NSW Threatened Species Scientific Committee

Conservation Assessment of Plains Mouse *Pseudomys australis*
Tim Cooney and Brad Law 21/04/2021
NSW Threatened Species Scientific Committee

Plains Mouse *Pseudomys australis* (Gray 1832) (Muridae)
Distribution: NSW, Queensland, Northern Territory, South Australia, Victoria, Western Australia
Current EPBC Act Status: Vulnerable
Current NSW BC Act Status: Extinct in NSW

Proposed listing on NSW BC Act: Vulnerable

Conservation Advice: Plains Mouse *Pseudomys australis*

Summary of National Conservation Assessment

Pseudomys australis was found to be eligible for listing as Vulnerable under Criterion B2ac(iv).

The main reasons for this species being eligible are: i) it has a moderately restricted geographical range; ii) it is severely fragmented and occurs at less than ten locations; iii) it experiences extreme fluctuations in the number of mature individuals.

Description and Taxonomy

Pseudomys australis is also known as Palyoora, plains mouse, plains rat, and eastern mouse, and was described by Gray in Owens (1832) as "a quadruped … forming a new genus of the Order *Rodentia* … The fur is soft, close, thick, blackish brown, and slightly grizzled at the tips of the hairs; beneath, it is of a reddish ash; and on the throat and breast greyish ash. The whiskers are slender, weak, and reach beyond the ears. The head and body measure $5^1/_4$ inches [13.3 cm]; the tail $3^1/_4$ [8.3 cm]; the fore foot $5^1/_2$ lines [1.2 cm]; and the hind foot 1 inch [2.5 cm]." *P. australis* is one of the largest rodents living in the arid zone and weighs between 30 and 50 grams (Moseby 2012) while DSEWPaC (2011) and Nunn (2006) report the average weight as high as 65 grams.

There has been some taxonomic instability involving this species mostly relating to reconciling the identity of a number of historically named forms which no longer occur over a large area of southern Australia (Woinarski *et al.* 2012). Watts and Aslin (1981) included all specimens previously described as *Pseudomys minnie*, *P. rawlinnae*, *P. australis* and *P. auritus* which were collected over a large area of southern Australia. Whilst there continues to be some doubt about the relationship between these taxa, Brandle *et al.* (1999) consider that the remaining arid-zone *P. australis* represent a single species.

Distribution and Abundance

Pseudomys australis historically had a patchy distribution over northern South Australia, southern Northern Territory, central and south-western Queensland, south-eastern Western Australia, southern Eyre Peninsula and Lake Albert in South Australia, northern New South Wales and southern Victoria. The current distribution is patchy in the western Lake Eyre Basin from Billa Kalina Station, south-east of Coober

Pedy, to Charlotte Waters, Northern Territory (Lee 1995). Sub-fossil records (Atlas of Living Australia accessed March 2020) show that *Pseudomys australis* historically had a distribution within New South Wales as far east as the Liverpool Plains in the Gunnedah area and as far west as Rawlinna in Western Australia. *Pseudomys australis* has suffered significant reduction in distribution since European colonisation and was considered to be extinct in NSW (DPIE 2019) with no live specimens recorded for over 150 years prior to 2008 (Atlas of Living Australia accessed March 2020). This status should be revised following discoveries of individuals in western NSW in the Sturt National Park in 2008 and 2020 (ABC 2008; D. Cullen pers. comm. 1 Apr 2020), and the Fowlers Gap area and Strzelecki Dune field between 2015 and 2017 (Leggett *et al*. 2017; P. Story *in litt.* 23 Jun 2020). These populations are located beyond the home range of the South Australian and Queensland borders and can be presumed to be extant at these locations within NSW.

Pedler *et al.* (2016) suggest that *Pseudomys australis* is expanding its area of occupancy and extent of occurrence in South Australia and reoccupying its former range after reductions in competitors and predators following rabbit control programs using the haemorrhagic disease virus introduced to Australia in 1995.

