

NSW Threatened Species Scientific Committee

Conservation Assessment of *Meridolum maryae* Clarke, 2009 (Camaenidae) (Maroubra Woodland Snail)

C Bray, J Rowley, June 2019

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***Meridolum maryae* Clarke, 2009 (Camaenidae)**

Distribution: Endemic to NSW

Current EPBC Act Status: Not listed

Current NSW BC Act Status: Not listed

Proposed listing on NSW BC Act and EPBC Act: Endangered

Conservation Advice: *Meridolum maryae* Clarke, 2009 (Camaenidae)

Summary of Conservation Assessment

Meridolum maryae Clarke 2009 (Maroubra Woodland Snail) was found to be eligible for listing as Endangered under the IUCN Criterion B1ab(iii)(iv) + 2ab(iii)(iv).

This species is eligible because i) the species has a highly restricted geographic range; ii) the habitat is severely fragmented iii) there are a number of threats affecting the habitat and mature individuals at all populations inferring continuing decline.

Description and Taxonomy

Meridolum maryae was described by Clarke (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. *Diagnosis*: Shell subglobose, 10.3–16.3 mm in height and 14.8–19.2 mm in width. Teleoconch sculpture with prominent growth lines and weak to well developed pustules. Shell pale yellow to tan, with small red umbilical patch and narrow red subsutural band. Animal greyish orange, mantle reddish orange. Epiphallic flagellum of medium length and slender. Penis longer relative to vaginal length.”

Common name: Maroubra Woodland Snail

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Distribution and Abundance

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).

Based on the current records for *Meridolum maryae*, the total extent of occurrence (EOO) is estimated to be 254 km², 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 km², based on 2 km x 2 km grid cells, the scale recommended for assessing area of occupancy by IUCN (2017).

Potential habitat within the known distribution is approximately 35 km². This was calculated by mapping all heathland/low woodland pockets located within the total extent of occurrence. 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 potential habitat for *M. maryae* is therefore likely to be an over estimate. In addition, most patches of remnant habitat within the predicted EOO of this species are small (<1 km²), fragmented and isolated (OEH 2016a; 2016b).

Most records of *Meridolum maryae* are over 20 years old and it is unknown if the species persists at all previously recorded locations (Clarke 2009; ALA 2019).

Meridolum maryae occurs on both public and private land. The species has been recorded from one conservation reserve, 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).

There is limited information regarding population size, density and trends of *M. maryae*. It is thought to have declined, and will continue to decline, in range and population, as a result of habitat loss and modification (Shea *et al.* 2016).

Very little survey work has been undertaken for this species. Clarke (2009) undertook land snail surveys with a focus on the genus *Meridolum* but population size or density was not estimated. The slightly larger camaenid *Pommerhelix duralensis* (shell 10.6 to 23 mm in height; 14.7 to 23.5 mm in width) has been recorded in densities of three mature individuals per hectare of suitable habitat (Ridgeway *et al.* 2014), however it is not known if this represents the true abundance for this species, and if so, whether *M. maryae* would have a similar density. Given the lack of available data, it is not possible to accurately estimate the population size or trends in *M. maryae*.

Ecology

Habitat Requirements

Meridolum maryae are found in the leaf litter of coastal vegetation communities, most commonly in heathland on foredunes (e.g. *Acacia sophorae* Coastal Fore-dune Wattle Scrub) (Clarke 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 Eastern Suburbs Banksia Scrub Critically Endangered Ecological

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Community (CEEC) (NSW TSSC 2018). The species has also occasionally been recorded in sandstone and clay heathland communities on headlands (Clarke 2009; ALA 2019). The species does not range very far from the coast (typically < 1 km) and does not appear to penetrate far into sclerophyll forest, which is typically found further inland (OEH 2016a; 2016b).

Members of the *Meridolum* genus are typically active at night but can also move about on overcast or rainy days (Clarke 2009).

The diet of *Meridolum maryae* is unknown, however it is expected to be like that of closely related camaenids, including *M. corneovirens*, which shows a 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 movement, territoriality or home range of *Meridolum maryae*, but the ability for individuals to disperse is expected to be similar to closely related camaenids (*M. corneovirens* and *Pommerhelix duralensis*) which can move around 3.5 m in a day (Ridgeway *et al.* 2014) and 350 m in a lifetime (Clarke and Richardson 2002).

Life cycle and reproduction

There have been no studies into the breeding biology of *Meridolum maryae*. McLauchlan (1951) described mating for another related species (*M. jervisensis*) as occurring between Spring and late Autumn, during the night or early morning after rain. This species of *Meridolum* lays a relatively small number of eggs (up to 32) in each season which are buried deeply under stones or coarse woody debris and incubated for 61 days (gestation of 92 days) (McLauchlan 1951). The mortality of offspring is 90% in the first year and overall mortality is 99.8% within 4-5 years (McLauchlan 1951).

