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Notice of and reasons for the Final Determination

The NSW Threatened Species Scientific Committee, established under the *Biodiversity Conservation Act 2016* (the Act), has made a Final Determination to list *Pseudomys novaehollandiae* (Waterhouse, 1843) as a VULNERABLE SPECIES in Part 3 of Schedule 1 of the Act. Listing of Vulnerable species is provided for by Part 4 of the Act.

The NSW Threatened Species Scientific Committee is satisfied that *Pseudomys novaehollandiae* (Waterhouse, 1843) has been duly assessed by the Commonwealth Threatened Species Scientific Committee under the Common Assessment Method, as provided by Section 4.14 of the Act. After due consideration of Commonwealth DCCEEW (2024), the NSW Threatened Species Scientific Committee has made a decision to list the species as Vulnerable.

Summary of Conservation Assessment

Pseudomys novaehollandiae (Waterhouse, 1843) was found to be Vulnerable in accordance with the following provisions in the *Biodiversity Conservation Regulation 2017*: Clause 4.2(1 c)(2 b) and Clause 4.3(c)(d)(e i,ii,iii,iv) because: 1) there is an inferred and suspected reduction of at least 30% in the species' total population size based on estimates of population decline caused by the 2019–20 bushfires; 2) it has a moderately restricted distribution (estimated area of occupancy is 544–844 km^2); 3) there are approximately six threat-defined locations based on the most serious plausible threat of severe and extensive fire; and 4) there is an inferred continuing decline in extent of occurrence, area of occupancy, habitat, number of locations and subpopulations, and number of mature individuals attributed to increasing fire severity and frequency, increasing number of hot days, prolonged drought, predation by cats (*Felis catus*) and foxes (*Vulpes vulpes*), habitat clearing for development, and habitat degradation by *Phytophthora cinnamomi*.

The NSW Threatened Species Scientific Committee has found that:

1. *Pseudomys novaehollandiae* (Waterhouse, 1843) (family Muridae) is commonly known as the New Holland mouse or pookila (derived from the Ngarigo name for mouse, 'bugila') (Braithwaite *et al.* 1995). It has grey-brown fur on the dorsal side, white or greyish-white underparts, and pink feet with white hairs. The species is similar in size and appearance to the introduced house mouse (*Mus musculus*) but can be distinguished by the combination of a usually bicoloured tail (darker dorsally) with hairs flattened against the scales, a broader neck, less pointed nose, and larger eyes (Burns *et al.* 2023). Mature pookila typically weigh 12–20 g in Queensland and New South Wales (NSW), 18–25 g in Victoria, and 19–28 g in Tasmania (Kemper 1980; Pye 1991; Burns *et al.* 2023).

2. The pookila has a disjunct and fragmented distribution occurring in southern Queensland, NSW, Victoria, and Tasmania, with a reintroduced (but not yet self-sustaining) colony in the Australian Capital Territory. The species now primarily occurs in coastal areas, with its range extending approximately 110 km inland in

parts of NSW and Queensland (Burns *et al.* 2023), and most remaining subpopulations occurring on the mid- and north coast of NSW. There is also a remnant subpopulation (the persistence of which is uncertain) near Parkes in Central West NSW approximately 300 km from the coast (Faulkner *et al.* 1997; Burns *et al.* 2023). Genetic and subfossil evidence suggest that the pookila population had a more continuous distribution in the past (Ford 2003; Smith *et al.* 2023). The changed distribution is attributed to both longer-term climatic and landscape changes, and a large population decline following European colonisation (Breed and Ford 2007; Roycroft *et al.* 2021). The species' distribution does not meet the IUCN definition of severely fragmented (IUCN 2024).

3. The pookila has an estimated area of occupancy (AOO) of 544–844 km^2, and an estimated extent of occurrence (EOO) of 293,000–360,000 km^2. As recommended by IUCN (2024), AOO is based on 2 x 2 km grid cells, while EOO was calculated using a minimum convex hull. The minimum and maximum estimates were obtained by using locality records from 2013–2022, or 2003–2022, respectively. Estimated AOO does not exceed 2,000 km^2 when all past records are included (ALA 2025).

4. The estimated total population size of the pookila is ~21,400 to ~26,400 mature individuals. This estimate was derived by first multiplying a density of 50 individuals/km^2 (*i.e*., the lowest density reported from field studies conducted in NSW, Kemper 1980; Fox 1982; Fox *et al.* 2003) by the midpoint of the estimated range for AOO (*i.e*., 694 km^2), resulting in an estimate of 34,700 individuals, with an unknown proportion of juveniles included. The estimated population decline one year after the 2019–20 bushfires of ~23.9%, along with the maximum confidence bound (80% confidence bounds were ~11.2–38.2%, Legge *et al*. 2021), were then subtracted to obtain the final estimated range of mature individuals. The lowest plausible estimate of population density, combined with the minimum AOO and the highest estimated population decline leads to an estimated total population size well in excess of 10,000 mature individuals.

