Abridged Threatened Species Nomination Form

For nominations under the Common Assessment Method (CAM) where supporting information is available, but not in a format suitable for demonstrating compliance with the CAM, and assessment against the IUCN Red List threat status.

Cover Page *(Office use only)*

Species name (scientific and common name)**:**	***Pseudocheirus occidentalis* (western ringtail possum, ngwayir)**
Nomination for (addition, deletion, change)**:**	**Change**
Nominated conservation category and criteria:	**Critically Endangered: A4bce**

Scientific committee assessment of eligibility against the criteria:		
This assessment is consistent with the standards set out in Schedule 1, item 2.7 (h) and 2.8 of the Common Assessment Method Memorandum of Understanding.		Yes ☐ No ☐
A.	Population size reduction	•
B.	Geographic range	•
C.	Small population size and decline	•
D.	Very small or restricted population	•
E.	Quantitative analysis	•

Outcome*:*			
Scientific committee meeting date:			
Scientific committee comments:			
Recommendation:			
Ministerial approval:		*Date of Gazettal/ Legislative effect:*	

Nomination summary *(to be completed by nominator)*

Current conservation status				
Scientific name:	*Pseudocheirus occidentalis*			
Common name:	western ringtail possum, ngwayir			
Family name:	Pseudocheiridae	Fauna ☒	Flora ☐	
Nomination for:	Listing ☐	Change of status ☒	Delisting ☐	

1. *Is the species currently on any conservation list, either in a State or Territory, Australia or Internationally?* 2. *Is it present in an Australian jurisdiction, but not listed?*	*Provide details of the occurrence and listing status for each jurisdiction in the following table*

Jurisdiction	**State / Territory in which the species occurs**	**Date listed or assessed (or N/A)**	**Listing category i.e. critically endangered or 'none'**	**Listing criteria i.e. B1ab(iii)+2ab(iii)**
International (IUCN Red List)	WA	1994 (reassessed 2008)	Vulnerable	B1ab(ii,iii,v)
National (EPBC Act)	WA	16/07/2000	Vulnerable	n/a
State / Territory	1. WA	08/04/1983 (reassessed VU to EN 2/12/2014)	Endangered	A2+3+4bce
		28/12/2016	Critically Endangered	A4bce
	2.			
Mammal Action Plan	WA	2012	Critically Endangered	A2bce+3bce+4bce

Consistent with Schedule 1, item 2.7 (h) and 2.8 of the Common Assessment Method Memorandum of Understanding, it is confirmed that:	
• this assessment meets the standard of evidence required by the Common Assessment Method to document the eligibility of the species under the IUCN criteria;	Yes ☒ No ☐
Comments:	
• surveys of the species were adequate to inform the assessment;	Yes ☒ No ☐
Comments:	Targeted regional surveys conducted at Upper Warren and numerous small-scale surveys conducted at development sites on the Southern Swan Coastal Plain. Community spotlighting surveys conducted in Busselton, Bunbury and Albany, and opportunistic sightings reported for the species' entire distribution but particularly near urban/suburban areas.

• the conclusion of the assessment remains current and that any further information that may have become available since the assessment was completed supports or is consistent with the conclusion of the assessment.		Yes ☒ No ☐
Comments:	The assessment was prepared in March 2016 for the WA TSSC meeting in June 2016. There has not been any additional information since this assessment was completed.	

Nominated national conservation status: category and criteria

Presumed extinct (EX) ☐ Critically endangered (CR) ☒ Endangered (EN) ☐ Vulnerable (VU) ☐

None (least concern) ☐ Data Deficient ☐ Conservation Dependent ☐

What are the IUCN Red List criteria that support the recommended conservation status category?	**A4bce**

Eligibility against the IUCN Red List criteria (A, B, C, D and E)

*Provide justification for the nominated conservation status; is the species eligible or ineligible for listing against the five criteria. For **delisting**, provide details for why the species no longer meets the requirements of the current conservation status.*

A.	Population size reduction (evidence of decline)	• (A1) Does not apply • (A2) Threshold for EN is >50%, for CR >80% in 10 years (three generations is considered to be c. 9 years) • After a substantial decline from drier parts of its range in the latter half of the 20th Century, there are now three main subpopulations: Upper Warren (including Perup), the southern Swan Coastal Plain (including the Cape to Cape region) from Bunbury to Augusta, and in and near Albany. Outside these areas, there are small numbers, e.g., in Preston-Blackwood rivers area and west of Manjimup, but numbers are negligible in assessing population numbers. • Population size reduction. Given the lack of data on subpopulation size for much of the species' range, it is not possible to estimate the population size reduction over the past 10 years. However, under Criterion A, population size reduction can be inferred or suspected. Given the lack of data, the only way of inferring or suspecting a population size reduction is via expert opinion, in this case from Barbara Jones. Note that the Guidelines state that suspected population size reduction can be based on evidence of qualitative habitat loss. Barbara Jones' expert opinion of the inferred/suspected numbers of mature individuals for 2006 (18 000, 10 years ago) and 2015 (3400) indicate a population size reduction of 80% or more in the past 10 years. Note that if the numbers at Upper Warren were higher than 32 000 in 2003 (as suggested by Adrian Wayne) then the decline would be greater. • (A3) The high rate of decline over the past 10 years (2006 to 2015), suggest that the population size reduction will continue. The rate will depend on whether rainfall continues to decline and temperatures continue to increase: based on recent history and climate change predictions, both are likely. It will also depend on the effects of the other threats (see below). Predicting the rate of reduction in the next 10 years is fraught with difficulties and depends on how precautionary an assessor chooses to be. Given that available data indicate that the decline since

		c. 1990 is probably correlated more with declining rainfall (and perhaps increasing temperature) causing nutritional stress and poor recruitment, than habitat loss or predation (although both these are significant), it can be projected that it will continue; however, how large a decline in population size (>80% in 10 years is required for CR) may be projected depends on how precautionary an assessor is. Noting the enormous declines that has happed recently in the Upper Warren, the nominator has tended to be precautionary (section 3.2.4 of the Red List guidelines is relevant here). • (A4) There has been a substantial population size reduction during the past five years, but as the Upper Warren decline bottomed out at about 2008, the rate is likely to have been less over five years that it was over ten years. As above, given that available data indicate that the decline since c. 1990 is probably correlated more with declining rainfall (and perhaps increasing temperature) causing nutritional stress and poor recruitment, than habitat loss or predation (although both these are significant), there must be a strong likelihood that it will continue; however, how large a decline in population size (>80% in 10 years is required for CR) may be projected depends on how precautionary an assessor is. Noting the enormous declines that have happened recently (Upper Warren), the nominator has tended to be precautionary (as with A3, section 3.2.4 of the guidelines is relevant here). • Note: The nominator assessed the species' as eligible for Critically Endangered using criteria A2bce+3bce+4bce however the WA TSSC determined that A4bce was the most applicable criteria, and this was endorsed. • **Meets criteria for Critically Endangered A4bce**
B.	Geographic range (EOO and AOO, number of locations and evidence of decline)	• EOO estimated as 40,000 km^2 and AOO estimated as >10km^2 and <500 km^2. • Criterion B requires an EOO of <100 km^2 or an AOO of <10 km^2 to meet CR. Although quality data are lacking, the western ringtail possum (WRP) does not meet these thresholds. The Mammal Action Plan (MAP) estimated the AOO as <500 km^2, based on 1992 to 2012 data, with the qualification that the figure was likely to be a significant over estimate due to rapid decline post-2002. The Recovery Plan estimated the AOO as <800 km^2, based on 1990-2013 Parks and Wildlife data; this is also highly likely to now be a significant over-estimate due to rapid decline since 1990. Estimation of AOO <500 km^2 using the 2kmx2km grid and records from 1993-2012. • Maps showing locations over the past 20 years (as published in the MAP and the Recovery Plan) or even the last 10 years are of limited value due to the recent substantial decline. • Regarded as one location due to prevailing threats, but occurs in 5 subpopulations that could be regarded as locations based on the combination of different threatening processes. • Distribution considered to be severely fragmented as WRP now restricted largely to isolated and fragmented mature peppermint forest. • Continuing decline projected in area and quality of habitat and number of mature individuals as described under criterion A. • **Meets criteria for Endangered B2ab(iii,v)**
C.	Small population size and decline	• Population estimated as 3,400 in 2015. • Estimated population decline exceeds 10% in 10 years or three generations.

	(population size, distribution and evidence of decline)	• **Meets criteria for Vulnerable C1**
D.	Very small or restricted population (population size)	• Population estimated as 3,400 in 2015. • **Does not meet criteria**
E.	Quantitative analysis (statistical probability of extinction)	• Unable to assess.

Summary of assessment information

EOO	40,000 km^2 (α-hull using records from 1993-2012)	AOO	<500 km^2 (2kmx2km grid using records from 1993-2012)	Generation length	3 years

No. locations	1	Severely fragmented	Yes ☒ No ☐ Unknown ☐
No. subpopulations	5	No. mature individuals	3,400

Percentage global population within Australia	100%
Percentage population decline over 10 years or 3 generations	>80%

Threats *(detail how the species is being impacted)*

Threat *(describe the threat and how it impacts on the species. Specify if the threat is past, current or potential)*	Extent *(give details of impact on whole species or specific subpopulations)*	Impact *(what is the level of threat to the conservation of the species)*
Climate change leading to a drying climate: *Past, present and future* The drying climate affects the nutritional quality of food and hence survival and recruitment. Rainfall has declined and continues to decline throughout the south-west. The last two years have been the, or close to the, driest on record near Albany. Albany mean rainfall (1877 to 2014): 929 mm; 2014: 638 (no data from December, mean is 30 mm, if 30 mm added = 668 mm); 2015: 621 mm (lowest on record). Busselton mean (1877 to 2014): 813.6 mm; 2014: 591 mm; 2015: 568 mm. WRPs 'are among the species most likely to be impacted by predicted climate change in the south-west because they have very specific habitat and dietary requirements, have a poor ability to migrate and have lost large areas of habitat. In addition they are sensitive to drought-induced stress. Over the past 30 years there has been an approximate 20 per cent decline in rainfall in the south-west of WA, with more reductions in rainfall and increased temperatures predicted due to global climate change (Timbal 2004). These changes could result in further contraction of the species to the most fertile and mesic remnants of their extant range (Wayne 2005, Jones and Francesconi 2007)' (Recovery Plan p. 10). Almost all remaining occurrences are associated with older-growth Peppermint, but few stands now seem to provide suitable	Entire	Severe

nutrition for the species to survive and recruit.		
Groundwater depletion and altered hydrology: *Past, present and future* Vegetation stress due to groundwater decline is likely to impact WRP's due to a decline in nutritional quality of food causing nutritional stress, threatening recruitment and survival. As a specialist folivore, successful recruitment depends on seasonal availability of high-quality foliage. Foliage water content affects nutritional quality and digestibility, with higher water content being the higher quality food. When food quality is poor, the sex ratio of young is biased towards males, and recruitment may fail. Vigorous canopy growth, flushes of new leaves, is required as the toxic components within the leaves increase as the leaves age into their second and third years. Increased intake of old leaves by WRP's may critically impair gut flora and organs and persistent dehydration due to insufficient water in consumed foliage may prevent the body from excreting the toxins (B. Jones *pers. comm*.). The South-West Western Australia Sustainable Yields Project (CSIRO 2009) determined that in SW WA climate change has resulted in water runoff decreasing by approx. half due to a 10-15% decrease in annual rainfall since 1975. Rainfall influences groundwater recharge and groundwater levels. This area of WA also has the highest proportion of the human population within the State, with groundwater the main source of water. Demand for domestic use, industry and irrigation is predicted to increase by 35% (range of 10-57%) by 2030. Future groundwater yields are modelled to be on average 2% lower by 2030 (range of +2 to -7%). The Blackwood and Collie groundwater areas are predicted to suffer the greatest decreases (decline) in groundwater yields. Possibly experiencing a reduction in yields of more than a third. Although not modelled, the Albany groundwater area may also be impacted and yield reduction may be at the same level as for Blackwood. Areas of native perennial vegetation over clay soils limit groundwater recharge and are predicted to have lower groundwater levels by the year 2030, in comparison to cleared areas over sandy soils. Vegetation stress is expected if groundwater levels fall too rapidly or too deeply. Using groundwater modelling for the southern Perth Basin, the degree of vegetation stress has been estimated as being 40-50% (median-extreme future climate) of the vegetation in the area may be impacted.	Entire	Unknown
Increasing temperature: *Past, present and future* 'WRPs are known to be susceptible to heat stress and can easily overheat at temperatures of 35°C (Yin 2006). Western ringtail possums have been observed to use evaporative cooling in hot weather by applying saliva to the forelimbs or panting (Jones *et al.* 1994b). Jones *et al*. (1994b) observed that in areas where dreys were used, WRPs went to the ground over several hot days. WRPs are the smallest of the specialist marsupial folivores indicating that they live close to the ecological and physiological limits of viability (B. Jones pers. comm. 2002)' (Recovery Plan pp. 6-7). As well, increasing temperatures exacerbate soil moisture reduction and further affect the nutritional quality of food.	Entire	Unknown
Land clearing: *Past, present and future*	Swan Coastal Plain, Cape to Cape and near Albany	Severe

Land clearing for urban development remains a threat in the Busselton – Augusta near coastal strip and near Albany. Most remaining WRP habitat is on private land; thus the major land management is via planning controls, not via biodiversity legislation.		
Feral predators: *Past, present and future* Translocation experiments in the past and other data demonstrate that foxes and feral cats are major threats, especially where the canopy becomes more open due to 'parkland clearing' and after fire. Native predators also impact the species.	Entire	Severe
Fire: *Past, present and future* Fire reduces food availability and opens up the canopy causing WRPs to spend more time on the ground where they can be predated by foxes and cats. Fire can have significant impact in urbanised environments where remnants are relatively isolated and patchiness of burns may be less resulting in greater impact on WRPs.	Entire	Severe
Tree decline and insect outbreaks: *Past, present and future* Coastal Peppermint decline, gum leaf skeletoniser and *Phytophthora* dieback in Jarrah, Tuart decline and other tree declines have resulted in extensive but mainly localised reductions in food and habitat quality.	Entire	Potentially severe, but varied across species' range
Competition for tree hollows: *Past, present and future* Increased numbers of Brushtail Possums where fox baiting occurs leads to competition for hollows: brushtails are more aggressive and will evict WRPs. Hollow loss is also caused by logging and feral bees.	Entire	Unknown, but varied across the species' range
Logging: *Past, present and future* WRPs are more abundant in unlogged forest or where logging has been least intense; logging leads to local mortality including via increased feral cat predation. However, current WRP distribution does not now significantly overlap areas to be logged. Ongoing regulation of logging activities is required in multiple use areas to manage this potential threat.	Forested areas outside lands reserved for nature conservation	High – can halve the productive output of females
Domestic dogs: *Past, present and future* 'In urban environments predation or injury by domestic dogs can be frequent (de Tores *et al*. 1998). High levels of dog ownership within the City of Busselton create dog densities at four to eight times greater per hectare than the average fox density in the south-west forests (K. Williams pers. comm. 2006)' (Recovery Plan, p.8). Ravens are a threat in urban areas where their numbers have increased.	Urban areas	Unknown
Myrtle rust: *Future* A plausible future threat is myrtle rust, which significantly affects peppermint (*Agonis flexuosa*), in the eastern States where it is planted horticulturally, noting that peppermint is now the main habitat and food tree for WRPs. Note that some threats are synergistic.	Entire	Unknown, but potentially severe.

Injury and mortality due to vehicle strike: *Past, present and future* Parks & Wildlife regularly receive reports of roadkill WRPs.	Developed areas	Unknown
Un-regulated relocation of orphaned, injured and rehabilitated western ringtail possums: *present and future* Unregulated releases can affect monitoring programs, artificially extend known geographic range, spread diseases, increase pressure on existing habitat, disturb resident WRPs at release sites, genetically mix populations and may even cause deaths of WRPs through predation or inappropriate habitat availability at release sites (Parks & Wildlife, 2014)	Busselton and Albany areas	Unknown

Management and Recovery

Is there a Recovery Plan (RP) or Conservation Management Plan operational for the species?	Yes ☒ No ☐

List all relevant recovery or management plans (including draft, in-preparation, out-of-date, national and State/Territory recovery plans, recovery plans for other species or ecological communities, or other management plans that may benefit or be relevant to the nominated species).

- Department of Parks and Wildlife (2014). *Wildlife Management Program No. 58: Western Ringtail Possum (Pseudocheirus occidentalis) Recovery Plan.* Available from: https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/197-approved-recovery-plans

List current management or research actions, if any, that are being undertaken that benefit the conservation of the species.