No information is available on age to maturity or longevity of *Meridolum maryae*. The related species, *M. jervisensis*, is reported as mature at two years with a maximum lifespan of up to five years (McLauchlan 1951).

Threats

The coastal dunes and headlands of the Sydney metropolitan area, where *Meridolum maryae* appears to be confined, has been subject to pressure from urbanisation resulting in threats to the species' habitat in the form of weeds, vegetation clearing and fragmentation and altered fire regimes. Another potential threat is predation by introduced foxes (*Vulpes vulpes*) and rats (*Rattus rattus* and *Rattus norvegicus*).

Weeds: The infestation of coastal 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 mechanical damage to the understorey.

Loss, fragmentation and modification of native habitat: The majority of vegetation that formerly occurred across the aeolian sand deposits of eastern Sydney, and was presumably habitat for *Meridolum 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 by 91.2% to 97.4% across its range (NSW TSSC 2018), as much of the known and predicted habitat of *M. maryae* occurs within this community.

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Native vegetation clearing, including tree removal, shrub removal, slashing, ploughing and mowing, may result in permanent loss of area 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). Based on the known movement of the slightly larger *Pommerhelix duralensis* (Ridgeway *et al.* 2014), the species is predicted to move less than 3.5 m per day, and any artificial clearing or space wider than this may also pose a significant barrier to dispersal by *M. maryae*, which may lead to the extirpation of local subpopulations and fragmentation of populations.

Wherever there is high human traffic, such as at beach-dune interfaces, beach access points, suburban access points, interfaces between cleared recreational space and bush walking tracks, trampling of habitat and dune vegetation is also likely to be impacting upon *Meridolum 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*. Wide tracks or erosion scars (e.g. >3.5 m wide) may even reduce the ability for *M. maryae* to traverse habitat patches (Ridgeway *et al.* 2014) and this could further fragment populations. It is expected that this threat will increase with projected increases in Sydney's human population and usage of open space, particularly beaches within the distribution of *M. maryae*.

Vegetation clearing has both reduced the amount of suitable habitat and increased fragmentation of *Meridolum maryae* across its distribution.

Loss of important microhabitat: Coarse woody debris (from native and/or exotic plants) is likely to form an important habitat feature for *Meridolum maryae*, as it does for the related *M. corneovirens* (Ridgeway *et al.* 2014). Loss of this habitat through the removal of firewood or urban bushland management practices (i.e. '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.

Inappropriate Fire Regimes: The impact of fire leading to direct mortality of individuals *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). It is also possible that *M. maryae* populations are susceptible to significant impacts from fire like the camaenid, *Pommerhelix duralensis*, which does not seek shelter but aestivates above leaf litter during the day (Ridgeway *et al.* 2014) and fire may cause extinction of local populations (Clarke 2009). The low dispersal ability overall and inability to disperse over cleared land, may increase the susceptibility of *M. maryae* to fire and the species may be less likely to repopulate areas after fire. Inappropriate fire regimes may also impact the species through mesic shift or weed infestation.

Predation by Feral Rats and Red Fox: Urban bushland reserves in Sydney contain high densities of feral rats (*Rattus rattus* and *Rattus norvegicus*) (Banks and Smith 2015). Although there is no direct evidence that *Rattus* spp. are impacting on populations of *Meridolum maryae*, they are known to prey upon land snails (Banks and Smith 2015; Parkyn and Newell 2013) and there is evidence from other habitats that they can have strong effects on abundance and species richness of large-bodied land snails (Barker 2016). It is likely that high densities of *Rattus* spp. apply ongoing predation pressures upon *M. maryae*, particularly in small, isolated urban bushland patches. Predation by red fox (*Vulpes vulpes*) is also a potential threat to this snail species.

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Other threats: It is possible that domestic 'snail and slug pellets' and other garden pesticides could have an impact on some populations of *Meridolum maryae*, particularly where the species occurs in suburban bushland remnants. Interspecies competition with the common exotic garden snail (*Cornu aspersum*) is also a potential threat to *M. maryae*.

Assessment against IUCN Red List criteria

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

Criterion A Population Size reduction

Assessment Outcome: Data Deficient

Justification: The majority of the former habitat that existed for this species (all of the vegetation that formerly occurred across the aeolian sand deposits of Eastern Sydney) has been historically removed through vegetation clearing and urbanisation. This includes Eastern Suburbs Banksia Scrub CEEC, which the species is known to inhabit and which has undergone a 91.2% to 97.4% decline in extent (NSW TSSC 2018). However, no quantifiable data are available on the population size or dynamics of this species and there are no data on population declines over any time frames relevant to this criterion (10 years or 3 generations). Therefore, there are insufficient data to assess *Meridolum maryae* against this criterion.