5. The habitats pookila have been recorded in following European colonisation include heathlands, woodlands and dry sclerophyll forests with a grassy or heath understorey, and vegetated sand dunes (Keith and Calaby 1968; Posamentier and Recher 1974; Fox and Fox 1978; Hocking 1980; Fox and McKay 1981; Pye 1991; Wilson 1991; Van Dyck and Lawrie 1997; Lock and Wilson 1999; Sparshott and Sparshott 2003; Wilson and Laidlaw 2003; Lazenby *et al.* 2007; Dixon 2014). During the day, this species shelters in underground burrows or nests above ground, which may be occupied by multiple individuals (Kemper 1981; Lazenby *et al*. 2007). At night, the species forages above-ground (Lazenby *et al*. 2007). Its diet includes seeds, plant material, invertebrates, flowers, and fungi (Cockburn 1980; Wilson and Bradtke 1999). Home range estimates for the pookila vary from 0.44 ha to 2.14±0.14 ha with overlap between adjacent ranges (Lazenby 1999; Lock 2004; Lazenby *et al.* 2007).

6. The generation length of the pookila is estimated to be 1–2 years. Lifespan is up to three years (Lock and Wilson 2017), while sexual maturity is reached at an average of ~13 (range 7–23 weeks) for females, and ~20 (range 11–36) weeks for males

(Kemper 1976a). Estimated average litter size in the wild is 4.6 pups (maximum six pups), with first-year females producing 1–2 litters per year and second-year females producing 3–5 litters (Kemper 1980). The breeding season typically occurs over approximately five months and begins earlier (late winter/early spring) in the north compared to the south (late spring) of the species' range (Kemper 1980; Pye 1991). Commencement and length of the breeding season (once observed to extend over ten months in NSW) may vary depending on food abundance or quality, which are ultimately influenced by rainfall patterns and fire succession (Kemper 1976b; Kemper 1980; Fox *et al.* 1993; Seebeck *et al.* 1996).

7. Subpopulations of pookila have been observed to peak in abundance following above average rainfall and decline during below average rainfall and drought (Lock 2004; Wilson *et al.* 2005; Lock and Wilson 2017; Wilson *et al.* 2018). Peaks in local abundance have also been observed during the early to mid-stages of vegetation succession induced by fire or sand mining (Posamentier and Recher 1974; Braithwaite and Gullan 1978; Fox and Fox 1978; Fox and McKay 1981; Fox and Fox 1984; Fox 1982; Wilson 1991; Wilson *et al.* 2018). However, the species' relationship with fire is complex, with burn severity, timing, size, predation pressure, and climatic conditions following fire affecting habitat suitability to a greater degree than a linear measure of time-since-fire (Burns and Phillips 2020).

8. The primary threats to the persistence of the pookila are increasing fire severity and frequency; increasing number of hot days, and prolonged drought; predation by cats and foxes; habitat clearing for development; and habitat degradation by *Phytophthora cinnamomi* (Seebeck *et al.* 1996; Smith and Quin 1996; Seebeck and Menkhorst 2000; Ford 2003). These threats often act synergistically, compounding their individual adverse effects. 'High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition', 'Anthropogenic Climate Change', 'Predation by the Feral Cat *Felis catus* (Linnaeus, 1758)', 'Predation by the European Red Fox *Vulpes vulpes* (Linnaeus, 1758)', 'Clearing of native vegetation', and 'Infection of native plants by *Phytophthora cinnamomi*' are listed as Key Threatening Processes under the Act.

9. The pookila has an estimated six threat-defined locations: One in Tasmania (Flinders Island), two in Victoria (Wilsons Promontory and Gippsland Lakes), two in NSW (assuming the Parkes subpopulation is extinct), and one in Queensland. Severe and extensive fire (including interactions with the changing climate and introduced predators) is the most serious plausible threat that could affect large areas of the species' distribution in a short period of time (*e.g.*, a single fire season).

10. Adverse fire regimes may result in a lack of habitat of suitable successional age, size, and distribution for the pookila, thereby contributing to declines in the species' abundance (Seebeck and Menkhorst 2000; Wilson *et al.* 2018; Burns and Phillips 2020). Since European colonisation, fire regimes in southeastern Australia have been altered by a combination of disruption to Aboriginal fire management practices, land use changes, and clearing for development and agriculture (SOE 2016). There has been a shift to very large fires occurring at shorter intervals. High-frequency and high-severity fires may inhibit the regeneration of habitat for the pookila, resulting in food shortage and amplified predation. It was estimated that

over 45% of the species' distribution was burnt during the 2019–20 bushfires, and a third of this area was burnt at very high severity (Legge *et al.* 2021). Overall, abundance of the pookila was estimated to have declined by ~23.9% one year after fire (Legge *et al.* 2021), with a larger decline estimated for ten years after the fire (see below). In addition, bushfires may exacerbate declines caused by drought (Hale *et al.* 2016; Crowther *et al.* 2018).