Pseudomys australis is an irruptive species with extreme fluctuations in numbers occurring in response to rainfall events and may disperse long distances when conditions are favourable (Murray *et al.* 1999). Brandle and Moseby (1999) reported an eighty-fold decrease in population size within three years. Dispersing individuals may move long distances to new locations, but these populations are unlikely to persist long term (C. Pavey, in litt. 6 Apr. 2020).

The Australian Mammal Action Plan (Woinarski *et al*. 2012) estimates that the population during drought periods is < 10,000 mature individuals. Within NSW, individuals have been caught over the past few years at five sites including at Fowlers Gap between 2015 and 2017 (Leggett *et al*. 2017; P. Story in litt. 23 Jun 2020), in the Strzelecki Dune field in 2015-2016 (Leggett *et al*. 2017) and in the Sturt National Park in 2008, 2019 and 2020 (ABC 2008; M. Letnic in litt. 5 Mar. 2020; D. Cullen pers. comm. 1 Apr 2020). Populations in the Sturt National Park, occurring 11 km apart, and in the Fowlers Gap area, eight kilometres apart, are considered as separate subpopulations as *Pseudomys australis* has a foraging range of less than five hectares and typically less than one hectare (Young *et al*. 2017). The five sites in NSW range between four and 69 km from the South Australian border and are therefore not considered to be transient individuals from another state.

Traces of *Pseudomys australis* have been identified in Australian raptor pellets, including the *Tyto alba* (barn owl) and the *Elanus scriptus* (letter-winged kite), which provide an indication of the presence of the species in an area (G. Medlin in litt.10 Mar.2020). Sub-fossil evidence of *P. australis* has been identified at Quinyambie Homestead and Bollards Lagoon in South Australia, ranging from 0.5 km to 45 km respectively from the NSW border and at Peregrine Pass, Mutawintji which is 109 km within the NSW border (G. Medlin, in litt. 10 Mar. 2020). These distances are within the NSW home range of *Tyto alba* of 0.02 to 0.53 km^2 (Thomsen *et al*. 2014) and 3.5 to 50 km^2 (Barn Owl Trust 2015). *Elanus scriptus* is nomadic and often disperses with the fall in rodent numbers following irruptive rodent breeding events (Pavey *et al.* 2009). While traces from raptor pellets cannot be used to calculate the Extent of

Occurrence or Area of Occupancy, they add support for a potential viable population of *P. australis* existing within NSW.

Ecology

Pseudomys australis is found on the barren gibber plains or stony deserts and cracking clay plains with a high gypsum content in arid and semi-arid regions of the Lake Eyre basin (Brandle and Moseby 1999). "It occurs at sites with more surface soil complexity which enables it to burrow in cracks or at the bases of low shrubs" (Brandle 1998). These cracking clay areas provide refuges for *P. australis* during non-irruptive periods providing more reliable resources of food and shelter (Brandle and Moseby 1999).

Pseudomys australis temporarily inhabits a variety of habitat types during natural irruptions. Brandle (1998) recorded *P. australis* from four main vegetation communities in a biological survey of the Stony Deserts in South Australia including: Low Open Shrubland (*Sclerolaena divaricata* / *Eragrostis setifolia* / *Atriplex vesicaria*); Low Very Open Shrubland (*Atriplex nummularia* subsp. *omissa* / *Abutilon halophilum*); Low Very Open Shrubland (*Maireana aphylla* / *Eragrostis setifolia* / *Astrebla pectinata* / *Atriplex vesicaria*); and Low Woodland (*Eucalyptus coolabah*). Following irruptive periods, when resources and habitat decline, the distribution of *P. australis* contracts to discrete areas in the landscape which provide refuges. Pavey *et al.* (2014) reported a contraction in population for the Simpson Desert NT to approximately 17% of the distribution during population peaks. Refuge areas occupied during drought are currently unknown in NSW.

The diet of *Pseudomys australis* is comprised of seeds and plant material although insects may also be taken (Murray *et al*. 1999). Pavey *et al*. (2016) found that many of the plants consumed by *P. australis* were shallow rooted, short lived, grazing tolerant and are likely to germinate after small rainfall events. This includes species such as *Dactyloctenium radulans*, *Chloris pectinata* and *Boerhavia schomburgkiana*.

