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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 shrub *Asterolasia rupestris* subsp*. recurva B.J.Mole* as a CRITICALLY ENDANGERED SPECIES in Part 1 of Schedule 1 of the Act. Listing of Critically Endangered species is provided for by Part 4 of the Act.

A Conservation Assessment report and Preliminary Determination for *Asterolasia rupestris* subsp*. recurva B.J.Mole* as an Endangered species was published from 29th July 2022 to 29th October 2022. Following consideration of advice and submissions received, *Asterolasia rupestris* subsp*. recurva B.J.Mole* is to be listed as a Critically Endangered species.

Summary of Conservation Assessment

Asterolasia rupestris subsp. *recurva* B.J.Mole (Rutaceae) was found to be Critically Endangered in accordance with the following provisions in the *Biodiversity Conservation Regulation 2017*: Clause 4.3 (a)(d)(e, i, iii) and 4.4 (a)(d, i),(e, i, ii (A, I)(B))

The NSW Threatened Species Scientific Committee has found that:

1. *Asterolasia rupestris* was described by Mole *et al*. (2002) as: "Upright shrub to 1.5 m tall. Stems with a stellate indumentum. Leaves shortly petiolate, or frequently sessile; lamina obcordate or obdeltate, 9–20 mm long, 6–15 mm wide, papery, apex emarginate, sometimes truncate, base attenuate, slightly conduplicate, margins recurved or flat; adaxial surface with a dense indumentum of hyaline multiangular stellate trichomes (15–31 trichomes per mm2); abaxial surface cobwebbed with stalked, multiangular stellate trichomes; petiole when present somewhat thickened and flat, often appressed to the stem. Inflorescence a terminal or axillary umbel of 3–5 flowers; peduncles 4–9 mm long; pedicels 6–15 mm long. Sepals inconspicuous, 0.5–1 mm long. Petals 5, elliptic, 5–9 mm long, yellow, abaxial surface with an indumentum of rust coloured stellate trichomes; adaxial surface glabrous. Stamens 10; filaments glabrous; anthers 1–2 mm long, each with a terminal gland. Carpels 5, stellate-tomentose; style glabrous; stigma hemispherical. Cocci beaked. Seed not seen."
2. *Asterolasia rupestris* subsp. *recurva* is distinguished from subsp. *rupestris* by the following: Leaf margins recurved (vs flat). Inflorescence an umbel of 3–6 flowers (vs 3–5 flowers); peduncles 4–8 mm (vs 4–6 mm) long; pedicels 8–15 mm (vs 7–10 mm) long. Petals 6–7 mm (vs 5–8 mm) long (Mole *et al*. 2002).
3. *Asterolasia rupestris* subsp. *recurva* is restricted to the Parlour Mountains northwest of Armidale on the New England Tableland, northern NSW. Only one population is known, with all individuals occurring along a single creekline on private freehold land (Mole *et al.* 2002; Copeland 2021). Further searches in potential habitat elsewhere, including prior surveys of the New England Batholith reported on in Hunter and Clarke (1998) and Hunter (1999), have failed to locate additional populations. Additionally, general flora surveys by staff and students of the

University of New England over many years have failed to locate further subpopulations of this taxon (P. Sheringham *in litt* July 2021; L. Copeland *in litt* June 2022).

4. Copeland (2021) also reported juveniles in the population, but these were not thoroughly surveyed. This very small population makes the species particularly vulnerable to stochastic processes.

5. *Asterolasia rupestris* subsp. *recurva* has an extremely restricted range, known only from a single small population along a short creek line. As a consequence, the Area of Occupancy (AOO) for the species is only 4 km^2. The extremely restricted range for the species means that Extent of Occurrence (EOO) is also very small, 0.057 km^2, and less than the calculated AOO. Where EOO is less than or equal to AOO then IUCN guidelines recommend EOO estimates be changed to be equal to AOO to ensure consistency with the definition of AOO as an area that fits within EOO (IUCN Standards and Petitions Committee, 2019). As such, EOO used for this assessment is also 4 km^2. EOO and AOO were estimated based on all records in Copeland (2021).

6. There is a minimum estimate of 115 mature individuals for *Asterolasia rupestris* subsp. *recurva,* drawn from the extensive survey conducted by Copeland (2021). The species is restricted entirely to a single extremely small site, the entirety of which was systematically surveyed by Copeland (2021), and so it is likely that the entire known population has been surveyed. As a consequence, while 115 is a reliable minimum estimate of mature individuals for the species, it is very unlikely that there are a large number of additional mature individuals that were not surveyed, and this minimum estimate is likely to reflect the maximum estimate for the species.

