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Notice of and reasons for the Final Determination

The NSW Threatened Species Scientific Committee, established under the *Biodiversity Conservation Act 2016* (the Act), has made a Final Determination to list the Maroubra Woodland Snail *Meridolum maryae* (Clark, 2009) as an ENDANGERED SPECIES in Part 2 of Schedule 1 of the Act. Listing of Endangered species is provided for by Part 4 of the Act.

Summary of Conservation Assessment

Meridolum maryae is eligible for listing as Endangered, as the highest threat category met by the taxon across all categories, under Clause 4.3 (b) (d) (e ii, iii, iv) because: i) the distribution of the species is highly restricted with an area of occupancy of 88 km^2 and an extent of occurrence of 254 km^2; ii) the habitat of the species is severely fragmented; iii) there is continuing decline in the quality of habitat, geographic distribution and number of populations due to loss and modification of native habitat, weeds and inappropriate fire regimes.

The NSW Threatened Species Scientific Committee has found that:

1. *Meridolum maryae* (Clark, 2009) (family Camaenidae) (Maroubra Woodland Snail), was described by Clark (2009) as "*Shell:* Subglobose, 10.3–16.3 mm in height, 14.8–19.2 mm in width. Spire moderately elevated. Aperture roundly ovate, height 7.2–10.9 mm, width 9.0–12.0 mm. Total number of whorls 4.7–5.5. Last teleoconch whorl rounded, or with slight angulation; height 9.1–13.3 mm. Teleoconch sculpture of fine to well developed growth lines (giving the shell a rough textured surface in older individuals), with weak to well developed pustules. Teleoconch periostracal sculpture of weak zigzag ridges with minor sculpture between major ridges. Protoconch sculpture strongly pustulose. Shell pale yellow to tan, to bleached white in older specimens, with small red umbilical patch and narrow red subsutural band. Inner lip pale pink to pale mauve, strongly reflected and partially obstructing the umbilical depression. Outer lip slightly to moderately deflected below midline of last whorl. Umbilicus partially open. *Non-genital Anatomy:* Animal colour greyish orange, mantle reddish orange. Kidney approximately 50–59% of length of mantle roof. *Genitalia*: Spermatheca head thin and bulbous, located at base of albumen gland. Penis long, longer than vagina, with one or two twists and bends. Epiphallus long, enters proximal apex of penis through short verge, epiphallic pore subterminal. Epiphallic flagellum of medium length and slender. Penial retractor muscle inserts on epiphallus about one quarter of its length from penis. Internal sculpture of upper half to two thirds of penial chamber of transverse wrinkled filaments with raised longitudinal central pilaster; lower portion of longitudinal folds of varying thickness. Vagina long, with one or two twists and bends. Albumen gland large."

2. *Meridolum maryae* are found in the leaf litter of coastal vegetation communities, most commonly in heathland on foredunes (*e.g*. *Acacia sophorae* Coastal Foredune Wattle Scrub) (Clark 2009). A large number of specimens have also been collected from areas of podsolised dunes/sand plains (Narla Environment 2016) that support taller heath communities including the Critically Endangered Ecological Community Eastern Suburbs Banksia Scrub (NSW TSSC 2018). The species has also occasionally been recorded in sandstone and clay heathland communities on headlands (Clark 2009; ALA 2019).

3. Members of the *Meridolum* genus are typically active at night but can also move about on overcast or rainy days (Clark 2009). The diet of *M. maryae* is unknown, however it is expected to be like that of closely related camaenids, including *M. corneovirens,* which is known to show preference for feeding on fungal fruiting bodies but may also feed on dead invertebrates, lichen and to a lesser extent, foliage or leaf litter (Ridgeway *et al.* 2014). No information is available on the dispersal, territoriality or home range of *M. maryae,* but the ability for individuals to disperse is expected to be similar to closely related camaenids (*Meridolum corneovirens* and *Pommerhelix duralensis*). These related species have been

recorded moving a maximum of 3.5 m in a day (Ridgeway *et al.* 2014) and are estimated to move a maximum of 350 m in a lifetime (*Meridolum corneovirens*; Clark and Richardson 2002).

4. There have been no studies of the breeding biology of *Meridolum maryae*. McLauchlan (1951) described mating for another unspecified species of *Meridolum* as occurring between spring and late autumn, during the night or early morning after rain. This species laid a relatively small number of eggs (up to 32) in each season which were buried deeply under stones or coarse woody debris, with incubation lasting for 61 days (gestation of 92 days) (McLaughlan 1951). The mortality of offspring was 90% in the first year and overall mortality was 99.8% within 4-5 years (McLauchlan 1951). No information is available on age to maturity or longevity of *M. maryae*. The related species *M. jervisensis* is reported as mature at two years with a maximum lifespan of up to five years (McLauchlan 1951).

5. *Meridolum maryae* is endemic to New South Wales (NSW). The species is confined to a narrow band of habitat along the coast from the north-eastern corner of the Royal National Park to Palm Beach in Sydney, a total linear distance of 65 km (ALA 2019; Clark 2009). Records of the species are generally within 1 km of the ocean but occur up to 5 km inland (ALA 2019; Clark 2009; Narla Environmental 2016). The number of locations is estimated to be 14 based on the number of disconnected habitat patches in relation to the prevailing threats.