Criterion B Geographic range

Assessment Outcome: Endangered under Criterion B1ab(iii)(iv)+2ab(iii)(iv)

Justification: *Meridolum maryae* has a highly restricted range occurring within a limited section of coastline from the north-eastern corner of the Royal National Park to Palm Beach in Sydney, a total linear distance of 65 km (Clark 2009; ALA 2019). 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). Potential habitat for this species (i.e. all heathland/low woodland pockets located within the total extent of occurrence) is estimated to be 35 km².

Extent of occurrence (EOO): The EOO was estimated to be 254 km², based on a minimum convex polygon enclosing all mapped occurrences, the method of assessment recommended by IUCN (2017). To be listed as Endangered under Criterion B1, a species must have an EOO of less than 5,000 km². *M. maryae* meets the EOO threshold for Endangered under B1.

The area of occupancy (AOO): The AOO was estimated to be 88 km², based on the species occupying 22 (2 km x 2 km) grid cells, the scale recommended for assessing area of occupancy by IUCN (2017). To be listed as Endangered under Criterion B2, a species must have an AOO of less than 500 km². *M. maryae* meets the AOO threshold for Endangered under B2.

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

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

Assessment Outcome: Subcriterion met as habitat is observed to be severely fragmented.

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Justification: A species is considered to be severely fragmented if most of its individuals are found in small and relatively isolated subpopulations, and the subpopulations may go extinct with a reduced probability of recolonization (IUCN 2017). “If >50% of its total area of occupancy is in habitat patches that are (1) smaller than would be required to support a viable population, or (2) separated from other habitat patches by a large distance” (IUCN 2017).

Much of the available habitat for this species has been historically isolated and fragmented and most patches of remnant habitat within the predicted EOO of this species are small (<1 km²). The related camaenid, *Meridolum corneovirens*, is estimated to move no more than 350 m in their lifetime (Clarke 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 *Pommerhelix duralensis* (Ridgeway *et al.* 2014). Individual *M. maryae* in these isolated populations are likely to be continually impacted on by the combined effects of genetic drift, random stochasticity and catastrophic events such as fire. Based on this, *M. maryae* is considered to be severely fragmented.

The best estimate for the number of locations is 14, based on the number of disconnected habitat patches (i.e. > 350 m apart) which contain records of this species. Disturbance due to recreational pressures and weeds and localised clearing of native vegetation are the most likely threats for each population. Each population would be independently disturbed, hence each population is considered a separate location.

- b) Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals

Assessment Outcome: Subcriterion met for (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations.

Justification: Continuing decline is inferred due to threats to the species and habitat including: the infestation of heathland habitat by weeds such as *Chrysanthemoides monilifera* (Bitou Bush); habitat loss and modification associated with urban development or recreational pursuits (e.g. golf courses) which is inferred to cause direct mortality, reduced habitat suitability, localised extirpation and fragmentation of sub-populations; loss of important microhabitat (e.g. coarse woody debris and possibly artificial debris) through firewood collection or ‘tidying up’; ongoing impacts caused by inappropriate fire regimes which may include habitat change through mesic shift or weed infestation or direct mortality and fragmentation of habitat; and likely ongoing predation by rats.

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c) Extreme fluctuations.

Assessment Outcome: Data Deficient.

Justification: Little is known about the biology of this species. There are currently no data to assess the likelihood of extreme fluctuations in population size or geographic distribution of *M. maryae*.

Criterion C Small population size and decline

Assessment Outcome: Data Deficient

Justification: There is insufficient data to assess *Meridolum maryae* against this criterion

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

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

Assessment Outcome: Data Deficient

Justification: There are insufficient data to assess *Meridolum maryae* against this criterion.

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

Assessment Outcome: Data Deficient

Justification: Continuing decline is inferred due to threats to the species and its habitat including: the infestation of heathland habitat by weeds such as *Chrysanthemoides monilifera* (Bitou Bush); vegetation clearing associated with urban development or recreational pursuits; loss of important microhabitat; trampling of habitat and dune vegetation; impacts caused by inappropriate fire regimes; and likely predation by rats.

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

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

Assessment Outcome: Data Deficient

Justification: There are insufficient data to assess *Meridolum maryae* against this subcriterion.

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

Assessment Outcome: Data Deficient

Justification: There are insufficient data to assess *Meridolum maryae* against this subcriterion.

- b. Extreme fluctuations in the number of mature individuals

Assessment Outcome: Data Deficient.

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Justification: Little is known about the biology of this species. There are currently no data to assess the likelihood of extreme fluctuations in population size or geographic distribution of *M. maryae*.