7. Mole *et al.* (2002) described habitat for this taxon as “low open forest on skeletal gravelly soils, along gullies”. Copeland (2021) added further detail and included floristic co-associates in his description: “layered open forest dominated by Apple Box (*Eucalyptus bridgesiana*), Youman’s Stringybark (*E. youmanii*), Silvertop Stringybark (*E. laevopinea*) and New England Blackbutt (*E. andrewsii*). Common shrubs included Grey Teatree (*Leptospermum brevipes*), Blunt Beard-heath (*Leucopogon muticus*) and Broad-leaf Geebung (*Persoonia cornifolia*), while the ground layer was dominated by Silvertop Wallaby Grass (*Rytidosperma pallidum*)”. Soils were described as loamy and derived from acid volcanics, and altitude ranged from 1120-1150 m above sea level. No plants were seen immediately to the west of this population where the geology changes to Parlour Mountains Leucoadamellite, a type of granite. Copeland (2021) stresses that all *Asterolasia rupestris* subsp. *recurva* individuals were within 100 m of a small creek line, but in relatively dry areas and not associated with riparian habitat.

8. There has been no targeted study of reproductive ecology in *Asterolasia rupestris* subsp. *recurva*; however, insights can be gained from studies in related *Asterolasia* species. *Asterolasia* flowers are generally insect-pollinated, with most visitors noted to be beetles and occasionally flies and bees (Armstrong 1979), and this is likely to also be true of *Asterolasia rupestris* subsp. *recurva*. Seeds in *Asterolasia* are generally dispersed ballistically in combination with gravity or water, and species in

the Sydney region are also known to be dispersed by ants, although distances are likely to be less than ten metres (Auld 2001).

9. There is no evidence for fragmentation in *Asterolasia rupestris* subsp. *recurva.* All known individuals occur in a single, extremely restricted subpopulation, and as a consequence all individuals are likely to be able to freely breed and disperse within this area.

10. There has been no targeted study of reproductive ecology in *Asterolasia rupestris* subsp. *recurva*; however, field observations and studies in related *Asterolasia* species strongly indicate the species is likely a fire obligate seeder, with adult plants also able to resprout following low-severity fire.

11. Population structure and site history for *Asterolasia rupestris* subsp. *recurva* suggest it is likely that the majority of the current cohort germinated in response to the last known fire at the site in 1982 and are now over 40 years old (Benson and McDougall 2001; Copeland 2021). Similar *Asterolasia* species live from 20-40 years, which is likely also true for *Asterolasia rupestris* subsp. *recurva*, and so plants in the current cohort may be approaching natural senescence, while the population has lacked subsequent fires necessary to rejuvenate the population (Benson and McDougall 2001; Copeland 2021).

12. Germination in related *Asterolasia* species is promoted by fire, and seed banks a relatively long-lived (>2 years) and this appears to also be true of *Asterolasia rupestris* subsp. *recurva*.

13. The main threats affecting *Asterolasia rupestris* subsp. *recurva* are; an increased likelihood and impact of drought as a consequence of anthropogenic climate change, adverse fire regimes, habitat degradation as a consequence of feral mammals, and root-rot, *Phytophthora cinnamomi.* Of these '*Anthropogenic Climate Change*', '*Competition and habitat degradation by Feral Goats, Capra hircus Linnaeus 1758'*, and '*Infection of native plants by Phytophthora cinnamomi*' are listed as Key Threatening Processes (KTPs) under the New South Wales *Biodiversity Conservation Act 2016* (NSW BC Act).

14. The single, very small population, and extremely restricted distribution of *Asterolasia rupestris* subsp. *recurva* means that all threats are likely to threaten all individuals across the entire known range of the species.

15. Drought has been observed to severely impact *Asterolasia rupestris* subsp. *recurva* and is likely to pose an ongoing and increasingly severe threat for the species. Drought in the region in 2018-2019 severely affect the population, causing mortality in mature individuals, and reduction of general health, including death of limbs in the rest of the population (Copeland 2021). Some recovery via basal resprouting with the return to wetter conditions was observed during surveys in October 2021. However, high incidence of recurrent drought may pose a risk to the long-term stability of this taxon and population.
16. While there is broad uncertainty around specific values, climate projections consistently predict drought to become more severe, and likely more frequent across NSW, including across the range of *Asterolasia rupestris* subsp. *recurva*

(Herold et al., 2021; Kirono et al., 2020; NESP Earth Systems and Climate Change Hub, 2020; Shi et al., 2020). While NARCLIM projections predict that there is likely to be a 0.63 – 3.07% increase in rainfall across the range of *Asterolasia rupestris* subsp. *recurva* between 2020-2069, this is likely to also be accompanied by a rise in average temperature of 0.79 - 2.24^{o}c, and an increase in 0.62-3.81 days of extreme heat (>35^{o}c) over the same period; predictions closely resembling those provided for the region by CSIRO, who also predict drought for the area as being increasingly likely over this period (CSIRO and the Bureau of Meteorology 2022; CSIRO 2023; Nishant et al. 2022).

17. Mortality and decline in health of plants associated with drought is also likely to interact with fire events, making the population more susceptible to fire, and less likely to recover than during non-drought periods.

18. Adverse fire regimes pose an ongoing threat to the entire population of *Asterolasia rupestris* subsp. *recurva.* While fire is likely necessary for germination, adverse fire regimes pose an ongoing threat to *Asterolasia rupestris* subsp. *recurva*, with too infrequent, too frequent, and high severity fire all likely to negatively affect mortality and recruitment.