- Statutory and local government planning approvals, including conditions placed on developments to deal with the impacts on the western ringtail possum. The primary objective is to reduce the direct and indirect threat to western ringtail possum from developments, and where this is not achievable, ensure environmental offsets reduce the net impact on the species.
- Revegetation of ex-pasture land and offset and rehabilitation areas to generate suitable habitat for the western ringtail possum.
- Translocations of WRPs at risk from development sites to secure locations to enhance or establish wild populations
- Development of fire management guidelines to reduce the direct and indirect effect on WRPs in urbanised and forested environments.
- Modified logging practices have been employed under the Forest Management Plan in areas where timber harvesting overlaps with the western ringtail possum's range.
- Western ringtail possum related research: translocation success, genetics, ecology in the Jarrah forests, physiology and refuge use.
- Parks & Wildlife and the Forest Products Commission have mapped known populations of fauna, including the western ringtail possum, to inform timber harvesting activities so as to ensure key habitat areas are maintained.
- Review of habitat availability that provides a basis for the identification, protection and enhancement of key habitats, and is used for informing environmental impact assessment of development proposals.
- Production of guidelines and other education information to raise awareness and understanding in the broader community about the western ringtail possum

List further recommended management or research actions, if any, that would benefit the conservation of the species.

Taken from the Recovery Plan:

- Protect and effectively manage habitat critical for survival to maintain viable subpopulations, including ongoing implementation of strategies to reduce and mitigate the effect of development on the species and its habitat, and undertaking climate change modelling to assess the potential effects on the distribution and abundance of the species.
- Mitigate threatening processes constraining the recovery of the western ringtail possum by implementing the following management practices: fire management strategies that reduce long term impact to western ringtail possum habitat and maintains a mosaic of habitat condition where fire is prevalent in the landscape; habitat restoration of core areas of occupancy and movement corridors; disease/pathogen/insect management strategies, and hygiene protocols to reduce direct threats to the western ringtail possum and its habitat; ongoing predator control programs to reduce direct predation of western ringtail possum; implementation of forest management practices that ensure the maintenance and protection of high quality western ringtail possum habitat; and ongoing negotiations for development offsets that reduce the net impact on western ringtail possum, including through the protection of areas of high quality habitat and relocation of animals to secure sites.
- Achieve an evidence-based management approach for western ringtail possums: establish standardised and long-term population monitoring across key sites and surveys for additional areas in suitable habitat.
- Manage displaced, orphaned, injured and rehabilitated western ringtail possums for the best conservation outcome for the species
- Raise awareness of the status of the western ringtail possum and gain support and behaviour change to mitigate threatening processes

Additional recommendations made by the nominators:

- Research: effects of drying climate and the nutritional status of food, and how it relates to the species' survival and recruitment
- Develop husbandry techniques in preparation for any future captive breeding programs

Nomination prepared by:	Andrew Burbidge & Barbara Jones
Contact details:	amburbidge@westnet.com.au
Date submitted:	1 March 2016
If the nomination has been refereed or reviewed by experts, please provide their names and contact details:	
Dr Tony Start, tonys@wn.com.au	

Summary of subpopulation information *(detailed information to be provided in the relevant sections of the form)*						
Location *(include coordinates)*	Land tenure	Survey information: Date of survey and No. mature individuals	Area of subpopulation	Site / habitat Condition	Threats *(note if past, present or future)*	Specific management actions
Southern Swan Coastal Plain (Peppermint-dominated woodland from near Bunbury to Dunsborough)	Mostly private	2015: estimated 2000 mature individuals	29,730ha of habitat remaining	Large areas of cleared land for urban development	Land clearing: *past, present and future* Predation: *past, present and future* Fire: *past, present and future* Hollow competition: Past, *present and future* Tree decline: *Past, present and future* Road mortality: *past, present and future* Drying climate: *past, present and future* Groundwater depletion and altered hydrology: *Past, present and future*	Assess development proposals and negotiate offsets where relevant Conduct predator control Implement fire management strategies including appropriate prescribed burning Implement disease/pathogen/insect management strategies and employ hygiene protocols where relevant Conduct habitat restoration activities/programs Raise awareness within the community Conduct climate change modelling specific to WRP habitat and changes in foliage nutrition
Cape to Cape	Mixed public and private	2015: estimated 500 mature individuals	-	Areas of cleared land for viticultural and agricultural purposes	Land clearing: *past, present and future* Predation: *past, present and future* Fire: *past, present and future* Hollow competition: Past, *present and future* Tree decline: *Past, present and future*	As above

					Road mortality: *past, present and future* Drying climate: *past, present and future* Groundwater depletion and altered hydrology: *Past, present and future*	
Upper Warren	Mostly Nature Reserve	Prior-2002: estimated >10,000 individuals 2015: estimated 100 mature individuals	-	Very good	Predation: *past, present and future* Fire: *past, present and future* Hollow competition: Past, *present and future* Tree decline: *Past, present and future* Logging: *past* Drying climate: *past, present and future* Groundwater depletion and altered hydrology: *Past, present and future*	As above Implement forest management practices
Other Forest Rivers	Mixed State Forest and private	2015: estimated 200 mature individuals	-	Unknown	Predation: *past, present and future* Fire: *past, present and future* Hollow competition: Past, *present and future* Tree decline: *Past, present and future* Logging: *past, and potentially present and future*	As above Implement forest management practices

					Drying climate: *past, present and future* Groundwater depletion and altered hydrology: *Past, present and future*	
Near Albany	Mostly private	2015: estimated 500 mature individuals	-	Areas of cleared land near town site for urban development and agricultural purposes	Land clearing: *past, present and future* Predation: *past, present and future* Fire: *past, present and future* Hollow competition: Past, *present and future* Tree decline: *Past, present and future* Road mortality: *past, present and future* Drying climate: *past, present and future* Groundwater depletion and altered hydrology: *Past, present and future*	As above

Threatened species nomination

For nominations to the WA Threatened Species Scientific Committee (and the Minister for Environment) to amend threatened species listings under the WA *Wildlife Conservation Act 1950* or their IUCN Red List threat status.

Cover Page *(Office use only)*

Species name (scientific and common name)**:**	***Pseudocheirus occidentalis* (Ngwayir, western ringtail possum)**
Nomination for (addition, deletion, change)**:**	**Change**
Nominated conservation category and criteria:	**Critically endangered A2bce+A3bce+A4bce**

TSSC assessment of eligibility against the criteria:		
A.	Population size reduction	•
B.	Geographic range	•
C.	Small population size and decline	•
D.	Very small or restricted population	•
E.	Quantitative analysis	•

Outcome*:*			
TSSC Meeting date:			
TSSC comments:			
Recommendation:			
Ministerial approval:		*Government Gazette:*	

Nomination summary *(to be completed by nominator)*

Current conservation status: Endangered				
Scientific name:	*Pseudocheirus occidentalis*			
Common name:	Ngwayir, Western Ringtail Possum			
Family name:	Pseudocheiridae	Fauna ☒	Flora ☐	
Nomination for:	Listing ☐	Change of status ☒	Delisting ☐	
Is the species currently on any conservation list, either in WA, Australia or Internationally?		Yes ☒ *If Yes; complete the following table*	No ☐ *If No; go to the next question*	

Jurisdiction	**List or Act name**	**Date listed or assessed**	**Listing category i.e. critically endangered**	**Listing criteria i.e. B1ab(iii)+2ab(iii)**
International	IUCN Red List	30 June 2008	VU	B1ab(ii,iii,v)
National	EPBC Act	eons ago	VU	none provided
State of WA	WC Act	2014	EN	A2bce+A3bce+A4bce
	DPaW Priority list	1☐	2☐ 3☐	4☐ 5☐
Other States or Territories	not relevant			

Nominated conservation status: category and criteria (including recommended categories for deleted species)

Presumed extinct (EX) ☐ Critically endangered (CR) ☒ Endangered (EN) ☐ Vulnerable (VU) ☐

None ☐ Priority 1 ☐ Priority 2 ☐ Priority 3 ☐ Priority 4 ☐ Other Specially Protected (Conservation Dependent) ☐

What criteria support the conservation status category above? *Refer to Appendix A table 'Summary of the five criteria (A-E)' and the check version that can be completed to indicate all criteria options*	A2bce+A3bce+A4bce

Eligibility against the criteria

*Provide justification for the nominated conservation status; is the species eligible or ineligible for listing against the five criteria. For **delisting**, provide details for why the species no longer meets the requirements of the current conservation status.*

A.	Population size reduction	• yes, see attached
B.	Geographic range	• yes, meets EN
C.	Small population size and decline	• yes, meets VU
D.	Very small or restricted population	• no

criteria

E.	Quantitative analysis	• none available

Reasons for change of status					
Genuine change ☒	New knowledge ☒	Taxonomic change ☐	Previous mistake ☒	Other ☐	
Summary of assessment information *(detailed information to be provided in the relevant sections of the form)*					
EOO	c. 40 000 km^2	AOO	<500 km^2	Generation length	c. 3 years

No. locations	1	Severely fragmented	Yes ☒ No ☐
No. subpopulations	5	No. mature individuals	c. 3400

Percentage global population within WA	100%
Percentage global population within Australia	100%
Percentage population decline over 10 years or 3 generations	>80%

criteria

Summary of subpopulation information *(detailed information to be provided in the relevant sections of the form)*						
Location *(include coordinates)*	Land tenure	Survey information: Date of survey and No. mature individuals	AOO	Site / habitat Condition	Threats *(note if past, present or future)*	Specific management actions
see attached						

Nomination detail

Please refer to the Departments guidelines on nominating species for amendment of the Western Australian threatened species lists at http://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/Threatened_Species_Nomination_Guidelines_2014.pdf

For technical information on terminology used in this form, and the intent of information requirements, as they relate to an assessment of this nomination against the IUCN Red List criteria, refer to the 2001 *IUCN Red List Categories and Criteria. Version 3.1*
http://www.iucnredlist.org/documents/redlist_cats_crit_en.pdf

and *Guidelines for Using the IUCN Red List Categories and Criteria Version 11* (February 2014)
http://cmsdocs.s3.amazonaws.com/RedListGuidelines.pdf

Section 1: Taxonomy

1.1 Current taxonomy		
Species name and Author:	*Pseudocheirus occidentalis* (Thomas, 1888)	
Subspecies name(s) and Author:	none	
Is the species/subspecies conventionally accepted?		Yes ☒ No ☐
Is there any controversy about the taxonomy?		Yes ☐ No ☒
If not conventionally accepted and/or if there is any controversy; provide details:		
Has the species/subspecies been formally named?		Yes ☒ No ☐
Has the species/subspecies been recently described?		Yes ☐ No ☒
If the species has not been formally named or described; is it in the process of being described? Is there an anticipated date for the publication of the description? Has a type specimen been deposited? And if so provide the registration number and where deposited.		
If there are any closely related taxa provide details and include key distinguishing features:		
1.2 Taxonomic history		
Are there recent synonyms for the species?		Yes ☐ No ☒
If Yes; provide details of synonyms:		
Have there been recent changes in the taxonomy or nomenclature?		Yes ☐ No ☒
If Yes; provide details of changes:		
1.3 Hybridisation		

Is there any known hybridism with other species in the wild?	Yes ☐ No ☒ Unknown ☐
If Yes; Where does this occur and how frequently?	

Section 2: Species information

2.1 Morphology / physical description	
Insert photograph(s) of species or provide as an attachment: see recovery plan available at https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/197-approved-recovery-plans#recoveryplans	
Species description:	A highly-specialised arboreal and folivorous marsupial. Mean adult body weight c. 775 g.
2.2 Biology *(provide details)*	
see attached; also see *The action plan for Australian mammals 2012* and the Recovery Plan	
2.3 Ecology *(provide details)*	
see attached for relevant ecological information; also see *The action plan for Australian mammals 2012* and the Recovery Plan	

Section 3: Geographic range

3.1 Distribution	
Insert map(s) of the species distribution, or provide as an attachment: Description provided in Attachments; maps in *The action plan for Australian mammals 2012* and the Recovery Plan, but out of date.	
What is the current distribution of the species within Western Australia?	see attached and the Recovery Plan, noting that it is dated
What percentage of the species distribution is within WA?	100%
What is the current distribution of the species within the other Australian States and Territories?	endemic to south west of Western Australia
Does the species occur outside of Australia?	Yes ☐ No ☒
If Yes, what percentage of the species distribution is within Australia, or what is the significance of the occurrence in Australia?	
What is the current international	

criteria

trend for the species?	
3.2 Migration	
Is the species migratory?	Yes ☐ No ☒
Is the migration within WA or within Australia or international?	
3.3 Extent of Occurrence (EOO) within Australia	
What is the current EOO?	c. 40 000 km^2
How has this been calculated?	GIS, see action plan
What is the historical EOO?	much larger
What is the current EOO trend?	Decreasing ☒ Increasing ☐ Stable ☐
Provide details on the current trend – quantify if possible	see attachments
If there has been a change in EOO when did this change occur?	ongoing reduction over the past 100+ years
Was the change observed, estimated, inferred or projected?	observed
If the EOO is decreasing / declining, is it continuing?	Yes ☒ No ☐
Is the continuing decline observed, estimated, inferred or projected?	observed
Is there extreme fluctuation in EOO?	Yes ☐ No ☒
If Yes, provide details:	
3.4 Area of Occupancy (AOO) within Australia	
What is the current AOO?	<500 km^2, possibly <100 km^2
How has this been calculated?	2012 calculation in action plan from GIS using 1992-2012 data was 732 km^2, thus very out of date; inferred as <500 km^2 in action plan
What is the historical AOO?	unknown
What is the current AOO trend?	Decreasing ☒ Increasing ☐ Stable ☐
Provide details on the current trend – quantify if possible	no detailed information available; insufficient recent records to calculate
If there has been a change in AOO when did this change occur?	continuing over past century, but particularly over the past 10-15 years, and continuing
Was the change observed, estimated, inferred or projected? Give details.	observed and inferred

criteria

If the AOO is decreasing / declining, is it continuing?		Yes ☒ No ☐
Is the continuing decline observed, estimated, inferred or projected? Give details.	observed, inferred and projected	
Is there extreme fluctuation in AOO?		Yes ☐ No ☒
If Yes, provide details:		
Does the species have a restricted AOO?		Yes ☒ No ☐
If Yes, provide details:	now largely restricted to mature peppermint (*Agonis flexuosa*) forest with closed to semi-closed canopy	

3.5 Number of Locations

'Locations' are defined as a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations. Where a taxon is affected by more than one threatening event, location should be defined by considering the most serious plausible threat. (IUCN 2001).

At how many locations does the species occur?	1, the most serious threat, declining rainfall and increasing temperature, is present throughout the species' range; other major threats (foxes, cats, inappropriate fire) are also present throughout species' range	
Has there been a change in the number of locations?	Decrease ☐ Increase ☐ No change ☒	
If there has been a change, when did this change occur?	No change in number of locations (1) over the past 10 years. Previous inferred pre-European settlement range (derived from all known records including sub-fossil records): extending from Geraldton on the west coast of WA, to the Hampton Tableland on the south coast about 200 kilometres west of the WA/SA border. An inferred original distribution at the time of colonial settlement: extending from just north of Perth, down to just east of Albany including Pingelly and Borden (de Tores 2000).	
Was the change observed, estimated, inferred or projected? Give details.	Observed and inferred.	
If the number of locations is decreasing / declining, is it continuing? N/A		Yes ☐ No ☐
Is the continuing decline observed, estimated, inferred or projected? Give details.	Observed, inferred and projected. See attached.	
Is there extreme fluctuation in the number of locations?		Yes ☐ No ☒
If Yes, provide details:		
Does this species occur on any off-shore islands?		Yes ☐ No ☒
If Yes, provide details:		

3.6 Fragmentation

criteria

Is the distribution fragmented?	Yes ☒ No ☐
The phrase '**severely fragmented**' refers to the situation in which increased extinction risks to the taxon results from the fact that most of its individuals are found in small and relatively isolated subpopulations (in certain circumstances this may be inferred from habitat information). These small subpopulations may go extinct, with a reduced probability of recolonization.	
Is the distribution severely fragmented?	Yes ☒ No ☐
If Yes, provide details:	Now restricted largely to isolated and fragmented mature peppermint forest
3.7 Land tenure	
Is the species known to occur on lands managed primarily for nature conservation? i.e. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation	Yes ☒ No ☐
If Yes; provide details:	small proportion of population occurs in a small number of conservation reserves
Is the species known to occur on lands that are under threat? i.e. mining tenement, zoned for development	Yes ☒ No ☐
If Yes; provide details:	now occurs mostly on private property, much of which is under threat from urban development and all of which is under threat from a drying climate
Provide details of other land tenures where the species occurs as this relates to the species conservation status	too many properties to list

Section 4: Habitat

4.1 Habitat *(provide details in response to the question below)*	
Described the habitat suitable for the species (biological and non-biological). Include descriptions of specific purpose habitat (e.g. foraging, breeding, roosting, seasonal migration, different life stages).	See attached. Now mostly restricted to mature peppermint closed forest; some occurrences in eucalypt forest. A specialist folivore that shelters in dreys and hollows. Peppermint forest has few hollows; most animals use dreys.
If the species occurs in a variety of habitats, is there a preferred habitat?	formerly several types of forest and woodlands; now mostly closed peppermint forest
Does the species use refugia? *(include what is it and when is it used)*	yes, dreys and hollows, used during the daytime
Is the habitat restricted in extent or number of locations?	Yes ☒ No ☐
If Yes, provide details:	Coastal mature peppermint forest very restricted and most is now unsuitable because most is not closed canopy; tree decline observed, due probably to the drying climate
Is this species reliant on a threatened or priority species or ecological community?	Yes ☐ No ☒

criteria

If Yes, provide details:		
Are there any other species (sympatric species) that may affect the conservation status of the nominated species?		Yes ☒ No ☐
If Yes, provide details:	brushtail possums outcompete ringtails for hollows. Red foxes and feral cat are major predators. Domestic cats and dogs are predators within urban environments.	
What is the area, extent, abundance of habitat?	DPaW has calculated area of habitat classes on Southern Swan Coastal Plain; most is unsuitable or unoccupied, see Attachment 1.	
What is the quality of habitat?	Majority is poor quality and declining.	
Is there a decline in habitat area, extent or quality?		Yes ☒ No ☐
If there is a decline, is the decline continuing?		Yes ☒ No ☐
Provide details:	Clearing of peppermint continues despite restrictions. Tree decline and decline in quality of forage due to drying climate are major issues.	
What is the critical habitat or habitat important for the survival of the species?	Closed canopy mature peppermint forest with regular flushes of new, high nutritional value foliage	

Section 5: Population

'Population' is used in a specific sense in the Red List Criteria that is different to its common biological usage. Population is here defined as the total number of mature individuals of the taxon. In the case of taxa obligately dependent on other taxa for all or part of their life cycles, biologically appropriate values for the host taxon should be used. (IUCN 2001)

'Subpopulations' are defined as geographically or otherwise distinct groups in the population between which there is little demographic or genetic exchange (typically one successful migrant individual or gamete per year or less).