Criterion D Very small or restricted population

Assessment Outcome: Data Deficient

Justification: There are insufficient data to assess *Meridolum maryae* against this criterion. To be listed as Vulnerable under D, a species must meet at least one of the two following conditions:

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

Assessment Outcome: Data Deficient

Justification: Currently there are no available census data to assess the population size of *M. maryae*.

D2. Restricted area of occupancy (typically <20 km²) or number of locations (typically <5) with a plausible future threat that could drive the taxon to CR or EX in a very short time.

Assessment Outcome: Not met

Justification: The area of occupancy (AOO) for all records was estimated to be 88 km², based on 2 km x 2 km grid cells, the scale recommended for assessing area of occupancy by IUCN (2017).

Criterion E Quantitative Analysis

Assessment Outcome: Data Deficient

Justification: Currently there are not enough data to undertake a quantitative analysis to determine the extinction probability of *Meridolum maryae*.

Conservation and Management Actions

There is no National Recovery Plan and no NSW Save our Species program for this species. The following information is derived from threat information for the species and recovery actions of the camaenid, the Dural Land Snail *Pommerhelix duralensis* (Department of the Environment 2015).

Habitat loss, disturbance and modification

- Avoid further loss of habitat.
- Maintain and enhance the species' habitat and connectivity.
- Prevent disturbance to the species and its habitat by implementing and maintaining measures to reduce trampling of vegetation and erosion, removal of woody debris, inappropriate management and 'tidying up' of bushland, mechanical disturbance, and inappropriate track use, expansion and maintenance activities at beach-dune interfaces and beach access points, suburban access points, interfaces between cleared recreational space and bush walking tracks, where the species is known to occur.

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- Investigate options for linking, enhancing or establishing additional populations.

Invasive species

- Develop and implement a management plan for the control of weeds currently occurring in the region.
- Monitor the presence and density of introduced rats and foxes in areas where the species is known to occur, and conduct monitoring of *Rattus* spp. predation on *Meridolum maryae*.

Stakeholders

- Engage with private landholders and land managers responsible for the land on which populations occur and encourage these key stakeholders to contribute to the implementation of conservation management actions.
- Investigate formal conservation arrangements, management agreements and covenants on private land with known occurrences.
- Provide advice to developers, consultants and approval authorities about the existence of the species and its significance.
- Where necessary and appropriate, restrict access to important sites by installing gates, fencing and educational signs.
- Raise awareness of the species within the local community.

Survey and Monitoring priorities

- Undertake survey work in suitable habitat and potential habitat to locate any additional populations/occurrences/remnants. Preferably, a specialist consultant should be engaged to assist in finding and identifying this species.
- Implement an ongoing monitoring program to monitor the progress of recovery, including the effectiveness of management actions and the need to adapt them if necessary. Monitoring to detect increased habitat degradation through loss of key habitat requirements and damage such as loss of coarse woody debris and trampling.
- Undertake regular surveys to determine trends in the population size.

Information and Research priorities

- More precisely assess the species' population size, distribution, ecological requirements, life history and the relative impacts of threatening processes.
- Identify key populations and habitat for priority protection and management, as well as strategic corridors and support populations.
- Design an ongoing monitoring program to track the species' recovery.
- Undertake genetic analyses to determine gene flow among fragmented populations.

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- Improve understanding of fire response and identify optimal fire regimes compatible with population persistence for the species, and response to other prevailing fire regimes, and develop a suitable fire management strategy for the habitat of the Maroubra land snail.
- Explore weed control mechanisms for *Chrysanthemoides monilifera* (Bitou Bush) that will not negatively impact upon the Maroubra land snail.

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APPENDIX

Assessment against BC Act criteria

Overall Assessment Outcome (Clause(s) with the highest category of threat)

Endangered under Clause 4.3 (b) (d) (e ii, iii, iv)

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,

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	(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.

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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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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* (Clarke, 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 km² and an extent of occurrence of 254 km²; 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* (Clarke, 2009) (family Camaenidae) (Maroubra Woodland Snail), was described by Clarke (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 Fore-dune Wattle Scrub) (Clarke 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 (Clarke 2009; ALA 2019).
3. Members of the *Meridolum* genus are typically active at night but can also move about on overcast or rainy days (Clarke 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

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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*; Clarke 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 km², 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 km², 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 km², 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

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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 (Clarke 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 (Clarke 2009). Inappropriate fire regimes may also impact the species through mesic shift or weed infestation. 'High frequency fire

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

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	(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.

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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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Dr Anne Kerle
Chairperson
NSW Threatened Species Scientific Committee

Supporting Document:

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

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<http://www.iucnredlist.org/documents/RedListGuidelines.pdf>

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