The generation length of *Pseudomys australis* is one year (Woinarski *et al.* 2012). They are highly social and huddle in burrows. A burrow usually contains a single nest chamber and a few side passages with neighbouring burrows generally being within 10m and connected by surface runways (Nunn 2006).

Pseudomys australis has an oestrus period of seven to eight days, gestation period of 30 to 31 days, litter sizes of one to four pups and the females experience post-partum oestrus (Nunn 2006). Breeding continues during dry periods in refuge areas but is known to cease during droughts and periods with low resources (Watts and Aslin 1981). Captive breeding in Alice Springs has shown that there are significantly less litters during winter (Nunn 2006).

Pseudomys australis has also been found to have a multimale breeding system with multiple paternity within the one litter being occasionally identified (Breed and Adams 1992).

Threats

Woinarski *et al*. (2012) and Watts and Aslin (1981) identify the threat from habitat degradation from livestock and feral herbivores and from predation by cats and foxes as severe over most of the range of *Pseudomys australis*.

Grazing and browsing and trampling of burrows by herbivores, is a key threat to *P. australis.* The long-term decline in *P. australis* abundance is probably due to the impacts of introduced stock and rabbits on vegetation through a combination of resource depletion and trampling of burrows (Lee 1995). In a landscape scale study in South Australia, Pedler *et al.* (2016) found that when rabbit populations were dramatically suppressed through biological control, *P. australis* increased 241% in extent of occurrence and 64% in area of occupancy. The explanation for these observations is that *P. australis* benefits both from changes in bottom-up ecosystem effects, such as reduced competition for plant and seed biomass, plus increased vegetation cover providing greater protection from predators (Pedler et al. 2016). Pavey *et al.* (2016) identified that most of the plants consumed by *P. australis* are also palatable to cattle and Moseby *et al.* (2020) found that an index of *P. australis* activity dropped dramatically from the outside edge of a fenced conservation area to zero 250m from the fence where cattle were present.

Predation by introduced cats and foxes is a threat to *P. australis* during good conditions and drought (Moseby 2012). During good conditions, foxes and cats may suppress sub-population irruptions and prevent large scale dispersal events. During drought conditions isolated populations are vulnerable to predation and local extinction. Dingoes have been known to prey on *P. australis* however their preferred prey are generally larger species such as rabbits and kangaroos (Moseby 2012).

Increased temperatures with climate change are likely to be a threat to remaining populations (Moseby (2012). The shallow burrows may become too hot for habitation and populations may contract even further to just the deepest cracking clay areas (Moseby 2012).

'Competition and grazing by the feral European Rabbit, *Oryctolagus cuniculus* (L.)', 'Predation by the European Red Fox *Vulpes vulpes* (Linnaeus, 1758)' and 'Predation by the Feral Cat *Felis catus* (Linnaeus, 1758)' are listed under the Biodiversity Conservation Act (2016) as Key Threatening Processes.

Assessment against IUCN Red List criteria

For this assessment it is considered that the survey of *Pseudomys australis* has been adequate and there is sufficient scientific evidence to support the listing outcome.

Criterion A   Population Size reduction

Assessment Outcome: Data Deficient

Justification: While the generation length of *Pseudomys australis* is one year (Woinarski *et al.* 2012), the population reduction for this species is assessed over ten years as recommended in IUCN Guidelines (2019) being the longer of three generations or ten years.

There is a lack of information on long-term population trends. There have been no targeted surveys to compile census data across the entire range of the species over 10 years to estimate population size or trend to assess this species under this criterion.

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Criterion B   Geographic range

Assessment Outcome: Vulnerable under Criterion B2ac(iv)

Justification: Nationally, the AOO is estimated to be approximately 648 km² based on 2 x 2 grid cells (as recommended by IUCN 2019). Species with an area of occupancy (AOO) of less than 2,000 km² meet the threshold for Vulnerable status. The EOO was estimated to be 521,337 km² based on a convex hull polygon fitted around all known species occurrences. In NSW, the EOO is estimated to be 3,467 km^2 and the AOO, 20 km^2.