5.1 Subpopulations

Location *(include coordinates)*	Land tenure	Survey information: Date of survey and No. mature individuals	AOO	Site / habitat Condition
Southern Swan Coastal Plain	mostly private	See attachments		See attachments
Cape to Cape	mixed public and private	See attachments		See attachments
Upper Warren	mostly nature reserve	See attachments		See attachments
Other Forest Rivers	mixed: state forest and	See attachments		See attachments

criteria

	private land			
Near Albany	mixed, mostly private	See attachments		See attachments

5.2 Population size (Australian context) *(include how numbers were determined/calculated)*	
What is the total population size?	c. 3400 mature individuals
What is the number of subpopulations?	5
What percentage of the population is within WA?	100%
What percentage of the population is within Australia?	100%

5.3 Population dynamics (Australian context) *(include how numbers were determined/calculated)*	
What is the number of mature individuals?	c. 3400
What is the number of immature individuals?	unknown, varies with season
What is the number of senescing/past reproductive individuals?	N/A
What is the maximum number of mature individuals per subpopulation?	c. 2000
What is the percentage of mature individuals in the largest subpopulation?	numbers above are for mature individuals
What percentage of mature individuals is within WA?	100%
What percentage of global mature individuals is within Australia?	100%
What is the age of sexual maturity?	1 year
What is the life expectancy?	3-6 years, but towards lower end nowadays
What is the generation length?	3 years, now possibly 2 years
What is the reproductive capacity? (i.e. litter size or number of seeds)	1
What is the reproductive success?	depends on nutritional status of food, see attachments

5.4 Population trend	
What is the current population trend (mature individuals)?	Decreasing ☒ Increasing ☐ Stable ☐
What is the percentage of the population	>80% over the past 10 years, see attachments

criteria

change and over what time period?	
How has this been calculated?	observed for Upper Warren, inferred for other subpopulations
If the trend is decreasing; are the causes of the reduction understood?	Yes ☒ No ☐
Have the causes of the reduction ceased?	Yes ☐ No ☒
Are the causes of the reduction reversible? **Some are, some are not: climate change not considered reversible in the medium-term**	Yes ☒ No ☒
Is the reduction continuing (continuing decline)?	Yes ☒ No ☐
Has the change been observed, estimated, inferred or is it suspected (direct observation, index of abundance appropriate to the species)?	all of these
When was the reduction or is it anticipated to occur?	Past ☒ Present ☒ Future ☒
What is the period of time for the reduction (in years and generations)?	past 10 and next 10 years for this evaluation
Has there been a reduction in the number of subpopulations?	Yes ☐ No ☒
If Yes, provide details:	not in the past 10 years, although significant reduction in size of all subpopulations
Are there extreme fluctuations in population size?	Yes ☐ No ☒
If Yes, provide details:	
5.5 Translocations and captive/enclosed subpopulations	
Have there been translocations (introduction or re-introduction)?	Yes ☒ No ☐
Are there proposed translocations (introduction or re-introduction)? **Recovery Plan proposes translocations**	Yes ☒ No ☐
Are There Captive/Enclosed/Cultivated Subpopulations? **Karakamia and Upper Warren**	Yes ☒ No ☐
Are there proposed captive/enclosed/cultivated subpopulations?	Yes ☐ No ☒
Are there self-sustaining translocated subpopulations?	Yes ☒ No ☐
If Yes, provide details:	Almost all past translocations failed; one near Yunderup has persisted so far in small numbers.
Are there translocated subpopulations that are not self-sustaining?	Yes ☐ No ☒
If Yes, provide details:	
Are there self-sustaining captive/enclosed subpopulations?	Yes ☒ No ☐
If Yes, provide details:	Karakamia has persisted for > 10 years; small number of animals
Are there captive/enclosed subpopulations that are not self-sustaining?	Yes ☒ No ☐

If Yes, provide details:	At Upper Warren within exclosure?
Other information on translocations and captive/enclosed subpopulations for the species (including failures):	

5.6 Important subpopulations

Identify any subpopulations that are important or necessary for the long-term survival of the species and provide details for why they are considered as such (i.e. key breeding, edge or range, maintenance of genetic diversity):

The subpopulations that are most important and most likely to persist with management are Southern Swan, Cape to Cape and Near Albany. Upper Warren subpopulation seems unlikely to persist in the medium term. Other Forest Rivers includes some wetter habitat and may persist with management.

Section 6: Survey

6.1 Survey methods *(Provide details)*

What survey methods are applicable to the species?	See Recovery Plan
Are there preferred or recommended survey methods that yield better results for the species?	Needs research
Are there special requirements, techniques, expertise or other considerations that are necessary when surveying for this species?	Survey methodology requires limited training by an expert.
Are there reasons why the species may not be detected during surveys?	Arboreal, not readily visible in dense canopy, rarely come to ground.

Can the species be identified in the field?	Yes ☒	No ☐
Provide details:	Readily separated from brushtail possum by a trained observer	
Can the species be easily confused within similar species in the field?	Yes ☐	No ☒
Provide details:	Not by a trained observer; some people may confuse with the brushtail possum.	

List any published survey guidelines, guidance statements, protocols, standard operating procedures or other documents that are relevant to conducting surveys for this species.

6.2 Survey effort

Has the species been well surveyed?	Yes ☐	No ☒
Have targeted surveys been conducted for the species?	Yes ☒	No ☐
Provide details of the successful and unsuccessful surveys undertaken for the	Only targeted regional surveys have been at Upper Warren; there have been numerous small-scale surveys at development sites on the Southern Swan Coastal Plain. These have not been collated and many are too old to be relevant.	

criteria

species:	
6.3 Research *(Provide details)*	
Has the species been well researched?	Yes ☐ No ☐ Partially ☒
What research has been or is being conducted?	Published studies shown in References to Attachments. Numerous consultants' reports. Current PhD study near Busselton, not published. Limited research at Upper Warren including logging effects at Kingston (logging kills a proportion of possums directly, and survival is greatly reduced after logging due to increased predation by foxes and cats).
What are the knowledge gaps for the species?	Insufficient knowledge of effects of watering on quality of peppermint foliage as possum food; there is unpublished evidence that watering will aid possum recruitment and some animals in urban areas recruit.
Research recommendations:	Establish standardised monitoring protocols; however, monitoring protocols will need to vary with habitat, research effects of watering on recruitment.
6.4 Monitoring *(Provide details)*	
Is the species being monitored, either directly (targeted) or indirectly (general monitoring)?	No
What methods are used for monitoring?	None currently; scat transects are possibly the best method but limited in dense vegetation; night counts are variable.
Monitoring recommendations:	Develop and implement monitoring protocols as per recovery plan

Section 7: Threats

7.1 Threats (*detail how the species is being impacted, i.e. how severe, the extent, evidence of the impact*)				
Threat *(describe how the threat impacts on the species. Include abiotic and biotic causes, human related e.g. exploitation, and biological characteristics of the species e.g. low genetic diversity)*	Extent *(give details of impact on whole species or specific subpopulations)*	Impact *(what is the level of threat to the conservation of the species)*	Evidence	Time period *(past, present, future)*
See Attachments				

Section 8: Management

8.1 Current management			
Is the species managed?	Yes, directly ☐	Yes, indirectly ☒	No ☐
If Yes; provide details of current or past management actions:	EPBC Act guidelines for development approvals, but development continues. Logging guidelines (but few possums now in state forest). Fire is an increasing threat noting the drying climate and increasing lightning-caused fires near the south coast.		
Does the species benefit from the management of another species or ecological community?	Yes ☐	No ☒	
If Yes; provide details:			

8.2 Recovery planning		
Is there an approved Recovery Plan (RP) or Interim Recovery Plan (IRP) for the species?	Yes ☒	No ☐
List all relevant recovery plans or interim recovery plans (including draft, in-preparation, out-of-date, national and other State/Territory plans, and plans for other species or ecological communities that may benefit or be relevant to the nominated species) Western Ringtail Possum (*Pseudocheirus occidentalis*) Recovery Plan. Wildlife Management Program No. 58.		
List other documents that may be relevant to the management of the species or the lands on which it occurs (i.e. area management plans, conservation advices, referral guidelines) http://www.environment.gov.au/resource/significant-impact-guidelines-vulnerable-western-ringtail-possum-pseudocheirus-occidentalis		

8.3 Management recommendations
Update and implement recovery plan.

Section 9: Nominator details

Nominator name(s):	Andrew A Burbidge, Barbara Jones
Contact details:	amburbidge@westnet.com.au
Date submitted:	1 March 2016
If the nomination has been refereed or reviewed by experts, please provide their names and contact details:	
Dr Tony Start, tonys@wn.com.au	

Section 10: References

9.1 References
see Attachments

SUMMARY OF THE FIVE CRITERIA (A-E) USED TO EVALUATE IF A TAXON BELONGS IN AN IUCN RED LIST THREATENED CATEGORY (CRITICALLY ENDANGERED, ENDANGERED OR VULNERABLE).[1]

A. Population size reduction. Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4

	Critically Endangered	Endangered	Vulnerable
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3 & A4	≥ 80%	≥ 50%	≥ 30%

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

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

A3 Population reduction projected, inferred 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 (AOO), extent of occurrence (EOO) and/or habitat quality
- **(d)** actual or potential levels of exploitation
- **(e)** effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

B. Geographic range in the form of either B1 (extent of occurrence) AND/OR B2 (area of occupancy)

	Critically Endangered	Endangered	Vulnerable
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			

C. Small population size and decline

	Critically Endangered	Endangered	Vulnerable
Number of mature individuals	< 250	< 2,500	< 10,000
AND at least one of C1 or C2			
C1. An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future):	25% in 3 years or 1 generation (whichever is longer)	20% in 5 years or 2 generations (whichever is longer)	10% in 10 years or 3 generations (whichever is longer)
C2. An observed, estimated, projected or inferred continuing decline AND at least 1 of the following 3 conditions:			
(a) (i) Number of mature individuals in each subpopulation	≤ 50	≤ 250	≤ 1,000
(a) (ii) % of mature individuals in one subpopulation =	90–100%	95–100%	100%
(b) Extreme fluctuations in the number of mature individuals			

D. Very small or restricted population

	Critically Endangered	Endangered	Vulnerable
D. Number of mature individuals	< 50	< 250	**D1.** < 1,000
D2. *Only applies to the VU category* Restricted area of occupancy or number of locations with a plausible future threat that could drive the taxon to CR or EX in a very short time.	-	-	**D2.** typically: AOO < 20 km² or number of locations ≤ 5

E. Quantitative Analysis

	Critically Endangered	Endangered	Vulnerable
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

1 Use of this summary sheet requires full understanding of the *IUCN Red List Categories and Criteria* and *Guidelines for Using the IUCN Red List Categories and Criteria*. Please refer to both documents for explanations of terms and concepts used here.

IUCN Red List Criteria Summary Sheet Version 11 (February 2014)

FORM VERSION OF IUCN RED LIST SUMMARY OF THE FIVE CRITERIA (A-E) to assist with determining eligible criteria

Check boxes in one or more of the following fields to support you nomination; refer to summary table above for explanations

A. Population size reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4

A1 ☐	*and one of the following*	≥ 90% ☐	≥ 70% ☐	≥ 50% ☐		
	and any of the following	(a) ☐	(b) ☐	(c) ☐	(d) ☐	(e) ☐
A2 ☒	*and one of the following*	≥ 80% ☒	≥ 50% ☐	≥ 30% ☐		
	and any of the following	(a) ☐	(b) ☒	(c) ☒	(d) ☐	(e) ☒
A3 ☒	*and one of the following*	≥ 80% ☒	≥ 50% ☐	≥ 30% ☐		
	and any of the following	(b) ☒	(c) ☒	(d) ☐	(e) ☒	
A4 ☒	*and one of the following*	≥ 80% ☒	≥ 50% ☐	≥ 30% ☐		
	and any of the following	(a) ☐	(b) ☒	(c) ☒	(d) ☐	(e) ☒

B. Geographic range in the form of either B1 (extent of occurrence) and/or B2 (area of occupancy)

B1 ☐	*and one of the following*	< 100 km² ☐		< 5,000 km² ☐		< 20,000 km² ☐	
	and at least two of the following three conditions [(a), (b), (c)]	(a) ☐	*and one of the following*	1 ☐	≤ 5 ☐	≤ 10 ☐	
		(b) ☐	*and any of the following*	(i) ☐	(ii) ☐	(iii) ☐	(iv) ☐ (v) ☐
		(c) ☐	*and any of the following*	(i) ☐	(ii) ☐	(iii) ☐	(iv) ☐
B2 ☐	*and one of the following*	< 10 km² ☐		< 500 km² ☒		< 2,000 km² ☐	
	and at least two of the following three conditions [(a), (b), (c)]	(a) ☒	*and one of the following*	1 ☒	≤ 5 ☐	≤ 10 ☐	
		(b) ☒	*and any of the following*	(i) ☐	(ii) ☒	(iii) ☒	(iv) ☐ (v) ☒
		(c) ☐	*and any of the following*	(i) ☐	(ii) ☐	(iii) ☐	(iv) ☐

C. Small population size and decline

C1 ☐	*and one of the following*	< 250 ☐	< 2,500 ☐	< 10,000 ☒	
	and one of the following	25 % ☐	20 % ☐	10 % ☒	
C2 ☐	*and one of the following*	< 250 ☐	< 2,500 ☐	< 10,000 ☐	
	and at least two of the following three conditions [(a)(i), (a)(ii), (b)] plus applicable size and/or percentage	(a)(i) ☐	≤ 50 ☐	≤ 250 ☐	< 1,000 ☐
		(a)(ii) ☐	90 - 100 % ☐	95 – 100 % ☐	100 % ☐
		(b) ☐			

D. Very small or restricted population

D ☐	*and one of the following*	< 50 ☐	< 250 ☐	D1 (< 1,000) ☐
D2 ☐	*and one of the following*	< 20 km² ☐	≤ 5 ☐	

E. Quantitative analysis

E ☐	*and one of the following*	≥ 50 ☐	≥ 20 % ☐	≥ 10 % ☐

The following table is to assist with determining eligibility under criteria B, C & D