6. The distribution of *Meridolum maryae* is highly restricted. Based on recorded occurrences of the species (ALA 2019; Clark 2009) *M. maryae* occupies an Extent of Occurrence (EOO) of 254 km^2, using a minimum convex polygon enclosing all mapped occurrences, the method of assessment recommended by IUCN (2017). The Area of Occupancy (AOO) is estimated to be 88 km^2, based on 2 km x 2 km grid cells, the scale recommended for assessing area of occupancy by IUCN (2017).

7. Total area of potential habitat within the known distribution of this species is approximately 35 km^2, based on the extent of all heathland/low woodland remnants (OEH 2016a; 2016b) located within the EOO. Patches comprised of woodland/forest on steep slopes (*e.g*. sandstone escarpments) were excluded as there are no records of *Meridolum maryae* from this habitat type (ALA 2019). Most of the potential habitat mapped occurs on aeolian sandplains and headland crests. A large proportion of the potentially suitable heathland remaining in eastern Sydney is highly modified (OEH 2016a; 2016b) and may no longer be suitable for *M. maryae* (*i.e*. has non-native grass understorey). The total area of suitable habitat for *M. maryae* is therefore likely to be considerably less than this estimated potential habitat figure.

8. *Meridolum maryae* occurs on both public and private land. The species has been recorded from one conservation reserve, the Royal National Park (ALA 2019), however potential habitat for the species occurs in Kamay Botany Bay National Park, Malabar Headland National Park, Sydney Harbour National Park, and the eastern edge of Ku-ring-gai Chase National Park at Barrenjoey Head (OEH 2016a; 2016b).

9. Loss and modification of habitat due to land clearing and urbanisation is an historic and ongoing threat to *Meridolum maryae*. The majority of vegetation that formerly occurred across the aeolian sand deposits of eastern Sydney, likely habitat for *M. maryae*, has been removed through vegetation clearing and urbanisation (OEH 2016a; 2016b). The loss of habitat available for *M. maryae* across its distribution may mirror the loss of Eastern Suburbs Banksia Scrub CEEC, which has declined from 91.2% to 97.4% of its original distribution across its range (NSW TSSC 2018), as much of the known and predicted habitat of *M. maryae* occurs within this community. Native vegetation modification and clearing, including tree removal, shrub removal, slashing, ploughing and mowing, may result in permanent loss of habitat available for the species. Even localised removal of native shrubs and groundcovers (especially heathland shrubs such as *Acacia sophorae*) are likely to impact *M. maryae*. Direct mortality of individuals may result from the clearing action (*i.e*. the use of machinery to clear vegetation). Wherever there is high human traffic (such as at beach-dune interfaces, beach access points, interfaces between cleared

recreational space and bushwalking tracks), trampling of habitat and dune vegetation is also likely to be impacting upon *M. maryae*. Human foot and vehicle traffic are likely to cause trampling of groundcover, localised dieback of vegetation and subsequent erosion. Areas that are no longer vegetated are unlikely to provide habitat suitable for *M. maryae*. It is expected that these threats will increase with projected increases in Sydney's human population and usage of open space, particularly beaches and headlands within the distribution of *M. maryae*. 'Clearing of native vegetation' is listed as a Key Threatening Process under the Act.

10. Much of the available habitat for *Meridolum maryae* now occurs as isolated fragments and most patches of remnant habitat within the predicted EOO of this species are small (<1 km²) (OEH 2016a; 2016b). The related camaenid *Meridolum corneovirens* is estimated to move no more than 350 m in its lifetime (Clark and Richardson 2002) and *Pommerhelix duralensis* was recorded as moving a maximum of 3.5 m per day (Ridgeway *et al.* 2014). The slightly smaller *M. maryae* is therefore predicted to move even less than this. It is likely that all *M. maryae* populations located in patches of habitat that are surrounded by cleared or developed land (*e.g*. roads and footpaths) are isolated and any artificial surfaces and clearings that are wider than 3.5 m are likely to pose impassable barriers to *M. maryae* (as they do for related species, Ridgeway *et al.* 2014). Such isolation may lead to the extirpation of local subpopulations and fragmentation of populations. Individual *M. maryae* in these isolated populations are likely to be continually impacted upon by the combined effects of genetic drift, random stochasticity and catastrophic events such as fire.

11. Loss of important microhabitat, including coarse debris from native and/or exotic plants, through firewood collection or 'tidying up', is likely to occur in all patches of habitat outside the National Parks estate. This threat is most significant on privately-owned lands or lands managed for recreational purposes such as parks, ovals and golf courses. Artificial debris such as discarded tarpaulins, corrugated iron, pots, and tiles may currently form important local microhabitat for *Meridolum maryae*. Removal of this habitat could cause exposure of sheltering *M. maryae* making them more susceptible to predation or desiccation. This is likely to be a greater issue in smaller habitat patches where natural debris is at lower densities.

