (a).

A continuing decline in the area or quality of habitat can be inferred, based on clearing for forestry, the extent of habitat impacted by the recent 2019-20 bushfires, and the ongoing impacts of Cinnamon Fungus, which meets subcriterion (b)(iii). A continuing decline in numbers

of mature individuals is also inferred (see Criterion 1), which meets subcriterion (b)(v). The number of mature individuals undergoes extreme fluctuations, with captures at individual sites known to decline by an order of magnitude (e.g. from 30−40 to fewer than 3) within a period of two years (L Broome 2019. pers comm 21 August). This meets subcriterion (c)(iv).

The Committee considers that the species' area of occupancy is likely to be restricted, the number of locations is limited, there is an inferred continuing decline in the area/quality of habitat and number of mature individuals, and the number of individuals undergoes extreme fluctuations. Therefore, the species has met the relevant elements of Criterion 2 to make it eligible for listing as Endangered.

Criterion 3. Population size and decline				
		Critically Endangered Very low	**Endangered Low**	**Vulnerable Limited**
Estimated number of mature individuals		**< 250**	**< 2,500**	**< 10,000**
AND either (C1) or (C2) is true				
C1	An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future)	**Very high rate 25% in 3 years or 1 generation (whichever is longer)**	**High rate 20% in 5 years or 2 generation (whichever is longer)**	**Substantial rate 10% in 10 years or 3 generations (whichever is longer)**
C2	An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions:			
(a)	(i) Number of mature individuals in each subpopulation	**≤ 50**	**≤ 250**	**≤ 1,000**
	(ii) % of mature individuals in one subpopulation =	**90 – 100%**	**95 – 100%**	**100%**
(b)	Extreme fluctuations in the number of mature individuals			

Evidence:

Eligible under Criterion 3 C2(b) for listing as Vulnerable

There is no robust estimate of population size for this species. The *Action Plan for Australian Mammals 2012* (Woinarski et al. 2014), which used information available up to December 2012, estimated that the total population may contain fewer than 10 000 mature individuals. Since that time the species has been recorded at some new sites (Lumsden et al. 2013) and there is evidence that it may occur across a wider range of habitats than considered previously (Burns et al. 2015). However, there is also some evidence of ongoing population decline (see Criterion 1).

Expert opinion is that the total population size is likely to be fewer than 10 000 mature individuals, with fewer than 1000 in NSW (L Broome 2019. pers comm 31 July; SAC 2019. pers comm 3 July). The species is inferred to be undergoing a continuing decline (see Criterion 1), and the number of mature individuals are likely to undergo extreme fluctuations (see Criterion 2), which meets subcriterion C2(b).

The Committee considers that the number of mature individuals are likely to be limited, there is an inferred continuing decline, and the geographic distribution is precarious for the survival of the species because the number of mature individuals undergoes extreme fluctuations. Therefore, the species has met the relevant elements of Criterion 3 to make it eligible for listing as Vulnerable.

Criterion 4. Number of mature individuals			
	Critically Endangered Extremely low	**Endangered Very Low**	**Vulnerable Low (Medium-term future)[1]**
Number of mature individuals	**< 50**	**< 250**	**< 1,000**
D2[1] Only applies to the Vulnerable category Restricted area of occupancy or number of locations with a plausible future threat that could drive the species to critically endangered or Extinct in a very short time	**-**	**-**	**D2.** Typically: area of occupancy < 20 km^2 or number of locations ≤ 5

[1] The IUCN Red List Criterion D allows for species to be listed as Vulnerable under Criterion D2. The corresponding Criterion 4 in the EPBC Regulations does not currently include the provision for listing a species under D2. As such, a species cannot currently be listed under the EPBC Act under Criterion D2 only. However, assessments may include information relevant to D2. This information will not be considered by the Committee in making its recommendation of the species' eligibility for listing under the EPBC Act, but may assist other jurisdictions to adopt the assessment outcome under the common assessment method.

Evidence:

Not eligible

The Committee considers that the population size of Smoky Mouse is very likely to be greater than 1000 mature individuals (see Criterion 3). The area of occupancy is estimated to be 264 km^2 and the species occurs at approximately five locations, which meets the quantitative threshold for Vulnerable under subcriterion D2. However, there is no plausible future threat that could drive the species to Critically Endangered or Extinct in a very short time. Despite ongoing threats from invasive predators, fire and drought, populations have persisted in some areas for decades, and the two major populations (at the Grampians and Central Highlands) are likely to persist. Therefore, the species does not meet the requirements for listing under D2.

The total number of mature individuals is not considered low; although the number of locations is restricted there is no plausible future threat that could drive the species to Critically Endangered or Extinct in a very short time. Therefore, the species has not met this required element of this criterion.

Criterion 5. Quantitative Analysis			
	Critically Endangered Immediate future	**Endangered Near future**	**Vulnerable Medium-term future**
Indicating the probability of extinction in the wild to be:	**≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)**	**≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)**	**≥ 10% in 100 years**

Evidence:

Insufficient data to determine eligibility

Population viability analysis has not been undertaken.

Conservation actions

Over the past few decades there have been ongoing survey and research actions for the Smoky Mouse, and some broad management actions including extensive predator control and fire management programs (Menkhorst 2003; Robley et al. 2009). In Victoria, most sites where Smoky Mouse have been recorded are now within conservation reserves (Menkhorst 2003). In NSW, there is a Smoky Mouse Species Management Plan that outlines conservation actions for the Nullica population. In areas subject to forestry activity, exclusion zones have been established around known sites (Menkhorst & Broome 2006).