What is the total number of mature individuals?						
Global	< 50 ☐	< 250 ☐	< 1,000 ☐	< 2,500 ☐	< 10,000 ☐	Unknown ☐
National	< 50 ☐	< 250 ☐	< 1,000 ☐	< 2,500 ☐	< 10,000 ☐	Unknown ☐
WA	< 50 ☐	< 250 ☐	< 1,000 ☐	< 2,500 ☐	< 10,000 ☐	Unknown ☐
How has this number been determined or calculated? suspected						
Reliability of total number of individuals (*other than for 'unknown' above)*						
Global	Known ☐	Estimated ☐	Modelled ☐	Expert opinion ☐		
National	Known ☐	Estimated ☐	Modelled ☐	Expert opinion ☐		
WA	Known ☐	Estimated ☐	Modelled ☐	Expert opinion ☐		
If from expert opinion, provide name of expert: Authors and reviewers						
How many subpopulations/locations?						
Global	1 ☐	≤ 5 ☐	≤ 10 ☐	Unknown ☐		
National	1 ☐	≤ 5 ☐	≤ 10 ☐	Unknown ☐		
WA	1 ☐	≤ 5 ☐	≤ 10 ☐	Unknown ☐		
How has this number been determined or calculated?						
Reliability of number of populations/locations (*other than for unknown above)*						
Global	Known ☐	Estimated ☐	Modelled ☐	Expert opinion ☐		
National	Known ☐	Estimated ☐	Modelled ☐	Expert opinion ☐		
WA	Known ☐	Estimated ☐	Modelled ☐	Expert opinion ☐		
If from expert opinion, provide name of expert:						
What is the total number and percentage of mature individuals in each subpopulation/location? *(include all known subpopulations/ locations; add subpop./ location name or reference below and add additional rows as required)*						
Subpop./ location 1	1 ☐	≤ 5 ☐	≤ 10 ☐	Unknown ☐		
	90 - 100 % ☐	95 – 100 % ☐	100 % ☐	Unknown ☐		
Subpop./ location 2	1 ☐	≤ 5 ☐	≤ 10 ☐	Unknown ☐		
	90 - 100 % ☐	95 – 100 % ☐	100 % ☐	Unknown ☐		
How has this number been determined or calculated?						
Reliability of the total number of mature individuals in each subpopulation/location? (*other than for unknown above)*						
	Known ☐	Estimated ☐	Modelled ☐	Expert opinion ☐		
If from expert opinion, provide name of expert:						

Attachment 1

CONSERVATION STATUS OF THE

NGWAYIR (WESTERN RINGTAIL POSSUM) *PSEUDOCHEIRUS OCCIDENTALIS*

REPORT TO THE WESTERN AUSTRALIAN THREATENED SPECIES SCIENTIFIC COMMITTEE

Andrew A Burbidge, February 2016

BACKGROUND

The Action Plan for Australian mammals 2012 (MAP, Woinarski *et al*. 2014) evaluated the status of the Ngwayir or Western Ringtail Possum (WRP) as CR A2bce+3bce+4bce. In 2014, the Western Australian Threatened Species Scientific Committee (WATSSC) considered a nomination to amend the Red List status of the WRP from VU to CR, based on the Action Plan evaluation. WATSSC after considering information provided by the Department of Parks and Wildlife (P&W), some of which was not available to the authors of the Action Plan, recommended that the WRP be listed as EN A2bce+3bce+4bce. The relevant part of the minutes of the April 2014 meeting are copied blow.

> The committee acknowledged the additional information provided by the department.
>
> There is a general lack of information for the species in the Albany area. For the species in general there is a lack of consistent survey across the range. There is a known decline in habitat in the coastal plain area. There is a known decline however a query was raised as to whether it is a CR or EN level decline. The recent decline in the forest area has been rapid. This has been the same for many of the critical weight range mammals in the southern forest region. Andrew mentioned that for the Mammal Action Plan (in press) they took a precautionary approach in the species assessment due to the lack of information for the Albany area.
>
> The predominant issue for this nomination is whether to take a precautionary approach or cautious approach. The nominated criteria are appropriate regardless of which category is applied. It was suggested that it is easier to justify the EN rather than the CR; it can be clearly justified as EN but it may be difficult to justify CR.
>
> There was discussion regarding the category and would the category make any difference for developments in habitats suitable for this species. Basically the category would make no difference to the assessment of a proposed development, it may only affect the level of offsets required for an approved development (under EPBC Act procedures). The issue of the threat of climate change, drought, and water availability was discussed and the potential to influence future decline. It was noted that the species has an unusual digestive process that may be impacted by water availability and that the sex ratio changes with food availability. Andrew mentioned historical records and records of the species in Tutanning Nature Reserve, Collie, and Darling Scarp areas.
>
> The crux of the decline is the number of individuals for the Perup area, and whether the population in the area is over 76% of the entire species. It should be possible to compare the remnant vegetation GIS layer from 10 years ago to the current layer, and the vegetation type layers, to calculate the proportion of suitable habitat that has been cleared in the coastal plain area.
>
> The committee noted that the assessment of category based on the current knowledge for this species results in the species being borderline between CR and EN. Therefore the committee decided that the cautious, conservative, approach should be taken to apply the category of EN. The species may be reassessed next meeting for potential upgrade to CR if additional information is provided that supports upgrade.
>
> The TSSC supported the nomination to change the category and criteria for the species and recommended the rank to be upgraded to Endangered, EN A2bce+3bce+4bce.
>
> ***Action 7 arising:*** **DPaW: investigate the potential of calculating habitat loss for the coastal plain area using GIS information. Contact the Albany District to ask if they have additional data. Collate survey reports for proposed developments in the Albany area. Determine if there is sufficient additional information to support further upgrading to Critically Endangered, and if so, work with nominator to prepare status update for the 2015 TSSC meeting.**

Information about the status of the WRP in the Albany Region, and about GIS data from the Busselton area, was provided to me only <u>one day</u> before the 2015 meeting, so it was impossible for me to prepare a status update for that meeting. The draft minutes of that meeting state:

GIS layers were obtained of the remnant vegetation in 2002 and 2012. Calculations using these shapefiles did not indicate a loss of remnant vegetation during the 10 year period. This is likely to be due to the methods used to create the remnant vegetation polygons from aerial imagery and an improvement in the accuracy of indicating areas of remnant vegetation since 2002. The 2002 shapefile was not accurate in covering areas of remnant vegetation; some areas were missed. The 2012 shapefile was considerably more accurate in covering all areas of remnant vegetation. This resulted in there being an increase in area of remnant vegetation during the 10 year period, 2002-2012, where GIS calculations were performed. The areas specifically trialled for the calculations were the Swan Coastal Plain and South Coast management zones for the western ringtail possum as indicated in the 2014 recovery plan.

A shapefile of the Department of Environment Regulation permits to cleared (sic) vegetation is available however this layer shows all application areas, including those not approved and those relinquished, and does not indicate if the vegetation was actually cleared.

Albany District advised that the status of WRP within their area is not dire and they would have difficulty in meeting the CR category. They noted that they are definitely not scarce in the Albany – Manypeaks area and would actually say that they are regionally common. The City of Albany has recently done surveys within the town and found 'really high' numbers in the Mt Melville reserve and are currently planning additional surveys in shire reserves. Mt Gardner and Manypeaks have 'very good' levels of activity and there is a proposed camera survey of these areas. There was a road kill collected at Cheyne Road – Hassell Highway intersection in April 2015 which is further northeast of other recent sightings.

Gilfillan 2009 [report dated 2008, my comment] increased the known records for WRP in the greater Albany area by 150% (from 83 known records to 298 records, an additional 215 records), simply by asking the public to report sightings.

There is recent report of a subpopulation (breeding) at Mt Barker. The South Coast Regional Ecologist is looking into this report.

and

The conservation status was upgraded from VU to EN as per the recommendation made in the 2014 TSSC meeting no. 19. The 2014 committee recommendation only supported upgrade to EN with further information requested on the subpopulation in the Albany area to support the upgrade to CR (refer to Agenda item 5. (Action 7 arising from meeting no. 19)).

Andrew commented that there are more threats impacting the species, not just the issue of habitat reduction (as would apply in the Albany area). There has been a reduction in rainfall that is causing decline in recruitment. Unpublished research demonstrated that artificial watering of trees increased possum recruitment by improving the quality of food available to the possums. The species also appears to be doing the 'best' and having the 'best' recruitment in or near town sites, probably also related to the availability and quality of food.

There is also the issue of severe canopy fires in drier conditions. Climate change, a drying climate, is a potential, projected threat. In addition, Myrtle rust is a potential future threat that would be very significant if the rust gets into south west WA. The recommendation to upgrade the rank to CR was suggested based on the population reduction, 'crash', in the Perup area during the past 10 years. Additional information is still required for the subpopulations in the South Coast and Warren regions.

The TSSC deferred assessment of the MAP recommendation pending the review of additional information on the possum subpopulations from the South Coast and Warren regions. The committee agreed to review and assess out-of-session, as soon as adequate information becomes available, or at the next meeting.

Action 8 ***arising: SCB to contact South Coast and Warren regions to request further information on the Western Ringtail Possum subpopulations in their areas; including data and survey reports from environmental consultants, not-for-profit organisations and researchers.***

INFORMATION USED IN THE 2012 ACTION PLAN

The justification for the evaluation as CR was:

The Western Ringtail Possum has an Area of Occupancy of <500 km^2, small severely fragmented subpopulations and is continuing to decline, being threatened particularly by a drying climate, urban development, inappropriate fire regimes, and Red Fox *Vulpes vulpes* and feral Cat *Felis catus* predation. The subpopulation in the Upper Warren was the largest prior to 2002 and underwent a severe decline of >95% (probably >99%) between 1998 and 2009. Remaining fragmented subpopulations in coastal habitats are also declining rapidly, equating to a population decline of >80% in the past 10 years. With rainfall in the south-west of Western Australia predicted to decline further and continuing urban coastal development, there is a suspected continuing decline of >80% in the next 10 years.

2015 RE-EVALUATION

Relevant information

There have been few refereed publications relating to the WRP over the past decade, with Adrian Wayne *et al*.'s work at the Upper Warren being the exception. Barbara Jones published extensively on the biology and populations of the species up to 2004, and de Tores *et al*. published several papers on the WRP, mainly between 1995 and 2005. Paul de Tores prepared a summary of research on the southern Swan Coastal Plain in 2009 and a bibliography has been published by Wright *et al*. (2007).

In the past there was some disagreement about the taxonomic status of the WRP with some authors suggesting it is conspecific with or a subspecies of the Common Ringtail *P. peregrinus*; however, its distinctiveness is widely accepted and it was included as a full species by Jackson and Groves (2015). Donaldson (n.d. ?2000) showed significant genetic differences between *P. occidentalis* and *P. peregrinus* from the east coast and concluded that they should be treated as separate management units.

Gilfillan (published 2009; prepared August 2008) on the Albany area is 7 years old. The recovery plan (Parks and Wildlife, February 2014) was prepared when the species was listed as VU and was based on earlier drafts (e.g. version 4, 2005). Parks and Wildlife have not been able to provide me with any updated information on the status of the WRP since the 2015 TSSC meeting.

The person with most expertise and experience with WRPs is Barbara Jones, who has worked on the species for >25 years.

There are several pers. comms from her in the species summary in the MAP. Of particular interest is information on diet and nutrition:

> The diet of the Western Ringtail Possum is variable. When available, Peppermint leaves form the majority of the diet. In their absence, the dominant myrtaceous species are preferred (Jones *et al.* 1994b). In urban areas (e.g. Bunbury and Busselton), they are known to feed on a variety of garden species, including rose bush leaves and flowers and a variety of fruits. The digestive system reflects adaptation to myrtaceous and other foliage of low nutritional value. Western Ringtail Possums are caecum fermenters having a large caecum where fine digestive material is retained. Larger, coarse, less nutritious material is passed more rapidly. Ringtail Possums are also caecotrophic (i.e., during the day they ingest softer, finer faecal material to assist in returning bacteria to the caecum to aid digestion: Hume and Sakaguchi (1993); Hume *et al*. (1994)). Successful recruitment depends on seasonal availability of high-quality foliage. When food quality is poor, the sex ratio of young is biased towards males, and recruitment may fail (B. Jones *pers. comm*.). Wayne (2005) reported that 84% of monitored deaths (mostly linked to predation) occurred between April and September, when both male and female body condition was significantly lower than October-March.

Barbara Jones has sent me her overview of the status of the WRP (Attachment 2). In summary, her view is that WRPs are in serious trouble, their habitat and they will continue to decline, and the species should be listed as CR. She has provided probable numbers of adults in 2003, 2006, 2009, 2012 and 2015, for five regions (Attachment 2, Table 3).

Notes on the five subpopulations

Southern Swan Coastal Plain. This subpopulation (or scattered numerous subpopulations) existed (and still exists at lower numbers) in fragmented remnants of Peppermint-dominated woodland from near Bunbury to Dunsborough. It is poorly reported in the scientific literature despite much work commissioned by land developers and some overview by Parks and Wildlife South West Region staff.

Shedley and Williams (2014) assessed the area and quality of WRP habitat in the southern Swan Coastal Plain between Binningup and Dunsborough and provided a habitat classification and GIS mapping dataset that can be used for prioritising habitat. Specifically they aimed to provide information on habitat patches that are most important to support a viable population of WRP in this area. They defined five management zones in the Bunbury to Dunsborough

region and calculated the area in each subdivided into three classes: A, B and C. They concluded that a total of 29 730 ha of habitat remained, of which only 630 ha was Class A, with 8490 ha Class B and 20 610 ha Class C. They mapped 0.2 ha of Class A in the Busselton zone and none in the Binningup zone. They noted that Class A habitat 'is the only vegetation type in which this species is known to reach high rates of reproduction that can contribute to maintaining population densities and act as a nucleus for potential species recovery. The remaining 630 ha of Class A habitat are therefore a priority for conservation' (page 53). They also stated that the area of Class C habitat mapped was likely to have been over-estimated. The report included no recommendations on how to achieve protection and management of the remaining Class A habitat.

The abstract of a paper presented to the scientific meeting of the Australian Mammal Society in July 2015 was published in the AMS Newsletter of October 2015. The paper was titled 'A predicted sharp decline of the western ringtail possum: urgent reduction in fox predation and road mortality needed' by Yokochi, Kaori; Black, Robert; Chambers, Brian; and Bencini, Roberta. The abstract stated that a PVA of a subpopulation near Busselton predicted a 96.5% probability of extinction within the next 20 years, and that fox predation was the most common cause of mortality followed by road mortality. Yokichi *et al*. (2015) studied a subpopulation at Locke Nature Reserve, one of the higher density subpopulations of the WRP, and concluded that Caves Road and an artificial waterway were significant barriers to movement. Yokochi and Bencini (2015) studied of the use of a rope bridge across Caves Road at the Locke Nature Reserve and found that WRPs quickly adapted to using it.

The grey literature (numerous Consultants' reports) has recorded >8000 sightings between 2006 and 2012, but these have not been compiled. The Recovery Plan states 'From existing survey data, the population in the Bunbury to Dunsborough region is possibly between 2,000 and 5,000 animals (Wilson 2009; B. Jones and G. Harewood pers. comm. 2013)'. Most habitat in this area is on private land. Barbara Jones (Attachment 2, considers that in 2015 there were probably c. 2000 mature individuals in the Southern Swan Coastal Plain.

Cape to Cape. There are no papers or reports that summarise WRP habitat or abundance for this area. Barbara Jones (Attachment 2) considers that in 2015 there were probably c. 500 mature individuals in Cape to Cape.

Upper Warren. In the 1990s, this was the largest and apparently the most stable subpopulation. The Recovery Plan states 'The number of western ringtail possums in the southern forests is not known but is considered to have been in the tens or hundreds of thousands (A. Wayne pers. comm. 2013), and thus is thought to be the largest population prior to 2002.' Spotlighting and trapping data suggest the decline in the Upper Warren took place between 2002 and 2009, with the timing when they became undetectable varying from place to place (Appendix 1). Note that some of the spotlighting transects (particularly those in Appendix 1, Fig 1) were in areas that had been logged in 1990s and it has been established that logging leads to a significant decline in WRP. Wayne *et al*.'s trapping data shows that the substantial decline bottomed out about 2008-10, c. 5-7 years ago (Attachment 2). There have been occasional spotlighting detections since 2010 demonstrating that WRP still occur in the Upper Warren, albeit at very low numbers (A. Wayne pers. comm.). Relevant references for this subpopulation are Wayne *et al*. (2011, 2012). Barbara Jones (Attachment 2) considers that in 2015 there were probably c. 100 mature individuals at Upper Warren.

Other forest rivers. There are no papers or reports that summarise WRP habitat or abundance for this area, so I am dependent on Barbara Jones for probable numbers. Barbara Jones (Attachment 2) considers that in 2015 there were probably c. 300 mature individuals in Other Forest Rivers.

Albany area. Gilfillan (2009) showed that, in 2008, WRPs remained near Albany, in scattered remnants of vegetation (with evidence of contraction from previously occupied areas). Areas searched revealed only low densities. Reports of sightings from the public suggested a few localities had reasonable numbers, such as at Mt Melville. The past two years (2014 and 2015) have been very dry years, and there have been major fires in some places. As is the case with the Southern Swan Coastal Plain, most habitat is outside the conservation estate. Barbara Jones (Attachment 2) considers that in 2015 there were probably c. 500 mature individuals in the Albany area.