12. The infestation of heathland habitat by weeds such as *Chrysanthemoides monilifera* (Bitou Bush) could potentially impact *Meridolum maryae* throughout its distribution as the species is considered unlikely to be tolerant of highly disturbed or weedy habitats (Shea *et al.* 2016). Disturbance due to weed control activities could also be a threat to the species where this involves herbicide application or mechanical damage to the understorey. 'Invasion of native plant communities by *Chrysanthemoides monilifera'* is listed as a Key Threatening Process under the Act.

13. The impact of fire on mortality of individual *Meridolum maryae* is unknown. The species may have some ability to burrow into the surface soil to retreat from fire, like the closely related *M. corneovirens* (Ridgeway *et al.* 2014). However, like *Pommerhelix duralensis,* it is also possible that *M. maryae* does not seek shelter but aestivates above leaf litter during the day (Ridgeway *et al*. 2014), in which case fire may cause extinction of local populations (Clark 2009). Inappropriate fire regimes may also impact the species through mesic shift or weed infestation. 'High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition' is listed as a Key Threatening Process under the Act.

14. Urban bushland reserves in Sydney contain high densities of feral rats (*Rattus rattus* and *Rattus norvegicus*) (Banks and Smith 2015) and although there is no direct evidence that *Rattus* spp. are impacting on populations of *M. maryae*, they are known to prey upon land snails (Barker 2016; Banks and Smith 2015; Parkyn and Newell 2013). It is likely that high densities of *Rattus* spp. impose high predation pressures upon *M. maryae*, particularly in small, isolated urban bushland patches.

15. *Meridolum maryae* (Clark, 2009) is not eligible to be listed as a Critically Endangered species.

16. *Meridolum maryae* (Clark, 2009) is eligible to be listed as an Endangered species as, in the opinion of the NSW Threatened Species Scientific Committee, it is facing a very high risk of extinction in Australia in the near future as determined in accordance with the following criteria as prescribed by the *Biodiversity Conservation Regulation 2017*:

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

(1) - The species has undergone or is likely to undergo within a time frame appropriate to the life cycle and habitat characteristics of the taxon:			
	~~(a)~~	~~for critically endangered species~~	~~a very large reduction in population size, or~~
	~~(b)~~	~~for endangered species~~	~~a large reduction in population size, or~~
	~~(c)~~	~~for vulnerable species~~	~~a moderate reduction in population size.~~
(2) - The determination of that criteria is to be based on any of the following:			
	~~(a)~~	~~direct observation,~~	
	~~(b)~~	~~an index of abundance appropriate to the taxon,~~	
	~~(c)~~	~~a decline in the geographic distribution or habitat quality,~~	
	~~(d)~~	~~the actual or potential levels of exploitation of the species,~~	
	~~(e)~~	~~the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.~~	

Clause 4.3 - Restricted geographic distribution of species and other conditions
(Equivalent to IUCN criterion B)
Assessment Outcome: Endangered under Clause 4.3 (b) (d) (e ii, iii, iv)

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

Clause 4.4 - Low numbers of mature individuals of species and other conditions
(Equivalent to IUCN criterion C)
Assessment Outcome: Data Deficient

The estimated total number of mature individuals of the species is:						
	~~(a)~~	~~for critically endangered species~~		~~very low, or~~		
	~~(b)~~	~~for endangered species~~		~~low, or~~		
	~~(c)~~	~~for vulnerable species~~		~~moderately low,~~		
and either of the following 2 conditions apply:						
	~~(d)~~	~~a continuing decline in the number of mature individuals that is (according to an index of abundance appropriate to the species):~~				
		~~(i)~~	~~for critically endangered species~~	~~very large, or~~		
		~~(ii)~~	~~for endangered species~~	~~large, or~~		
		~~(iii)~~	~~for vulnerable species~~	~~moderate,~~		
	~~(e)~~	~~both of the following apply:~~				
		~~(i)~~	~~a continuing decline in the number of mature individuals (according to an index of abundance appropriate to the species), and~~			
		~~(ii)~~	~~at least one of the following applies:~~			
			~~(A)~~	~~the number of individuals in each population of the species is:~~		
				~~(I)~~	~~for critically endangered species~~	~~extremely low, or~~
				~~(II)~~	~~for endangered species~~	~~very low, or~~
				~~(III)~~	~~for vulnerable species~~	~~low,~~
			~~(B)~~	~~all or nearly all mature individuals of the species occur within one population,~~		
			~~(C)~~	~~extreme fluctuations occur in an index of abundance appropriate to the species.~~		

Clause 4.5 - Low total numbers of mature individuals of species
(Equivalent to IUCN criterion D)
Assessment Outcome: Data Deficient

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

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

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

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

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

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NSW Threatened Species Scientific Committee

Supporting Document:

Bray C, Rowley J (2019) Conservation Assessment of *Meridolum maryae* (Clark, 2009) (family Camaenidae). (NSW Threatened Species Scientific Committee: Hurstville, NSW).

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