11. The pookila is rated as highly susceptible to predation by cats and foxes (DOE 2015; Radford *et al.* 2018). Adverse effects on the species are inferred based on apparent declines of the related ash-grey mouse (*Pseudomys albocinereus*) and sandy inland mouse (*Pseudomys hermannsburgensis*) with increasing cat activity (Risbey *et al*. 2000). Given that feral cats have greater hunting success on small mammals in relatively open habitats (McGregor *et al.* 2014) the removal of vegetation cover by fire would increase the exposure of pookila to predators. Further, multiple predation events at the communal burrow entrances of pookila could cause rapid local declines (Burns 2020a).

12. Development and other land use changes (*e.g.,* agriculture, roads, etc.) has led to permanent loss of substantial tracts of habitat and connectivity for the pookila. The magnitude of ongoing habitat loss to development has reduced over the last ten years, but much of the species' coastal habitat remains vulnerable to real estate development (Commonwealth DCCEEW 2024).

13. Dieback of vegetation caused by infection with *Phytophthora cinnamomi* is a habitat modifier that reduces food availability for the pookila, thereby affecting survival and breeding success. Infection of native vegetation by *P. cinnamomi* has been observed across the range of the pookila but may have the greatest adverse effects on the small and isolated subpopulations in Victoria and Tasmania (Seebeck *et al.* 1996, Wilson *et al.* 2020).

14. Decreases in the bioclimatic range of pookila in the south-east of mainland Australia are projected from modelling of potential climate change scenarios that include an increase of 3°C and either no change to rainfall, an additional 10% rainfall in all months, or a 10% decrease in rainfall in all months (Brereton *et al.* 1995). Declining rainfall and increased drought prevalence have previously been implicated in the precipitous declines of pookila subpopulations at Anglesea and Wilsons Promontory (Wilson *et al.* 2005; Wilson *et al.* 2018), and climate change may increase the frequency of such conditions in parts of the species' range (CSIRO and BOM 2024). The mechanisms of decline in the pookila due to these changes may include reduced reproductive output (Kemper 1976b; Kemper 1980), changes to the availability or abundance of plant species used for food or shelter (Choat *et al.* 2018; Nolan *et al.* 2021), and increased probability of catastrophic, broad-scale bushfires (CSIRO and BOM 2024) that adversely affect the species' recolonisation capacity (Wilson *et al.* 2018).

15. There is an inferred and suspected reduction of at least 30% in the total population size of pookila over a ten-year period that includes both the past and the future. It has been estimated that ten years after the 2019–20 bushfires, the population size of the pookila will be 26.1% (80% confidence interval: 8.6–47.4%) below the pre-fire levels (Legge *et al*. 2021). This reduction is accompanied by an inferred

continuing decline in EOO, AOO, habitat, number of locations and subpopulations, and number of mature individuals. Surveys conducted in Victoria between 2013 and 2018 failed to detect the pookila in seven of 12 areas where the species was recorded since European colonisation (Burns 2020a; Wilson *et al.* 2018), with rapid decline in the abundance of the remaining subpopulations recorded between 2018–2020 (Burns 2020b, Burns 2020c). In Tasmania, there was a >99% reduction in detections per unit effort in 2008–16 compared to 1998–2007, with detections made at only two of 16 sites where it was previously found (Lazenby *et al.* 2019). Despite systematic surveys (Modave 2017; Visoiu and Driessen 2018; Lazenby *et al.* 2019), the only confirmed detections of the species in Tasmania since 2010 were observed in 2021 on Flinders Island (B. Lazenby pers. comm. October 2021; AAP 2021). Although there is a paucity of systematic monitoring of the pookila in NSW, monitoring near the Tomago aluminium smelter (from 1982 to 2013) recorded large interannual fluctuation in capture rates with an overall decline apparent over time (SMEC 2015). A possible declining trend was also recorded from monitoring in Munmorah State Conservation Area between 2003 and 2009 (Beckers 2009), and monitoring in Wyrrabalong National Park in 1993 compared to 2013 (O'Brien 1993; Mjadwesch 2013). It is inferred that these declining trends will continue and also occur at other sites in NSW.

16. *Pseudomys novaehollandiae* (Waterhouse, 1843) is not eligible to be listed as an Endangered or Critically Endangered species.