CONSIDERATION OF RED LIST CRITERIA

Criterion A

Criterion A1. *Population size reduction where the causes of the reduction are reversible and understood and ceased*.

Does not apply.

Criterion A2. *Population size reduction over the last 10 years or 3 generations*.

Threshold for EN is >50%, for CR >80% in 10 years (three generations is considered to be c. 9 years)

After a substantial decline from drier parts of its range in the latter half of the 20th Century, there were, until recently, three main subpopulations: Upper Warren (including Perup), the southern Swan Coastal Plain (including the Cape to Cape region) from Bunbury to Augusta, and in and near Albany. Outside these areas, there are small numbers, e.g., in Preston-Blackwood rivers area and west of Manjimup, but numbers are negligible in assessing population numbers.

Population size reduction. Given the lack of data on subpopulation size for much of the species' range, it is not possible to estimate the population size reduction over the past 10 years. However, under Criterion A, population size reduction can be inferred or suspected. Given the lack of data, the only way of inferring (indirect evidence) or suspecting (circumstantial evidence) a population size reduction is via expert opinion, in this case from Barbara Jones. Note that the Guidelines state that suspected population size reduction can be based on evidence of qualitative habitat loss. Barbara Jones' expert opinion of the inferred/suspected numbers of mature individuals for 2006 (18 000, 10 years ago) and 2015 (3400) are provided in Attachment 2 and indicate a population size reduction of 80% or more in the past 10 years. Note that if the numbers at Upper Warren were higher than 32 000 in 2003 (as suggested by Adrian Wayne) then the decline would be greater.

Criterion A3. *Population size reduction within the next 10 years*

The high rate of decline over the past 10 years (2006 to 2015), suggest that the population size reduction will continue. The rate will depend on whether rainfall continues to decline and temperatures continue to increase: based on recent history and climate change predictions, both are likely. It will also depend on the effects of the other threats (see below). Predicting the rate of reduction in the next 10 years is fraught with difficulties and depends on how precautionary an assessor chooses to be. Given that available data indicate that the decline since c. 1990 is probably correlated more with declining rainfall (and perhaps increasing temperature) causing nutritional stress and poor recruitment than habitat loss or predation (although both these are significant), it can be projected that it will continue; however, how large a decline in population size (>80% in 10 years is required for CR) may be projected depends on to how precautionary an assessor is. Noting the enormous declines that has happed recently in the Upper Warren, I would tend to be precautionary (section 3.2.4 of the Red List guidelines is relevant here).

Criterion A4. *Population size reduction over any 10 year period, where the time must include both the past and the future*

There has been a substantial population size reduction during the past five years, but as the Upper Warren decline bottomed out at about 2008, the rate is likely to have been less over five years that it was over ten years. As above, given that available data indicate that the decline since c. 1990 is probably correlated more with declining rainfall (and perhaps increasing temperature) causing nutritional stress and poor recruitment than habitat loss or predation (although both these are significant), there must be a strong suspicion that it will continue; however, a how large a decline in population size (>80% in 10 years is required for CR) may be projected depends on to how precautionary an assessor is. Noting the enormous declines that have happed recently (Upper Warren), I would tend to be precautionary (as with A3, section 3.2.4 of the guidelines is relevant here).

Criterion B

Criterion B requires an EOO of <100 km^2 or an AOO of <10 km^2 to meet CR. Although quality data are lacking, the WRP does not meet these thresholds. The MAP estimated the AOO as <500 km^2 , based on 1992 to 2012 data, with the

qualification that the figure was likely to be a significant over-estimate due to rapid decline post-2002. The Recovery Plan estimated the AOO as <800 km^2, based on 1990-2013 Parks and Wildlife data; this is also highly likely to now be a significant over-estimate due to rapid decline since 1990.

Maps showing locations over the past 20 years (as published in the MAP and the Recovery Plan) or even the last 10 years are of limited value due to the recent substantial decline.

Criterion C

Criterion C requires a pop size of <250 mature individuals for CR and <2500 for EN; the WRP does not qualify as either EN or CR under this criterion.

Criterion D

There are >250 mature individuals; the WRP does not qualify as CR or EN under this criterion.

2015 REVISED EVALUATION

Conservation status:

Pseudocheirus occidentalis (Ngwayir or Western Ringtail Possum) is evaluated as Critically Endangered A2bce+A3bce+A4bce

Justification

The Ngwayir has an Area of Occupancy of <500 km^2, small severely fragmented subpopulations and is continuing to decline, being threatened particularly by a drying climate (which affects the nutritional quality of its food) and hence survival and recruitment), Red Fox *Vulpes vulpes* and feral Cat *Felis catus* predation, urban development, inappropriate fire regimes and, possibly in the future, myrtle rust. The subpopulation in the Upper Warren was the largest prior to 2002 but underwent a severe decline of >95% (probably >99%) between 1998 and 2008/09. Remaining fragmented subpopulations in coastal habitats are also declining, equating to a population decline of >80% in the past 10 years. With rainfall in the south-west of Western Australia predicted to decline further along with increasing temperatures, more extensive and intense fires, and continuing urban coastal development, there is a suspected continuing decline of >80% in the next 10 years.

THREATS

Current threats are:

1. The drying climate, affecting the nutritional quality of food and hence survival and recruitment. Rainfall has declined and continues to decline throughout the south west. The last two years have been the, or close to the, driest on record near Albany. Albany mean rainfall (1877 to 2014): 929 mm; 2014: 638 (no data from December, mean is 30 mm, if 30 mm added = 668 mm); 2015: 621 mm (lowest on record). Busselton mean (1877 to 2014): 813.6 mm; 2014: 591 mm; 2015: 568 mm. WRPs 'are among the species most likely to be impacted by predicted climate change in the south-west because they have very specific habitat and dietary requirements, have a poor ability to migrate and have lost large areas of habitat. In addition they are sensitive to drought-induced stress. Over the past 30 years there has been an approximate 20 per cent decline in rainfall in the south-west of WA, with more reductions in rainfall and increased temperatures predicted due to global climate change (Timbal 2004). These changes could result in further contraction of the species to the most fertile and mesic remnants of their extant range (Wayne 2005, Jones and Francesconi 2007)' (Recovery Plan p. 10). Almost all remaining occurrences are associated with older-growth Peppermint, but few stands now seem to provide suitable nutrition for the species to survive and recruit.

2. Increasing temperature. 'Western ringtail possums are known to be susceptible to heat stress and can easily overheat at temperatures of 35°C (Yin 2006). Western ringtail possums have been observed to use evaporative cooling in hot weather by applying saliva to the forelimbs or panting (Jones *et al.* 1994b). Jones *et al*. (1994b) observed that in areas where dreys were used, western ringtail possums went to the ground over several hot days. Western ringtail possums are the smallest of the specialist marsupial folivores indicating that they live close to the ecological and physiological limits of viability (B. Jones pers. comm. 2002)' (Recovery Plan pp. 6-7). As well, increasing temperatures exacerbate soil moisture reduction and further affect the nutritional quality of food.
3. Land clearing. Land clearing for urban development remains a threat in the Busselton – Augusta near coastal strip and near Albany. Land clearing continues despite application of the EPBC Act guidelines that aim to assist in determining whether a proposed action is likely to have a significant impact on the Western Ringtail Possum on the southern Swan Coastal Plain. Most remaining WRP habitat is on private land; thus the major land management is via planning controls, not via biodiversity legislation.
4. Feral predators. Translocation experiments in the past and other data demonstrate that foxes and cats are major threats, especially where the canopy becomes more open due to 'parkland clearing' and after fire. Native predators also impact the species.
5. Fire. Fire reduces food availability and opens up the canopy causing WRPs to spend more time on the ground where they can be predated by foxes and cats.
6. Tree decline and insect outbreaks. Coastal Peppermint decline, gum leaf skeletoniser and *Phytophthora* dieback in Jarrah, Tuart decline and other tree declines have resulted in extensive but mainly localised reductions in food and habitat quality.
7. Competition for tree hollows. Increased numbers of Brushtail Possums where fox baiting occurs leads to competition for hollows: brushtails are more aggressive and will evict ringtails. Hollow loss is also caused by logging and feral bees.
8. Logging. Western Ringtail Possums are more abundant in unlogged forest or where logging has been least intense; logging leads to local mortality including via increased feral Cat predation. However, current WRP distribution does not now significantly overlap areas to be logged to a significant degree.
9. Domestic dogs. 'In urban environments predation or injury by domestic dogs can be frequent (de Tores *et al*. 1998). High levels of dog ownership within the City of Busselton create dog densities at four to eight times greater per hectare than the average fox density in the south-west forests (K. Williams pers. comm. 2006)' (Recovery Plan, p.8). Ravens are a threat in urban areas where their numbers have increased.
10. A plausible future threat is myrtle rust, which significantly affects peppermint (*Agonis flexuosa*), in the east where it is planted horticulturally, noting that peppermint is now the main habitat and food tree for WRPs.

Note that some threats are synergistic.

CURRENT MANAGEMENT

Recovery Goals, Objectives, Criteria for success and failure, and recovery actions are described in the Recovery Plan, although that was based on a status of Vulnerable. I do not have information about the implementation or otherwise of the actions or whether the criteria for success or failure are likely to be met, but there is no recovery team and no coordinated monitoring. The Parks and Wildlife library has annual reports of a recovery team for the WRP, but the most recent is 2005. Some other highly endangered mammals have research projects underway and an active recovery team, the WRP does not.

MANAGEMENT AND RESEARCH REQUIREMENTS

These were listed in the MAP. The 2014 Recovery Plan includes >30 actions. In my view the most urgent ones are:

Monitoring. It is clear that, for an EN marsupial that is declining and is Critically Endangered, there is insufficient monitoring, especially noting the short-term crash that happened at the Upper Warren where the subpopulation went from >10 000 (probably many tens of thousands) to near zero in about 10 years, and average species' longevity of c. 3 years. Of particular concern is declining rainfall and increasing temperatures and resulting effects on survival and recruitment, not only in the Bunbury to Augusta area, but also near Albany where there has been a series of dry years and severe, lightning-caused fires in the conservation estate.

Research into effects of drying climate, nutritional status of food and how it relates to survival and recruitment. Work with Barbara Jones to use her data and develop further experiments on the effects of rainfall and artificial watering on recruitment.

Predation. Conduct experiments with Eradicat in key WRP habitat and measure prey response.

Captive breeding. If the WRP continues to decline at rates seen in the past, captive breeding may be needed at some future time. A pilot study to develop husbandry techniques is indicated.

CONCLUSION

The Ngwayir or Western Ringtail Possum *Pseudocheirus occidentalis* has declined substantially, particularly over the past 12 years, and continues to decline. It meets IUCN Red List Criterion A for Critically Endangered.

Given the lack of monitoring data on population trends, there is clearly an urgent need for systematic monitoring of this species. The Recovery Plan was published two years ago after revision of drafts going back several years, but there is no recovery team, nor any significant implementation.

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APPENDIX 1

Ngwayir (*Pseudocheirus occidentalis*) declines in the Upper Warren, the issue in brief

Adrian Wayne, Colin Ward, Chris Vellios, Marika Maxwell, Ian Wilson, Julia Wayne, Bruce Ward, Graeme Liddelow, Juanita Renwick, Peter Orell

January 2012

Summary

A collation of spotlight records across the Upper Warren indicates that the ngwayir has undergone a substantial and extensive decline. Beginning in 1998 in Warrup, ngwayir have been undetectable along three routine spotlight transects in the Greater Kingston area (Winnejup, Warrup and Kingston blocks) since 2002 (except one sighting in 2006). Ngwayir have not been detected across much of the remaining routine monitoring sites throughout the Perup since 2004-2007 (Balban, Yendicup, Moopinup, Yackelup, Camelar, Boyicup, Chariup forest blocks). The last record of a ngwayir detected from a routine spotlight transect in the Upper Warren was in 2009 in Keninup. Donnelly District spotlight surveys have not been conducted in the Upper Warren region since 2009.

Some key points and notes

- The ngwayir is Nationally listed as Vulnerable (*Environment Protection and Biodiversity Conservation Act 1999*) and as 'rare or likely to become extinct' (*Wildlife Conservation Act 1950*) in Western Australia.
- The Upper Warren region has supported the largest remaining inland ngwayir population and is of significant conservation value for the species
  - the Upper Warren population is genetically distinct and had higher genetic diversity than Bunbury and Busselton (K. Wilson 2009). It may also have had a greater effective population size than the swan coastal populations combined. An update on any findings and progress has been requested (P. Spencer is unavailable until after 13th Feb 2012).
- Other information is available to develop a more complete situation assessment;
  - other sources for an assessment across the Warren region include, public sighting records (Fauna file), Wayne et al. 2005, and Swinburn 2008
- A meeting to consider the issue and develop an appropriate response plan is highly recommended.
- Surveys are recommended to be conducted along the routine monitoring transects managed by Donnelly District (Boyicup, Chariup, Keninup, Moopinup) since they have not been done since 2009.
- Nine spotlight surveys conducted in the Perup Sanctuary (423 ha, established 2010) since October 2010 have not yet detected a ngwayir. Upto 1.7 ngwayir per km were detected during spotlight surveys in and around the subsequent location of the Perup Sanctuary in 2001-2004 (conducted by the DEC fauna management course). The habitat in the sanctuary remains suitable and is an opportunity to potentially establish a genetically representative insurance colony free from introduced predators.

Background

The best ngwayir monitoring dataset available from the Upper Warren region comes from routine spotlight surveys along three transects in Warrup, Winnejup and Kingston forest blocks (1996-2011, however 1996 data is not included here given the different methodology used). Conducted as part of the 'Kingston Study' (Wayne et al. 2001, 2005), the data indicates that ngwayir began declining in Warrup and southern Kingston forest blocks in 1998 and simultaneously on the other two transects in 1999. Ngwayir have remained undetectable within the greater Kingston area since 2002, except for one sighting in 2006 (Figure 1).

Annual or biannual spotlight surveys (2000 – 2010) in Yendicup and Yackelup forest blocks indicate that ngwayir began declining in these areas in 2002 and 2003 respectively (Bushranger program, B. Ward and G. Liddelow, unpublished data). No ngwayir have been detected on either of these transects since 2007 (Figure 2).

Spotlight surveys conducted by the Donnelly District along several transects (Boyicup, Chariup, Keninup, Moopinup) across the Upper Warren (2004-2009) indicate that ngwayir have been declining since surveys began. No ngwayir have been detected on these transects since 2006 except for Keninup, which detected seven individuals in 2007 and one individual in 2009 (J. Wayne and I. Wilson, unpublished data). The results for the surveys across different transects conducted by the Donnelly District have been combined given the limited nature of the data (Figure 3).

The DEC Fauna Management Course have conducted annual spotlight surveys (late October/Early November 2001-2011) along four transects per year. There has been some variation in the location of these transects over time. The transects have covered parts of central Perup (Balban, Yendicup, Moopinup, Yackelup and Camelar forest blocks). The length (generally around 10 km each) of the transects and number/experience of observers per transect have also varied between years. Nonetheless the data clearly indicates a decline in ngwayir detection rates, with no ngwayir having been detected since 2004 (Figure 4).

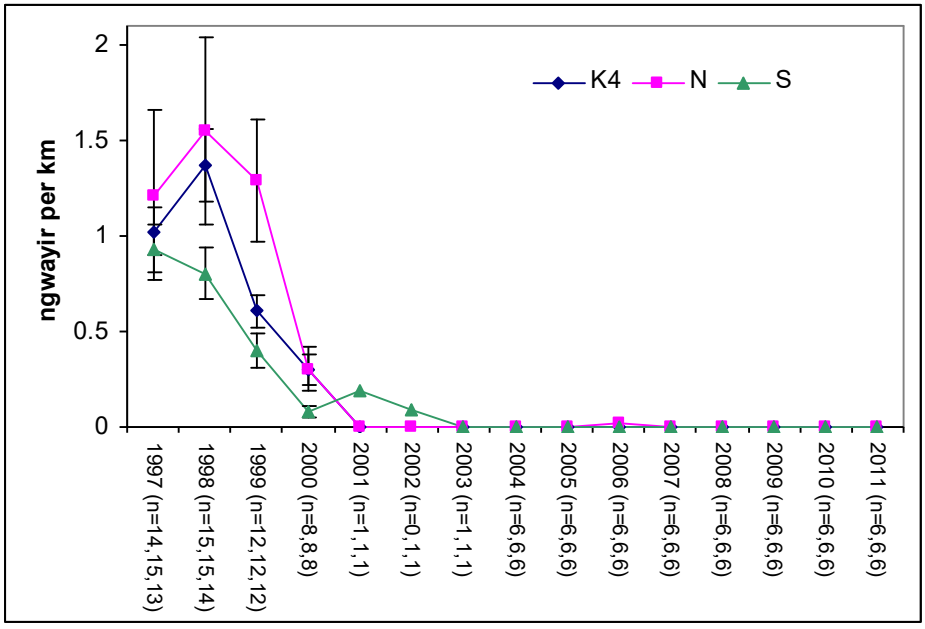

Figure 1. Annual average spotlight detection rate (individuals per km, +/-SE) of ngwayir (*P. occidentalis*) along three transects in the greater Kingston area – 'K4' = Kingston 4 forest coupe, Northern (N) = Winnejup & northern Kingston, Southern (S) = Warrup and southern Kingston (Source: Kingston study, Wayne et al. 2005 and unpublished). Note: n = total number of surveys conducted within a given year on each of the three transects: K4, N, S respectively.