19. Future fire regimes for the range of *Asterolasia rupestris* subsp. *recurva* are difficult to determine, however fire in Australia is generally predicted be more frequent and more severe in the future as a consequence of rising average temperatures (Canadell et al., 2021; Department of Agriculture, Water, and the Environment 2022). Increased frequency of drought is also likely to contribute to an increase in the frequency and severity of fire across the range of *Asterolasia rupestris* subsp. *recurva*.

20. Conversely, *Asterolasia rupestris* subsp. *recurva* is confined to private land generally managed to reduce the frequency of fire, which also poses a severe threat for the species, which requires fire to prompt germination and remove older plants as they reach senescence. The last significant fire occurred in the area in 1982 (P. Sheringham *in litt*), and it is likely that this event triggered germination of the current cohort of plants. As a consequence these plants are around 40 years old, and may soon start to naturally senesce, with fire required to rejuvenate the population.

21. Without sufficiently frequent fire there will be no germination, while the existing population will senesce, restricting reproduction and resulting in ongoing population decline.

22. As with other *Asterolasia*, it is suspected that fire is needed to break dormancy in the soil seed bank for *Asterolasia rupestris* subsp. *recurva.* However, too frequent fire events are likely to kill seedlings and deplete the seedbank, preventing successful reproduction. Seedlings are likely to be fire sensitive, killed by repeat fire events prior to reaching sufficient size to survive or resprout. Similarly, while fire is likely required for germination, the population requires a sufficiently long fire-free interval for individuals to mature and replenish its soil seedbank; too frequent fire will cause seeds to germinate, but kill the new cohort before it has the opportunity to reach maturity and produce seed.

23. While fire is likely necessary for germination and population rejuvenation in *Asterolasia rupestris* subsp. *recurva,* high severity fire may have the opposite effect, killing both mature plants and seeds and preventing recovery through either resprouting or seed germination (Le Breton et al., 2023). While loss of mature plants to fire is a normal part of life history and population dynamics for obligate seeders, the loss of a high percentage of mature individuals during severe fires, combined with death of seeds in the seed bank, means that germination following these fire events may not be sufficient to replace those mature individuals that have been lost, and the population will continue to decline with each successive fire event.

24. Fire is likely to become more severe across the range of *Asterolasia rupestris* subsp. *recurva,* regardless of whether fire becomes more frequent as a consequence of increased temperatures and drought, or remains infrequent as a result of private land management. Increased temperature and drought cause fires to become generally become more severe, while infrequent fire may increase fuel loads, meaning that when fires do finally occur they will have more fuel to burn, and will be more severe as a result.

25. Habitat degradation as a consequence of feral mammals, in particular pigs (*Sus scrofa*) and goats *(Capra hircus*), pose an ongoing threat to *Asterolasia rupestris* subsp. *recurva*. While pigs and goats do not currently appear to directly impact *Asterolasia rupestris* subsp. *recurva,* Copeland (2021) noted evidence of feral pig foraging near the western extent of the population, while goat populations are known throughout the wider area and have been reported grazing on other threatened plant species (Copeland 2021).

26. Root-rot, *Phytophthora cinnamomi* poses a plausible and severe future threat for *Asterolasia rupestris* subsp. *recurva*. *Phytophthora cinnamomi* is an introduced water mould (oomycete) pathogen that has had a devastating effect on plant communities worldwide, causing catastrophic dieback in many species, and is listed as the Key Threatening Process *'Dieback caused by the root-rot fungus Phytophthora cinnamomi*' on the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act), and '*Infection of native plants by Phytophthora cinnamomi*' on the NSW BC Act. *Phytophthora cinnamomi* affects a huge variety of plants across families, including severely affecting the closely related *Asterolasia phebalioides,* and moderately affecting *A. buxifolia*, and so is likely to also pose a considerable threat to *Asterolasia rupestris* subsp. *recurva* (Government of South Australia Phytophthora Technical Group, 2006; NSW Department of Environment and Climate Change, 2008; Reiter et al., 2004; Wan et al., 2019).

27. *Asterolasia rupestris* subsp. *recurva* B.J.Mole (Rutaceae) is eligible to be listed as a Critically Endangered species as, in the opinion of the NSW Threatened Species Scientific Committee, it is facing an extremely high risk of extinction in Australia in the immediate future as determined in accordance with the following criteria as prescribed by the *Biodiversity Conservation Regulation 2017*:

Assessment against *Biodiversity Conservation Regulation 2017* criteria

The Clauses used for assessment are listed below for reference.

Overall Assessment Outcome: Critically Endangered under Clause 4.3 (a)(d)(e, i, iii) and 4.4 (a)(d, i)(e, i, ii (A, I)(B))

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: Critically Endangered 4.3 (a)(d)(e, i, iii)

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: Critically Endangered under 4.4 (a)(d, i)(e, i, ii (A, I)(B))

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: Endangered under 4.5 (b)

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: Met for Vulnerable under D2

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.

Senior Professor Kris French
Chairperson
NSW Threatened Species Scientific Committee

Supporting Documentation

Bell, S. Rowell, T. (2024) *Asterolasia rupestris* subsp. *recurva* B.J.Mole (Rutaceae). NSW Threatened Species Scientific Committee.

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