Recovery plan

The 'National Recovery Plan for the Smoky Mouse *Pseudomys fumeus*' (Menkhorst & Broome 2006) was developed by the Victorian state government and adopted under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) in 2008. It is due to expire in 2022.

The recovery plan has been partially implemented, with some management and research actions undertaken at state/territory levels. The Committee recommends that following expiry of the existing recovery plan, a new national recovery plan for *Pseudomys fumeus* is not required as it would not have a significant conservation benefit above existing mechanisms. An approved Conservation Advice provides sufficient direction to implement priority actions and mitigate against key threats.

Primary conservation actions

1. Conduct rapid on-ground surveys to establish extent of population loss, following the 2019-20 bushfires, and provide a baseline for ongoing monitoring.
2. Protect unburnt areas within or adjacent to recently burnt ground to provide refuge sites, as well as unburnt areas that are not adjacent to burnt areas.
3. Undertake weed control and habitat restoration works to promote the natural regeneration of the forest.
4. Protect all known populations from habitat loss, degradation and fragmentation.
5. Minimise levels of feral cat and fox predation on Smoky Mouse.
6. Control Cinnamon Fungus infestation in Smoky Mouse habitat.

Methods to minimise predation on the Smoky Mouse must include the effective ongoing control of both feral cat and fox numbers (to prevent meso-predator release; Hardman et al. 2016) and consider how other prey species (e.g. rabbits) may influence predator abundance. Some re-introductions of threatened species have failed primarily due to predation, even with intensive predator control measures in place (Short 2016; Hardman et al. 2016).

Conservation and management priorities

- Invasive species
    - Develop and implement long-term strategies to control numbers of foxes, feral cats and wild dogs, particularly in Smoky Mouse protection zones.
    - Construct and trial small mammal refuges at key sites and improve habitat complexity where required. Monitor population numbers inside and outside the refuges and assess the efficacy of the refuges at reducing levels of predation.
    - In areas burnt by the 2019-20 bushfires, undertake weed control and habitat restoration works to promote the natural regeneration of the forest.

Habitat loss and degradation

  - Protect unburnt areas of habitat within or adjacent to recently burnt ground to provide refuge sites, as well as unburnt areas that are not adjacent to burnt areas.
  - Designate protection zones around known populations to prevent further loss and fragmentation of Smoky Mouse habitat, including in areas subject to logging.
  - Retain and improve habitat connectivity in areas with known populations.
  - Reduce the incidence and spread of Cinnamon Fungus infection by spraying, adopting strict hygiene protocols, and implementing other management strategies as appropriate.

- Fire and climate change
  - Implement appropriate ecological burning regimes as determined by further research, in order to maintain a dense and diverse understorey in areas with known Smoky Mouse populations. Undertake predator control following burns where required.

- Breeding and other ex situ recovery actions
  - Establish a captive breeding colony as an insurance population.
  - Release captive-bred animals to supplement wild populations that are at risk (e.g. Nullica) in conjunction with intensive predator control and predator exclusion (e.g. fencing) measures.

Stakeholder Engagement

- Develop and disseminate communication tools to improve public awareness of the species and encourage stakeholders to report sightings.
- Encourage stakeholder and community involvement in conservation actions for the Smoky Mouse, such as habitat management.

Survey and Monitoring priorities

- Use remote camera traps and appropriate statistical techniques to assess detection probabilities (with surveys conducted late in the breeding season when detectability is higher) and determine whether and where populations persist at low density or are ephemeral (e.g. become locally extinct and are re-occupied).
- Conduct rapid on-ground surveys to establish extent of population loss, following the 2019-20 bushfires, and provide a baseline for ongoing monitoring.
- Using modern survey methods (e.g. detector dogs), undertake targeted surveys to improve knowledge of the species' distribution and abundance, and locate new populations.
- Undertake monitoring to assess the effectiveness of management actions on reducing the impact of threats.

Information and Research priorities

- Undertake research to better understand and assess the relative impacts of different threats to the species, including whether the low persistence of populations is mainly due to nutritional limitations, predation or a combination of factors.
- Conduct further research into the floristic composition (including hypogeal fungi) of Smoky mouse habitat in each broad vegetation type, to improve knowledge of the species' habitat and dietary requirements.

- Investigate the species' utilisation of habitat, including in undisturbed and disturbed (e.g. burnt, logged) areas, to improve knowledge on the effects of disturbance on population survival.
- Develop an ecological niche model at a scale appropriate to the Smoky Mouse, to guide survey efforts to detect the species.
- Develop harvesting prescriptions for State Forests where Smoky Mouse populations or habitat occurs, to minimise the impacts of logging on the species.
- Develop and trial different ecological burning regimes as a method of maintaining and enhancing habitat quality and monitor the response of vegetation and Smoky Mouse populations to ecological burns.
- Determine optimal husbandry techniques for establishing a captive population, and which maximise the survival of released individuals in the wild.
- Conduct genetic research to better understand population partitioning between and within biogeographical regions.

Recommendations

(i) The Committee recommends that *Pseudomys fumeus* retain its current listing status of Endangered in the list referred to in section 178 of the EPBC Act, as there is insufficient evidence to support transferring it to a different category and inclusion of the species in that category is having a beneficial impact on the continued survival of the species.

(ii) The Committee recommends that there not be a recovery plan for this species.

Threatened Species Scientific Committee

5 April 2020

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