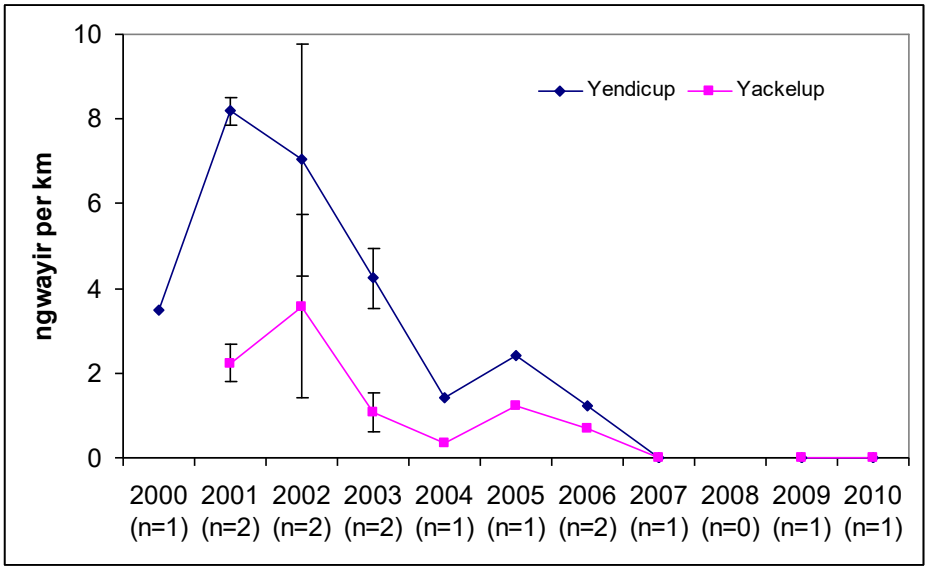

Figure 2. Annual average spotlight detection rate (individuals per km, +/- SE) of ngwayir (*P. occidentalis*) along two transects in central Perup (Source: Bushranger surveys, B. Ward and G. Liddelow). Note: n = number of repeat surveys along the same transect in any given year.

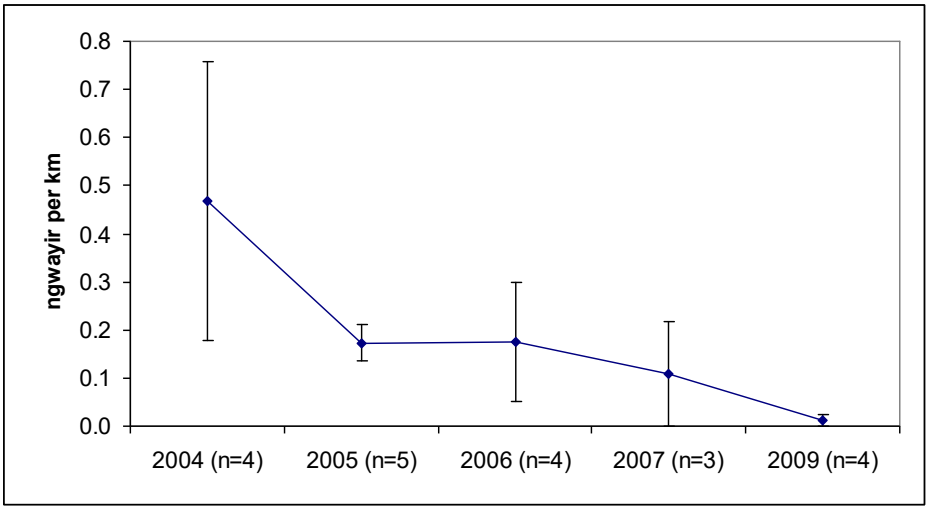

Figure 3. Average (+/- SE) detection rate of ngwayir (*P. occidentalis*) from Donnelly District spotlight records within the Upper Warren region (transects from Boyicup, Chariup, Keninup and Moopinup forest blocks combined) (Source: Donnelly District monitoring, I Wilson and J. Wayne). Note: n = number of transects surveyed in any given year. Each transect was generally surveyed twice (range 1-3) within a year.

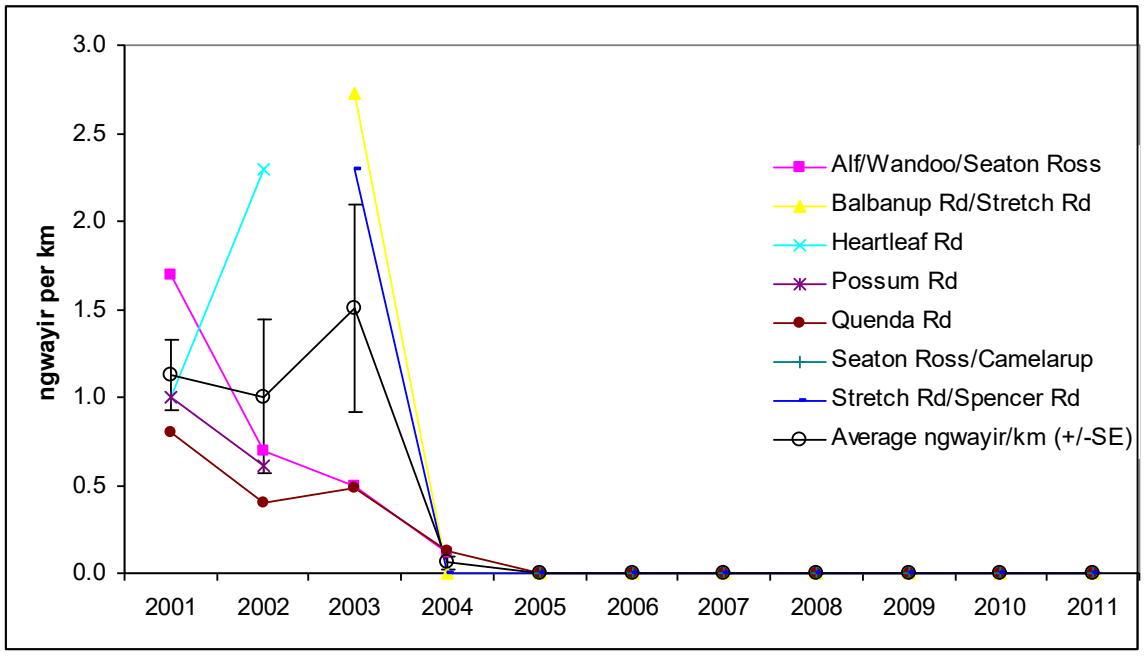

Figure 4. Detection rate of ngwayir (*P. occidentalis*) from annual spotlight surveys (n=4 transects per year) conducted by the Fauna Management Course in the Perup (Source: Species and Communities Unit, J. Renwick and P. Orell).

Attachment 2

While Southwestern Australia's rainfall was disappearing 2001-15, it was taking the possum *Pseudocheirus occidentalis* with it

Barbara Jones, February 2016, landline 0893302665

SUMMARY

For Southwestern Australia's ringtail possum, *Pseudocheirus occidentalis*, a 2015 re-examination of regional population estimates, along with ringtail and rainfall decline outcomes, indicated that:

- in 2000-2002, the two largest populations used the driest parts of the species' 1990s footprint and probably accounted for about 95% of the species' numbers;
- in 2000-2002, the species' largest occurrence (Upper Warren) probably accounted for about 80% of the species' numbers, and about 80% of the area of the species' 1990s footprint;

and then:

- between 2002 and 2010 the only large coastal population (Southern Swan) started showing patchy declines that became increasingly common and were strongly linked to patchy impacts on stand growth (re-foliation and de-foliation) of dry and very dry years, and the retreating water table, and this population went on to lose about 60-65% of its 2003 numbers by 2015;
- between 2004 and 2009 the species' largest reserved population (Perup, in the Upper Warren) was crashing, with probable retention of less than 1% of the 2000-2002 numbers persisting 2012-15;
- in combination, the recent declines of the two driest and largest populations seem to have left about 10% of the 2003 species numbers surviving in 2015;
- An entrenched 15-year climate trend suggests more critically-dry years can be expected, and it would be no surprise if numbers halved again in a few years.

Most of the surviving remnants of the species are heavily exposed to legal and compliant, but still negative, destructive, cumulative, and significant human impacts - from multiple sources of authority (diverse government entities and landowners). For the small and fragmented part of the 1990s population that survived to 2015, an upcoming period of 'acceptable' or 'necessary' habitat loss is locked in, and backed up by a State approved species recovery plan and a Commonwealth compliance document. Both official ringtail management documents are seriously outdated - their intent and content relates to the abundant, pre-decline populations of this possum - in their formerly well-watered habitat.

1. INTRODUCTION

These notes were prepared to help inform 2016 considerations of the changing conservation status of the Western Ringtail Possum, *Pseudocheirus occidentalis*, over the last decade or so. The content of these notes relies primarily on my long-term research on and interest in this possum. I first started studying field populations in 1990.

An earlier draft of these notes was provided to Andrew Burbidge in December 2015, who made helpful comments to improve them, and suggested that they could be attached as an Appendix to a Threatened Species Nomination Form that could, in 2016, trigger a formal Western Australian reconsideration of this species' listed status.

The focus of this set of notes was partially predetermined by the species account in *The Action Plan for Australian Mammals 2012*, which concluded that the species' recent decline was so substantial that *P. occidentalis* had very probably reached IUCN criteria for a Critically Endangered status ranking by 2012 (Woinarski *et al.* 2014). The work presented here uses more information and supports the conclusion in *The Action Plan for Australian Mammals 2012*.

Woinarski *et al.* 2014 provide a wealth of information about Australia's threatened mammals, more valuable because of the consistent approach used by the principals to access and accommodate diverse sources and then deliver their work. This resource made it possible for me to tabulate conservation rank trends for the most increasingly endangered 10% of Australia's marsupial diversity in 2012. The 2012 Action Plan reported 24 marsupials were considered to be Endangered or Critically Endangered in 2012, and Woinarski *et al.* determined retrospective rankings, using the 2012 information, for each taxon in 1992 and 2002. These 24 marsupials, and their overall conservation trends for 1992-2012, are listed in Table 1 (Tables are provided as separate .pdf files).

Fourteen of the 24 species (58%) listed in Table 1 remained at the same risk ranking in 1992, 2002 and 2012. Two marsupials (8%) improved enough for their risk ranking to be downgraded. At the other extreme, four marsupials showed the worst recent endangerment trends for Australian marsupials, with increases of 2-4 ranks. *Pseudocheirus occidentalis* was the only possum included in Australia's four worst marsupial conservation records 1992-2012.

2. ECOLOGY - FOOD

Ringtail possums in the genus *Pseudocheirus* have been some of Australia's most successful marsupials, highly adapted to living in the woodland and forest stands of southern and eastern Australia. In some areas, they have also been relatively successful at surviving in suitably vegetated parts of Australia's developing landscapes 1900-2000.

One important ecological feature distinguishes the Southwest's (SW's) ringtail possum from the rest of the SW's medium-sized marsupials. *Pseudocheirus occidentalis* is the SW's most arboreal marsupial, and its most specialized folivore.

In the field, resident populations of *P. occidentalis* raise new cohorts of young possums on the sequential canopy growth flushes that their stands produce. This means that resident populations in suitably good stands with reliable and vigorous canopy growth flushes can recruit young ringtails well.

For resident ringtails in southwestern Australia, the day-to-day feeding trend is to systematically and strategically browse a suitable component of younger leaves on their stands' canopy - because this daily staple offers the best nutritional outcomes. This foliar dietary strategy means that the ringtails' gut flora is an absolutely vital ecology that individuals and resident populations must depend on to survive and breed well. Strong recruitment outcomes on good canopy characterized resident populations that remained resilient 1990-2010.

As new leaves age into their second and third years, their level of difficult, indigestible, or toxic components tends to rise. So if an annual canopy growth flush is compromised or fails, resident ringtails must increase their regular

intake of problematic elements in older foliage until the next canopy growth flush appears. Too long on such a suboptimal diet could critically impair the gut flora long before organ symptoms appear in a sick possum's body. If increasing seasonal toxicity links to environmental conditions that are a bit too dry, otherwise tolerable but persistent dehydration may inhibit the cleansing of increased toxic loads from the possum's gut or body.

In summary, *P. occidentalis* cannot persist as resilient resident populations unless their currently occupied stands offer BOTH:

- regular canopy growth flushes that are good enough to support sound recruitment outcomes for sequential generations, and
- a seasonal backup food supply of suitable mature leaves that does not drift into serious seasonal toxicity between sequential canopy growth flushes.

3. SOUTHWESTERN AUSTRALIA'S DISAPPEARING RAINFALL 2001-15

The SW's rainfall decline trends 2001-15 had different impacts for the species' two largest 1990s populations (Table 2). This section examines the 2001-15 rainfall outcomes for each population by contrasting them with the rainfall outcomes for 1986-2000. Busselton's rainfall record is used for the Southern Swan habitat, and Deeside's record is used for the Perup habitat (Table 2). The 1961-90 average annual rainfall for Busselton was 797 mm, and for Deeside, 799 mm, and both are treated here as having a long-term rainfall average of 800 mm.

Formerly, populations of this species had lived in a 450-750mm rainfall zone, but most were gone from such drier habitat by the 1960s, and none survived the 1990s. The species' two largest 1990s populations persisted in the 1960-2000 habitat with yearly rainfall that usually exceeded 750 mm, and rarely exceeded 1000 mm. Where the SW's annual rainfall often exceeded 900 mm, small patchy populations persisted 1960-2010, but not one of these wetter regional habitats supported a large population after the 1930s-40s. More than 80% of the species 1990s range had annual rainfall totals that usually exceeded 900mm. With very rare exceptions (i.e. < 500 hectares), only low-density ringtail populations persisted in that part of the SW where the annual rainfall often exceeded 900mm.

The Deeside rainfall records showed that, during the period 2004-10, the area's stands had to cope with a steep and serious reduction in the amount of rainfall in the driest years: starting with 634 mm and 639 mm in 2001 and 2004, then down to 573 mm in 2006 and down further to only 359 mm in 2010 (Figure 3). This period of increasingly dry stand conditions finds its peak 2007-11, but its progression from 2004 on, and from 2006 on, coincides with the 2004-9 ringtail crash in the main reserved part of the Upper Warren habitat (details in Section 4).

In the Southern Swan habitat, the prevailing trend was for increasing rainfall deficits over 2001-15 (Figure 2). Very dry years occurred in 2001, 2006, and 2010 (Figure 1). Examples of patchy site declines (canopy + possums) were starting 2002-3, and were stacking up after 2004-6. 2005 was the only year of the decade 2001-10 to get over 800 mm, and this rainfall triggered the best canopy growth flush since 2000. And that canopy growth flush supported a strong breeding effort, with many females weaning a second youngster following the good year of rainfall in 2005. Then came Busselton's driest year, 2006, which ended up being some 46% drier than the average of 800 mm. By the end of summer in early 2007, the strong re-foliation of late 2005 was collapsing, and by autumn 2007 ringtails had started dropping out of the trees (dying or dead), and a following wave of tree death became evident over 2008-10. So another period of patchy site declines spanned 2007-11. During this period, evidence of a serious and suspicious disease problem was detected in the Busselton ringtails. Calcium based bladder-stones started being detected in the ongoing sequence of Busselton ringtails going into the local wildlife rehabilitation system 2008-10. These mineral stones move around in the bladder and can become fatal (Figure 5, see separate pdf). In peppermint, calcium levels are often high, and excess calcium is stockpiled in the older and oldest foliage. Particularly poor re-foliations 2006-11 seem likely to have forced hungry Southern Swan ringtails onto a more toxic diet of older foliage.