17. *Pseudomys novaehollandiae* (Waterhouse, 1843) is eligible to be listed as a Vulnerable species as, in the opinion of the NSW Threatened Species Scientific Committee, it is facing a high risk of extinction in Australia in the medium-term future as determined in accordance with the following criteria as prescribed by the *Biodiversity Conservation Regulation 2017*:

Assessment against *Biodiversity Conservation Regulation* 2017 criteria
The Clauses used for assessment are listed below for reference.

Overall Assessment Outcome: Vulnerable under Clause 4.2(1 c)(2 b) and Clause 4.3(c)(d)(e i,ii,iii,iv)

Clause 4.2 – Reduction in population size of species
(Equivalent to IUCN criterion A)
Assessment Outcome: Vulnerable under Clause 4.2(1 c)(2 b)

(1) - The species has undergone or is likely to undergo within a time frame appropriate to the life cycle and habitat characteristics of the taxon:			
	(a)	for critically endangered species	a very large reduction in population size, or
	(b)	for endangered species	a large reduction in population size, or
	(c)	for vulnerable species	a moderate reduction in population size.
(2) - The determination of that criteria is to be based on any of the following:			
	(a)	direct observation,	
	(b)	an index of abundance appropriate to the taxon,	

	(c)	a decline in the geographic distribution or habitat quality,
	(d)	the actual or potential levels of exploitation of the species,
	(e)	the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.

Clause 4.3 – Restricted geographic distribution of species and other conditions (Equivalent to IUCN criterion B)
Assessment Outcome: Vulnerable under Clause 4.3(c)(d)(e i,ii,iii,iv)

The geographic distribution of the species is:			
	(a)	for critically endangered species	very highly restricted, or
	(b)	for endangered species	highly restricted, or
	(c)	for vulnerable species	moderately restricted.
and at least 2 of the following 3 conditions apply:			
	(d)	the population or habitat of the species is severely fragmented or nearly all the mature individuals of the species occur within a small number of locations,	
	(e)	there is a projected or continuing decline in any of the following:	
		(i)	an index of abundance appropriate to the taxon,
		(ii)	the geographic distribution of the species,
		(iii)	habitat area, extent or quality,
		(iv)	the number of locations in which the species occurs or of populations of the species.
	(f)	extreme fluctuations occur in any of the following:	
		(i)	an index of abundance appropriate to the taxon,
		(ii)	the geographic distribution of the species,
		(iii)	the number of locations in which the species occur or of populations of the species.

Clause 4.4 – Low numbers of mature individuals of species and other conditions
(Equivalent to IUCN criterion Clause C)
Assessment Outcome: Not met.

The estimated total number of mature individuals of the species is:				
	(a)	for critically endangered species		very low, or
	(b)	for endangered species		low, or
	(c)	for vulnerable species		moderately low.
and either of the following 2 conditions apply:				
	(d)	a continuing decline in the number of mature individuals that is (according to an index of abundance appropriate to the species):		
		(i)	for critically endangered species	very large, or
		(ii)	for endangered species	large, or
		(iii)	for vulnerable species	moderate,
	(e)	both of the following apply:		
		(i)	a continuing decline in the number of mature individuals (according to an index of abundance appropriate to the species), and	
		(ii)	at least one of the following applies:	

			(A)	the number of individuals in each population of the species is:		
				(I)	for critically endangered species	extremely low, or
				(II)	for endangered species	very low, or
				(III)	for vulnerable species	low,
			(B)	all or nearly all mature individuals of the species occur within one population,		
			(C)	extreme fluctuations occur in an index of abundance appropriate to the species.		

Clause 4.5 – Low total numbers of mature individuals of species
(Equivalent to IUCN criterion D)
Assessment Outcome: Not met.

The total number of mature individuals of the species is:			
	(a)	for critically endangered species	extremely low, or
	(b)	for endangered species	very low, or
	(c)	for vulnerable species	low.

Clause 4.6 – Quantitative analysis of extinction probability
(Equivalent to IUCN criterion E)
Assessment Outcome: Data Deficient.

The probability of extinction of the species is estimated to be:			
	(a)	for critically endangered species	extremely high, or
	(b)	for endangered species	very high, or
	(c)	for vulnerable species	high.

Clause 4.7 – Very highly restricted geographic distribution of species–vulnerable species
(Equivalent to IUCN criterion D2)
Assessment Outcome: Not met.

For vulnerable species,	the geographic distribution of the species or the number of locations of the species is very highly restricted such that the species is prone to the effects of human activities or stochastic events within a very short time period.

Professor Caroline Gross
Chairperson
NSW Threatened Species Scientific Committee

Supporting Documentation:

Commonwealth DCCEEW (Department of Climate Change, Energy, the Environment and Water) (2024) Conservation Advice for *Pseudomys novaehollandiae* (New Holland mouse, Pookila). Australian Government, Canberra, ACT.

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