In addition to these thresholds, at least two of three other conditions must be met. These conditions are:

a) The population or habitat is observed or inferred to be severely fragmented or there is 1 (CR), ≤5 (EN) or ≤10 (VU) locations.

  Assessment Outcome: Sub-criterion met for endangered threshold.

  Justification: Woinarski *et al* (2012) suggest the species occurs in five locations nationally, based on the widespread main threats of predation by cats, foxes and dingoes and habitat degradation from livestock and feral animal grazing. Even with the addition of rediscovered sites in NSW, the number of locations will be less than 10 and all these threats, except the dingo, are widespread in NSW.

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

  Assessment Outcome: Data deficient.

  Justification: The species naturally undergoes significant declines in extent of occurrence, area of occupancy, number of locations and number of mature individuals during drought periods. Since European colonisation there has been a reduction in distribution of 50-90% (Lee 1995), believed to be due to the impact of introduced stock and rabbits on vegetation and predation from dingoes, foxes and owls. While these threats remain, the reduction in rabbit numbers, from haemorrhagic disease virus, and subsequent associated decline in predator numbers is considered to have reduced those threats, but cats, foxes and overgrazing remain as major threats. It remains uncertain if continuing decline is occurring.

c) Extreme fluctuations.

  Assessment Outcome: Sub-criterion met

  Justification: *Pseudomys australis* is an irruptive species with extreme fluctuations in numbers occurring in response to rainfall events (Murray *et al.* 1999). Numbers remain high while conditions are favourable and then decline rapidly (Moseby 2012).

Criterion C   Small population size and decline

Assessment Outcome: Near Threatened.

Justification: Woinarski *et al.* (2012) estimates the population of *Pseudomys australis* during drought periods to be less than 10,000 mature individuals which meets the threshold for Vulnerable status. *P. australis* is subject to several threats that could cause a significant decline including predation, the depletion of food resources by grazing livestock and rabbits and trampling of burrows by cattle. Whilst there are naturally extreme fluctuations in the number of mature individuals of *P. australis,* it is uncertain whether there is continuing decline.

At least one of two additional conditions must be met. These are:

C1. An observed, estimated or projected continuing decline of at least: 25% in 3 years or 1 generation (whichever is longer) (CE); 20% in 5 years or 2 generations (whichever is longer) (EN); or 10% in 10 years or 3 generations (whichever is longer) (VU).

>   Assessment Outcome: Data deficient

>   Justification: There has been no targeted survey across the entire range of the species and insufficient survey and census data over 10 years to estimate population size trends and assess this species under this sub criterion. Ten years is used to assess population decline as recommended by the IUCN Guidelines (2019) being the longer of 3 generations or 10 years. *Pseudomys australis* has a generation length of one year (Woinarski *et al.* 2012).

C2. An observed, estimated, projected or inferred continuing decline in number of mature individuals.

>   Assessment Outcome: Data deficient.

>   Justification: The species naturally undergoes significant declines in extent of occurrence, area of occupancy, number of locations and number of mature individuals during drought periods. Since European colonisation there has been a reduction in distribution of 50-90% (Lee 1995), believed to be due to the impact of introduced stock and rabbits on vegetation and predation from dingoes, foxes and owls. While these threats remain, the reduction in rabbit numbers, from haemorrhagic disease virus, and subsequent associated decline in predator numbers is considered to have reduced those threats, but cats, foxes and overgrazing remain as major threats. It remains uncertain if continuing decline is occurring.

>   In addition, at least 1 of the following 3 conditions:

>>   a (i).Number of mature individuals in each subpopulation ≤50 (CR); ≤250 (EN) or ≤1000 (VU).

>>>   Assessment Outcome: Data deficient

>>>   Justification: There have been no targeted surveys and census data available to determine the number of mature individuals in each subpopulation.

a (ii).   % of mature individuals in one subpopulation is 90-100% (CR); 95-100% (EN) or 100% (VU)

Assessment Outcome: Data deficient

Justification: There have been no targeted surveys of subpopulations to determine the proportion of mature individuals within each subpopulation.

b.   Extreme fluctuations in the number of mature individuals

Assessment Outcome: Sub-criterion met.