For the decade 2006-15, the Southern Swan's annual rainfall averaged just 615 mm, nearly 200 mm drier than the 1990s driest surviving populations. The area's shallower water-tables (close to a floodplain) seem to be still

supporting viable ringtail stands despite the unsuitably low rainfall of 2005-16. Still, as little as 20-30 cm of effective and carefully applied supplementary watering each year has potential to turn unsuitably dry and near toxic stands back into suitably watered stands with good re-foliation and defoliation patterns.

Both of the driest and largest 1990s populations were responding to the increasingly dry conditions 2001-3, but the very dry peak 2006-10 was associated with the most serious reduction in numbers (so far). After 2004, even the core reserved populations (Ludlow and Perup) shifted into their most serious decline phases.

4. THE DECLINE TIMELINE FOR THE PERUP HABITAT

The Perup habitat carried the main reserved part of the species' largest regional population in the least disturbed and largest natural habitat patch still used by this species in the 1990s. Three Perup area decline timelines were provided by Wayne *et al.* 2012 (their Figures 2-4) - they show serious ringtail decline trends active from 2003 to 2007, from 2004 to 2009, and after 2003.

The fourth timeline presented by Wayne *et al.* (2012) (their Figure 1) was anomalous. It showed that, for one small part of the Upper Warren, a local, monitored and eventually severe decline trend started to become evident in night counts after mid-1999 (Appendix 2 in Wayne *et al.* 2001 lists the dated night-counts). The three sampling lines (North, South and K4, used for the Figure 1 decline graph in Wayne *et al.* 2012 and in Woinarski *et al.* 2014) were subject to clustered forestry impacts and intensive disturbance in three subsequent seasons, in 1995, 1996 and 1997 (see both Figure 1 maps in Wayne *et al.* 2000 and Wayne *et al.* 2001). The monitored (North, South, and K4) decline, with its 1998-2003 timeline, rightly belongs to a localized decline in a small Upper Warren harvesting patch with plenty of forestry disturbance impacts accumulating over the first, second and third years (1995, 1996, and 1997, but perhaps also 1998 and 1999?). Given the 1995-7 habitat disturbance footprint (see the Figure 1 map in Wayne *et al.* 2001), the studies' nominated 'control' (line or area) in the 1997-2001 studies were too close to the overall 1995-7 forestry impact footprint to function as a reliably independent 1997 control habitat. In text, Wayne *et al.* 2012 described their Figure 1 decline graph for the period 1998-2003 as "the best ngwayir monitoring dataset available for the Upper Warren region…". Most other ringtail authors 2012-15 (e.g. Woinarski *et al.* 2014, Shedley and Williams 2014, and the 2014 version of the Species Recovery Plan) have followed the 2012 lead of Wayne *et al.*, and re-used the 1998-2003 decline graph for the forestry disturbed Kingston-Warrup habitat, implying that this single site timeline meant that the recent and serious Upper Warren ringtail decline could be thought of as being mostly finished by 2003, or starting at least six years before 2004.

Just before the Perup's serious decline phase, Adrian Wayne's field studies collected ringtail survey, habitat and capture results between late 2001 and late 2003. These field results were first reported as a PhD thesis dated May 2005. Over late 2001 and early 2002 field results were collected for a well-designed relative abundance and habitat variable survey. The analysis found all the expected associations or correlates (e.g. stand attributes such as lower fire and logging over recent decades, hollow abundance, canopy cover; scat scores and night-counts). Had there been serious or notable ringtail decline in the Perup study area before 2003, the survey analysis using 2001-2 field data would have failed: scat abundance and night counts would not have matched up properly (they did), and habitat associations would have been indiscernible or weak.

During 2002-3 Adrian Wayne and his team were catching ringtails in the Perup habitat. Using hand captures and elevated trapping, he recorded a total of 146 captures of 81 individuals, 34 of which were recaptured an average of three times, with 47 ringtails caught only once. For this species, this is a strong sample size. These mixed-source capture results were consistent with at least 16-17 catchable ringtails (mature+subadult, female+male) in the first sampling season (winter 2002), and, in the last sampling month (November 2003), at least 12 catchable ringtails (mature+subadult, female+male) (see Adrian's thesis Table 5.1). Taking a closer look at the detail in Table 5.1 revealed that at least 8-9 females (mature+subadult) remained catchable throughout most of the field study, even in the last sampling month (November 2003). Even if this is a sampling artifact (with a hand and trap capture approach, 8-9 females might've been enough), this number of catchable females was still maintained until sometime after the end of the fieldwork in November 2003. These minimum 'at least' indicators suggest that female activity levels were mostly retained, and any active study site decline was probably male dominated. With hindsight, the 2002-3 captured ringtails seem to show discernible precursors to worsening stand conditions 2001-3. As expected, body condition was seasonally lowest in winter, when detected predation events peaked. But

body condition also seemed to be notably more negative in winter 2003 than it had been in winter 2002 (see Adrian's thesis Figure 5.3). And, overall, body condition was negative for seven of the 12 sampling months (between June 2002 and August 2003), which is for this species, too long. Good body condition is required for good recruitment outcomes.

The Perup habitat and study area had no forestry disturbance or impacts over recent decades. There is apparently no convincing field evidence consistent with serious Perup decline 1998-2003. So there is also no convincing field evidence of serious or broad-scale decline of the Upper Warren ringtails 1998-2003. But real decline does start appearing for both of the species' core forest populations (Ludlow and Perup) from 2004 on, increasing from 2006 on.

5. PROBABLE RINGTAIL NUMBERS

This section describes my 2015 estimates relating to the sizes of the different regional occurrences, and hence the species, back in the 1990s, before broad-scale decline started seriously eroding species size. For this exercise, I'm using five regional occurrences: Southern Swan, Cape to Cape, Upper Warren, Other Forest Rivers, and Around Albany – and my 25 year interest in learning about how field populations worked to survive, prosper or fail. A sixth regional occurrence should have been still extant in the extensively wooded and well-watered south-coastal habitat strip between the eastern end of the Lower Blackwood ringtails, the southern end of the Other Forest Rivers ringtails, and the western end of the Albany ringtails. But over decades, the species has apparently remained surprisingly rare and virtually absent over an extensive area of largely un-cleared south-coastal country.

Four of the six regional occurrences were extant in regional habitat archipelagos in broad-scale landscapes with lots of cleared, logged, thinned, stocked or over-burned habitat components. Three were small occurrences. The Cape to Cape, Other Forest Rivers, and Around Albany ringtails all persisted as mostly low or very low density populations using patchy remnant habitat in an area where the annual rainfall frequently exceeded 900 mm. The Cape to Cape and Around Albany remnants were, and are, prone to windy wildfire, but the species' two largest and driest occurrences, the Upper Warren and Southern Swan, were not. The Cape to Cape and Other Forest Rivers shared similar histories of prescribed firing over the last 3-4 decades. The mostly empty and un-cleared southern region is prone to big, fast and hot windy wildfires.

One coastal occurrence, the Southern Swan, was at least five, and maybe up to ten times larger than the smaller ones. It also had hotspot habitat patches where ringtail densities were much higher than in the other regional occurrences of the species. The densest part of this population used a unique habitat asset: the coastal peppermint stands that fringed the southern margin of Geographe Bay, principally between the ocean and floodplain. Compared to the rest of the species' occupied footprint, this distinctive ringtail asset had low 1970-2010 exposure to regular or running fire, and a low rate of lightning ignitions.

Unlike the four occurrences that persisted in habitat archipelagos within their regional landscapes, the Upper Warren ringtails had access to extensive inland forest with about 800-950mm. Much of this retained canopy had a history of only light, patchy forestry disturbance or patch clearing impacts, and a history of good retention of local marsupial diversity 1960-2000. In my early 1990s work, locals (Grant Wardell-Johnson and Graeme Liddelow) sent me to their best ringtail spots (where Gary Inions, and later Adrian Wayne, worked on possums), and I found ringtails were not uncommon in the Perup, Mordalup, and Tone River habitat of the early 1990s. This occurrence was important because ringtails were definitely not common in the wetter bulk of the jarrah forest – where they were generally absent or very rare (Other Forest Rivers). But unlike the other four regional occurrences, the natural canopy of the southern inland jarrah array just kept on going. At that time, even the locals did not seem to know how far beyond the main Perup area this population might extend, and probing for its limits was beyond the scope and resources of my early ringtail work or any subsequent field research project.

At the end of my early 1990s work on the species, I could say with confidence that the two largest occurrences were much larger than the other three. But I remained uncertain about just how large the largest population was, or how small each of the three smaller populations, might turn out to be.

Then, the Kingston forestry impacts started being studied for the arboreal mammals 1995-7, and this work found that ringtails were common in the pre-logging Kingston - Warrup habitat (i.e. common enough to be caught and collared, Wayne *et al.* 2000, and common enough to be crushed when their hollow trees were dropped, Rhind 2004). Then, over 2001-3, Adrian Wayne did his PhD fieldwork in the Perup habitat (Wayne 2005).

For this 2015 exercise, I have come to the conclusion that the two Upper Warren populations where ringtails were common in the 1990s implied a very large and extensive population in an area with lots of retained canopy, including plenty of older-growth stands, that were mostly undisturbed for decades, and that had rainfall mostly about 800-950 mm. This very large habitat patch had its longest east-west axis through stands that were near-continuous for about 20 km, and its longest north-south axis spanned about 40 km of habitat. The two studied Upper Warren populations where ringtails remained common in the 1990s were towards the NW and SE margins of this patch. This large regional habitat patch had a canopy footprint that was at least five times larger than the collective habitat footprint of the occupied remnant stands in the more cleared habitat archipelago country. I now conclude that about 85% of the hectares (of canopy) used by this species in the 1990s were, very probably, in the Upper Warren.

The Southern Swan ringtails were heavily surveyed 2002-12, mostly by dozens of site surveys for potential or approved development impact sites during the busy development decade 2002-12. Two larger and non-commercial survey studies were also undertaken (one published, Jones *et al.* 2007). Two independent ringtail consultants worked through that busy decade, between them doing 70-80% of the decade's total Southern Swan survey effort, and one bigger survey study each. By 2012, these two surveyors had, between them, some 10 000 sightings and three decades of ringtail specific site work.

During my early commercial ringtail work, I had access to Southern Swan sites where I could count ringtail numbers in a pre-approval phase, as well as just before clearing, and again when the machines and crews were onsite for the progressive clearing work. This meant that when occupied and surveyed habitat patches were cleared, I had, for each appropriate site, sound and independent during-clearing tallies to compare with my own pre-clearing night counts. Since then, the Southern Swan's main ringtail surveyor 2006-15 and main site-clearing ringtail manager 2006-15 have had multiple site opportunities to check (his) pre-clearing counts against (her) during-clearing counts. Few academic or scientific survey approaches have such a luxurious opportunity to see repeated site calibration checks, as a free by-product, via different habitat removal events at sites with low, medium and high-density habitat. My main decade of Southern Swan site survey work (2002-12) gave me the tested field tools to estimate probable numbers by daytime inspections of scat and discernible habitat values, and then check these against sound night counts, and then, for a subset of fully cleared sites, check both estimates and counts against an independent during-clearing tally. Water Corporation jobs in the Harvey Valley and around Binningup supported the more intensive field study needed to understand two informative field examples of very low-density local occurrences.

This period of onsite ringtail habitat work, 2002-12, gave me increasing confidence to start estimating ringtail numbers at the lower and higher ends of space, time, or habitat quality gradients (i.e. habitat+density variation, and decline or increase). And, as the severity of the species decline kept developing during the second half of this work period, 2006-12, there was increasing pressure for informed calls on the probable sizes of different local or regional occurrences. I am now taking this opportunity to propose my best 2015 call on probable or suspected 1990s numbers in five regional occurrences of the species' 1990s range.

The three smaller occurrences, Cape to Cape, Other Forest Rivers, and Around Albany were likely to have persisted with as few as 200-400 breeding females 1990-2010, and habitat constraints make it very unlikely that any of these small regional occurrences would have exceeded 1000 adults in any part of the decades 1970-2000. For this 2015 exercise I've nominated the Cape to Cape ringtails as the largest, because it retained (1990-2010) three dispersed main resident populations (including Yallingup), each of which was likely to have persisted in the range of 200 ± 100 adults over 1980-2010. The two smaller regional populations, Other Forest Rivers, and Around Albany, showed no such aggregations 1990-2010.

For the Southern Swan, the 1990s Ludlow possum studies (Jones *et al.* 1994, Jones and Hillcox, 1995, How and Hillcox 2000, and Jones unpublished) yielded sampled population parameters that, collectively used, allowed for

an informed estimate of up to about 1500 mature ringtails in the 1990s Ludlow+Sabina habitat. The Busselton 1990s ringtail habitat carried the species' largest and densest local occurrence, probably up to around 3000 adults (mostly Wonnerup to Siesta Park). In the rest of the Swan Coastal Plain habitat used by the species 1990-2010 I'd have expected a total 1990s count of about 1500. Using these estimates suggests a 1990s total of about 6000 ringtails on the Swan Coastal Plain.

Using the above, I can now a list a set of reasonable and internally consistent pre-decline estimates for the four smaller regional occurrences using fragmented habitat archipelagos in the 1990s:

Southern Swan	6000
Cape to Cape	800
Other Forest Rivers	600
Around Albany	700

This listing implies a probable 1990s total of about 8000 adult ringtails for these four regional occurrences.

Given that the Upper Warren canopy patch was at least five times larger than the 1990s habitat footprint that was used by 8000 ringtails, it seems reasonable to propose an extensive 1990s Upper Warren habitat patch with about 32 000 ringtails, and a 1990s species population of about 40 000.

Adrian Wayne was kind enough to chat with me (in about 2004) about his THEN best estimate of the probable, averaged, (pre-decline) ringtail density across his two Upper Warren study sites. THEN, he suggested there was probably about one ringtail per hectare in his study areas, and proposed that this average may have fitted an area of some 50 000 hectares of Upper Warren ringtail habitat.

For this 2015 exercise, I am now comfortable with a probable 1990s size for the Upper Warren population of 30-35 thousand, with about 8000 left in the regional habitat archipelagos used by the rest of the species, the largest of these having about 6000 on the Swan Coastal Plain. But I readily acknowledge that the 1990s Upper Warren population could have been much larger than my proposed 32 000, and perhaps as large as 50 000.

Clarification Note

In Jones (2004), my 1990-2002 ringtail assessment concluded that the species' largest population was associated with the Ludlow – Busselton habitat on the southern Swan Coastal Plain (page 154 in Jones 2004). This was, and still is, the species' largest local resident population.

But then, subsequent work, mostly by government authors, defined and redefined THE Southern Swan as a regional occurrence, eventually even including part of the Cape-to-Cape occurrence. It seems that some later readers decided that my 2004 comment on the large size of the Ludlow – Busselton population could be simply re-applied to whatever definition of THE Southern Swan Population they were working with, and then easily conclude that the species' largest regional occurrence was associated with their version of THE Southern Swan Population. As author, I apologise for an unfixed ambiguity. But, around 2002-3, I could not have foreseen how much subsequent workers could complicate things 2005-14.

6. QUANTIFIED DECLINE TRENDS FOR *PSEUDOCHEIRUS OCCIDENTALIS*

A modern consideration of a species' changing field status seems to need verified or suspected estimates related to an observed decline trend. When population numbers were changing as much as they were for *P. occidentalis* 2003-12, even verified population counts would swiftly transform into dated estimates of suspected or probable field numbers.

Pseudocheirus occidentalis is known to have a very long-term trend of contraction, and a range of perpetual habitat impacts have been driving a background decline trend since the 1920s and 1930s (Jones *et al.* 1994, Jones 2004). Since the 1970s, the accumulation of localised site declines dominated each decade's version of this background decline trend. But for *P. occidentalis*, the serious and broad-scale species decline that's dominated

the last decade or so is something entirely different. It occurred on a much larger scale, and a much swifter timeline, and it severely impacted broad-scale habitat and important populations in conservation estate.

The exercise described in Table 3 uses the suspected pre-decline ringtail numbers that were presented in the previous section for five extant regional occurrences (Southern Swan, Cape to Cape, Upper Warren, Other Forest Rivers, and Around Albany), along with my understanding of observed field trends, coupled with the timeline-reliable details of the changing rainfall patterns (canopy growth conditions) as they related to the species' two driest and largest regional occurrences, to quantify probable decline rates, in order to estimate overall species decline in sequential periods.

Table 3 suggests some 90% of the population would have been lost in about 12 years (after 2003, and by 2015). Over 2003-6, about half of the species numbers would have been lost, and for the fastest bulk of the decline, 2003-9, about 80% of species numbers would have been lost. This period, 2003-9, was a peak development period for the Southern Swan ringtail habitat, associated with the State's high cash-flow and a surging human population on the Swan Coastal Plain.

Based on the probable field trends (Table 3), the species' field population would have first exceeded Endangered criteria in 2006, and first exceeded Critically Endangered criteria in 2009. The species conservation status has been listed in three jurisdictions (international, national, Western Australian) and all agreed it was, 2008-13, a Vulnerable species. In 2015, the national and international status listings remained at Vulnerable. Western Australia did not reconsider the species' Vulnerable listing until eight years after the field populations would have matched the relevant criteria for Endangered. Overall, for the critically dry decade 2006-16, *P. occidentalis* was kept seriously under-listed by the relevant authorities in all three jurisdictions.

7. REFERENCES

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So how bad has it been for Southwestern Australia's ringtail possum ?

Barbara Jones, February 2016

TABLE 1.

Retrospective status trends for the two decades 1992-2012, from Woinarski et al 2014 (AP2012), for the 24 marsupials found to be Endangered or Critically Endangered in 2012 by Woinarski et al . These 24 taxa approximate the most endangered 10% of Australia's marsupial diversity.

Codes quantified herein as:	*Code*	*Score*	*Category*
	LC	1	Least concern
	NT	2	Near Threatened
	VU	3	Vulnerable
	EN	4	Endangered
	CR	5	Critically Endangered
	EXW	6	Extinct in the Wild

	Retrospective status in				Recent status			
AP pg #	1992 code	1992 score	2002 code	2002 score	2012 code	2012 score	maximum score change	species or subspecies
93	LC	1	LC	1	EN	4	**3**	***Dasyurus viverrinus***
76	NT	2	EN	4	EN	4	**2**	***Dasyurus hallucatus***
106	VU	3	EN	4	EN	4	1	*Sarcophilus harrisii*
165	VU	3	EN	4	EN	4	1	*Myrmecobius fasciatus*
406	VU	3	EN	4	EN	4	1	*Petrogale lateralis lateralis*
91	EN	4	EN	4	EN	4	0	*Dasyurus maculatus gracilis* Nth Qld
97	EN	4	EN	4	EN	4	0	*Parantechinus apicalis*
135	EN	4	EN	4	EN	4	0	*Phascogale tapoatafa* Kimberley
150	EN	4	EN	4	EN	4	0	*Sminthopsis griseoventer aitkeni*
243	EN	4	EN	4	EN	4	0	*Petaurus australis* wet tropics
246	EN	4	EN	4	EN	4	0	*Petaurus gracilis*
313	EN	4	EN	4	EN	4	0	*Bettongia tropica*
389	EN	4	EN	4	EN	4	0	*Petrogale coenensis*
418	EN	4	EN	4	EN	4	0	*Petrogale lateralis* W Kimberley
426	EN	4	EN	4	EN	4	0	*Petrogale persephone*
197	CR	5	CR	5	EN	4	-1	*Peramles gunnii* Victoria
358	CR	5	EXW	6	EN	4	-2	*Lagorchestes hirsutus* inland
304	LC	1	VU	3	CR	5	**4**	***Bettongia pencillata ogilbyi***
271	NT	2	VU	3	CR	5	**3**	***Pseudocheirus occidentalis***
233	EN	4	EN	4	CR	5	1	*Gymnobelideus leadbeateri*
214	CR	5	CR	5	CR	5	0	*Lasiorhinus krefftii*
225	CR	5	CR	5	CR	5	0	*Burramys parvus*
318	CR	5	CR	5	CR	5	0	*Potorous gilberti*
394	CR	5	CR	5	CR	5	0	*Petrogale concinna conncina* Vic. River District

SUMMARY	% of 24	Overall, between 1992 and 2012
One went up by four ranks.	4.2	4.2 % went backwards by ≥ 4 ranks
Two went up by three ranks.	8.3	12.5 % went backwards by ≥ 3 ranks
One went up by two ranks.	4.2	16.7 % went backwards by ≥ 2 ranks
Four went up by one rank.	16.7	33% went backwards by ≥ 1 rank
Two showed improvement (-1 or -2).	8.3	8% improved
Fourteen were neutral (0).	58.3	58% didn't change rank

The four endangered Australian marsupials with the worst 1992-2012 status trends showed an endangerment increase of ≥ 2 ranks, and this group approximates the most increasingly endangered 2% of Australia's marsupial diversity in 2001-2010.

So, for Southwestern Australia's ringtail possum, it seems to have been pretty much as grim as it got.

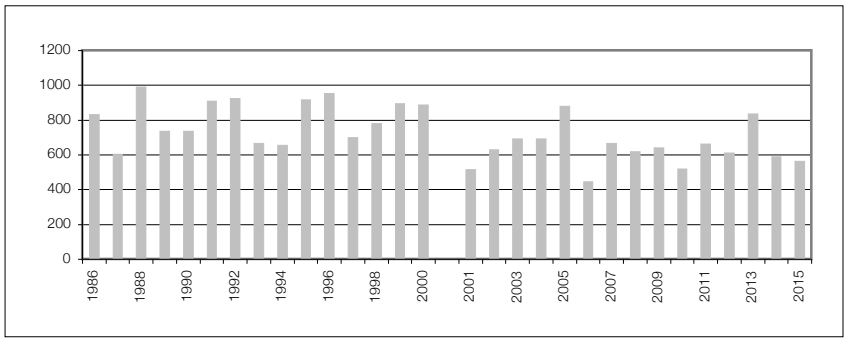
TABLE 2. THE SOUTHWEST'S DECLINING RAINFALL

Barbara Jones, February 2016

This exercise tabulates and compares 2001-15 rainfall outcomes with those of 1986-2000 for the two driest and largest 1990s populations of the endangered possum *Pseudocheirus occidentalis*

TABLE 2A. BUSSELTON rainfall for the SOUTHERN SWAN ringtail habitat

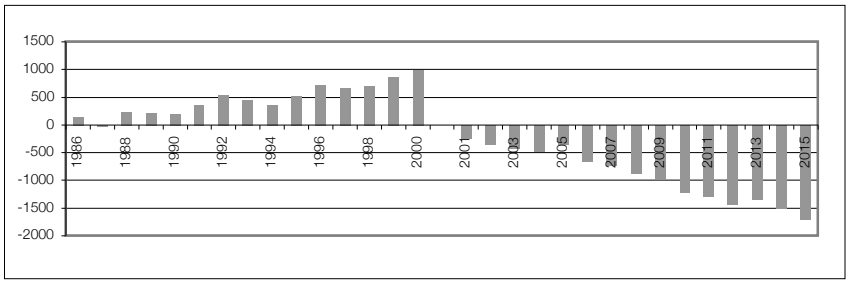
Figure 1. Histogram of Busselton's annual rainfall in mm.



1986-2000 average - 812mm 2001-2015 average - 638mm

2001-4 av. of 634mm , 2006-10 av. of 578mm

Figure 2. Shows cumulative surpluses /deficits for Busselton 1986-2000 and 2001-15 after the removal of a yearly stand growth allowance of 750mm (so 0=750mm).



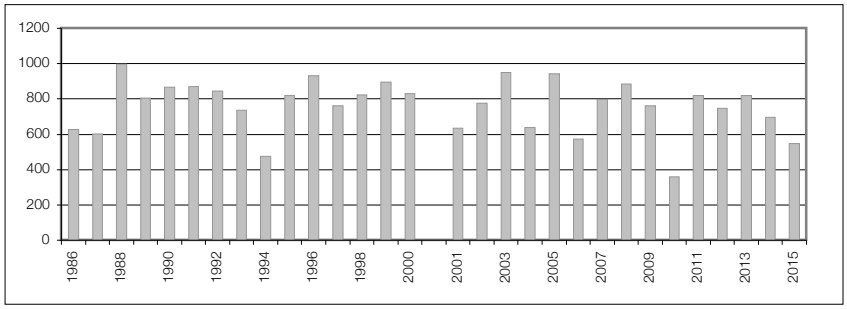
deficit persists from 2001

BOM Stn No	YEAR	TOTAL mm	TOTAL mm minus 750	Cumulative SURPLUS / **DEFICIT**
9515	1986	833	83	133
9515	1987	603	-147	-14
9515	1988	992	242	228
9515	1989	735	-15	213
9515	1990	736	-14	199
9515	1991	908	158	357
9515	1992	923	173	530
9515	1993	667	-83	447
9515	1994	654	-96	351
9515	1995	918	168	519
9515	1996	954	204	723
9515	1997	699	-51	672
9515	1998	782	32	704
9603	1999	895	145	849
9603	2000	888	138	987
9603	**2001**	**517**	-233	**-233**
9603	2002	631	-119	**-352**
9603	2003	693	-57	**-409**
9603	2004	693	-57	**-466**
9603	2005	878	128	**-338**
9877	**2006**	**445**	-305	**-643**
9877	2007	667	-83	**-726**
9877	2008	618	-132	**-858**
9877	2009	640	-110	**-968**
9515	**2010**	**518**	-232	**-1200**
9515	2011	663	-87	**-1287**
9515	2012	610	-140	**-1427**
9515	2013	836	86	**-1341**
9515	**2014**	**590**	-160	**-1501**
9515	**2015**	**565**	-185	**-1686**

Bold years < 600mm

TABLE 2B. DEESIDE rainfall for the Perup and Upper Warren ringtail habitat

Figure 3. Histogram of Deeside's annual rainfall in mm.

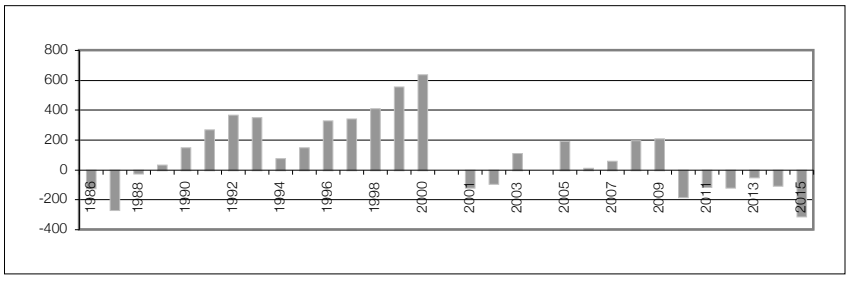


1986-2000 average - 793mm 2001-2015 average - 730mm

BUT NOTE the stand minimum trend 1986-2000

vs the decline trend for very dry years 2001, 2004, 2006, 2010

Figure 4. Shows cumulative surpluses /deficits for Deeside 1986-2000 and 2001-15 after the removal of a yearly stand growth allowance of 750mm (so 0=750mm).



deficit persists from 2010

BOM Stn No	YEAR	TOTAL mm	TOTAL mm minus 750	Cumulative SURPLUS / **DEFICIT**
9530	1986	628	-122	-122
9530	1987	603	-147	-269
9530	1988	997	247	-22
9530	1989	805	55	33
9530	1990	866	116	149
9530	1991	871	121	270
9530	1992	846	96	366
9530	1993	735	-15	351
9924	1994	475	-275	76
9530	1995	821	71	147
9530	1996	931	181	328
9530	1997	762	12	340
9530	1998	822	72	412
9530	1999	895	145	557
9530	2000	831	81	638
9530	**2001**	**634**	-116	-116
9530	2002	775	25	-91
9530	2003	950	200	109
9530	**2004**	**639**	-111	-2
9530	2005	942	192	190
9530	**2006**	**573**	-177	13
9530	2007	796	46	59
9530	2008	886	136	195
9530	2009	763	13	208
9924	**2010**	**359**	-391	**-183**
9530	2011	819	69	**-114**
9530	2012	746	-4	**-118**
9530	2013	818	68	**-50**
9530	2014	695	-55	**-105**
9530	2015	547	-203	**-308**

Dry years were increasingly dry

Barbara Jones, February 2016

TABLE 3. Suspected and probable decline rates for *Pseudocheirus occidentalis* as the SW rainfall was disppearing 2001-15 (Table 2)

IF the Upper Warren had started at 32 thousand adults

	in 2003	in 2006	in 2009	in 2012	in 2015	*And, overall*
Southern Swan	6000	5000	4000	3000	2000	
Cape to Cape	800	800	700	600	500	
Upper Warren	32000	11000	1100	200	100	
Other Forest Rivers	600	550	500	400	300	
Around Albany	700	650	600	550	500	
Species #	40100	18000	6900	4750	3400	
Percent retained	100%	45%	17%	**12%**	9%	*91% gone 2003-15*
Percent retained		100%	38%	**26%**	19%	*81% gone 2006-15*

AND, for a general case example -

IF the species size had halved in each three year period, and started at 40000

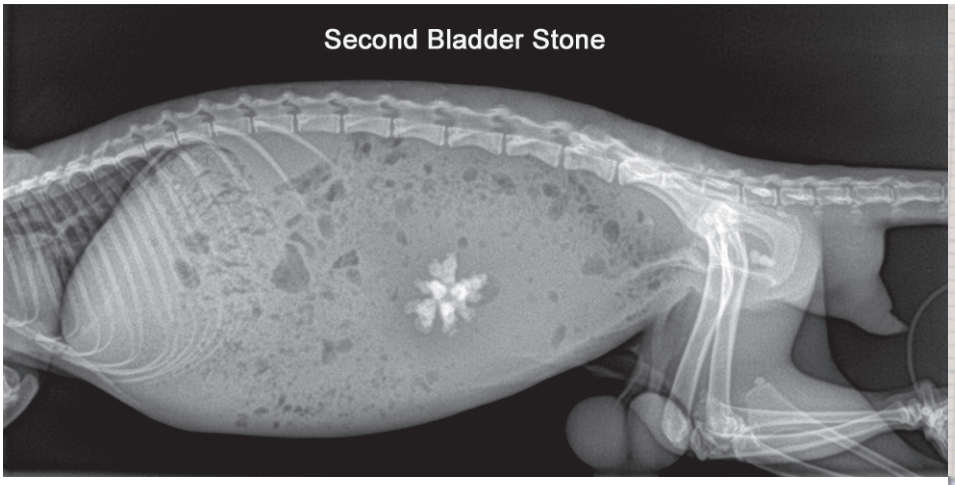
	in 2003	in 2006	in 2009	in 2012	in 2015	
Number retained	40000	20000	10000	5000	2500	
Percent retained	100%	50%	25%	**13%**	6%	*93% gone 2003-15*
Percent retained		100%	50%	**25%**	13%	*87% gone 2006-15*

BY 2012
both % retained examples match

Status trends for 2003-15

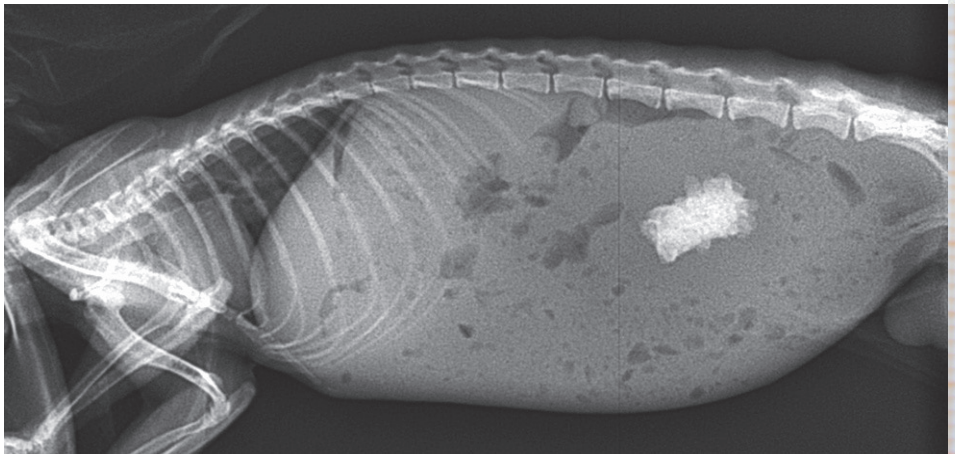
	in 2003	*in 2006*	*in 2009*	*in 2012*	*in 2015*	Codes & Categories
Probable Field Status	*VU*	*EN*	*CR*	*CR*	*CR*	VU: Vulnerable
Listed Status in WA	*VU*	*VU*	*VU*	*VU*	*EN*	EN: Endangered
Commonwealth Status	*VU*	*VU*	*VU*	*VU*	*VU*	CR: Critically Endangered

Bladder Stones in Pseudocheirus occidentalis



Wild young adult
Diagnosed one month after coming into care (severely dehydrated)
Composition of calculi: Calcium oxalate
New stone had formed six month after surgery
Stone dimensions:
1. 18.5 x 16.3 mm; 1.2 gms
2. 26.3 x 22.0 mm; 3.9 gms

Died in care - second stone retrieved.



Wild young adult
Diagnosed one week after coming into care
Composition of calculus: Calcium carbonate, Calcium phosphate and uric acid
Stone dimensions: 27.6 x 19.8 mm; 4.4 gms

Died the day after surgery

Figure 5. Two examples of the type of bladder stones that have been found in young adults from the Busselton habitat over the period 2008-15. Thanks to Uta and Helmut Wicke, and the Busselton Possum Centre.