Justification: *Pseudomys australis* is an irruptive species with extreme fluctuations in numbers occurring in response to rainfall events (Murray *et al.* 1999). Numbers remain high while conditions are favourable and then decline rapidly (Moseby 2012).

Criterion D   Very small or restricted population

Assessment Outcome: Criterion not met.

To be listed as Vulnerable under D1 or D2, a species must meet at least one of the two following conditions:

D1. Population size estimated to number fewer than 1,000 mature individuals

Assessment Outcome: Criterion not met.

Justification: The population exceeds 1,000 mature individuals and is estimated to be less than 10,000 mature individuals during drought periods (Woinarski *et al.* 2012).

D2. Restricted area of occupancy (typically <20 km^2) or number of locations (typically <5) with a plausible future threat that could drive the taxon to CR or EX in a very short time.

Assessment Outcome: Criterion not met.

Justification: The national area of occupancy is 648 km^2, and there is considered to be less than 10 locations. However, it is unlikely there are threats that could drive this taxon to Critically Endangered or Extinct within a very short time.

Criterion E   Quantitative Analysis

Assessment Outcome: Data Deficient.

Justification: There is insufficient data to quantify the species extinction risk.

Conservation and Management Actions

The following is derived from threat information and management actions from the National Recovery Plan (Moseby 2012), Action Plan for Australian Mammals

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(Woinarski *et al.* 2012), other reference material and personal communications. There is no NSW Saving our Species program for this species.

<u>Habitat loss, disturbance and modification</u>

- De-stock areas and prevent grazing of domestic and introduced species in areas with significant populations and identified drought refuge areas.

- Fence high priority areas to establish exclosures to exclude terrestrial predators and manage grazing pressures.

<u>Invasive species</u>

- Develop broad scale feral cat and fox control measures.

- Develop broad scale control of feral grazers such as goats, camels and rabbits.

<u>Ex situ conservation</u>

- Undertake a captive breeding program to maintain an *ex-situ* population of the species.

- Translocate species to conservation areas within former distribution.

<u>Stakeholders</u>

- Inform landowners and managers of sites where there are known populations and consult with these groups regarding options for conservation management and protection of the species.

Survey and Monitoring priorities

- Monitor for increased habitat degradation and outcomes of threat management actions.

- Intensive surveys in western NSW are required to better define distribution, identify drought refuges, determine whether there is a decline in the population and understand the factors that influence their persistence.

- It is recommended that a detailed genetics assessment be undertaken of the three emergent NSW populations to determine their origins (Leggett *et al*. 2017).

Information and Research priorities

- Assess the abundance and impact of introduced predators on population viability within the range of this species.

- Identify refuge habitat.

- Assess the species' response across a range of grazing intensities and land-use practices.

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Expert Communications

Cullen, Dympna (2020) PhD Candidate, Centre for Ecosystem Science School of Biological, Earth and Environmental Sciences UNSW, Sydney.

Letnic, Michael (2020) Professor University of NSW.

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Medlin, Graham C (2020) South Australian Museum.

Pavey, Chris (2020) Senior Research Scientist, CSIRO Land and Water, Darwin, Australia.

Story, Paul (2020) Ecotoxicologist (Research Scientist), Australian Plague Locust Commission, Department of Agriculture.

Appendix 1

Assessment against Biodiversity Conservation Act criteria
The Clauses used for assessment are listed below for reference.

Overall Assessment Outcome:
Pseudomys australis **was found to be Vulnerable under Clause(s) 4.3(c)(d)(f)(i).**

Clause 4.2 – Reduction in population size of species
(Equivalent to IUCN criterion A)
Assessment Outcome: Data deficient

(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)(f)(i).

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: Near Threatened.

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: Clause 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
(Equivalent to IUCN criterion D2)
Assessment Outcome: Clause 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.

Established under the Biodiversity Conservation Act 2016
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