

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 *Bossiaea bombayensis* K.L.McDougall as a Critically Endangered species in Part 1 of Schedule 1 of the Act and, as a consequence, to omit reference to *Bossiaea bombayensis* K.L.McDougall in Part 3 of Schedule 1 (Vulnerable Species) of the Act. Listing of Critically Endangered species is provided for by Part 4 of the Act.

Summary of Conservation Assessment

Bossiaea bombayensis K.L.McDougall was found to be Critically Endangered in accordance with the following provisions in the *Biodiversity Conservation Regulation 2017*: Clause 4.3(a)(d)(ei,iii) because: (1) it has a very highly restricted geographical range on the banks of the Shoalhaven River west of Braidwood (EOO is 20 km²); (2) the species is known from a single threat-defined location; (3) continuing decline is inferred in habitat quality and area because of competition from weeds, especially scotch broom, blackberry, willow and African lovegrass, following increasingly frequent flood and fire events resulting from climate change; and (4) continuing decline is inferred in population size and in habitat area and quality because of increased severity of floods resulting from climate change destroying mature plants and washing away the soil seedbank.

The NSW Threatened Species Scientific Committee has found that:

1. *Bossiaea bombayensis* K.L.McDougall (family Fabaceae), also known as Bombay Bossiaea, is a small, wiry shrub of the legume family. Thompson (2012) described the species as an “erect rhizomatous leafless shrubs to c. 1.5 m high with cladodes to c. 5 mm wide, with inflorescences borne on both long and short cladodes, but not generally on a regular series of short side-branchlets; inflorescence bearing cladodes sub-erect to erecto-patent, mostly 2–5 mm wide, not recessed at nodes or with recession to c. 0.7 mm deep, mostly soon glabrescent; marginal ridges poorly to moderately defined, mostly minutely uneven; new growth narrow-linear in profile, with scattered hairs adjacent to scales, and occasional hairs elsewhere along margins and sometimes also on faces; hairs occasionally persisting; epicuticular wax occasionally developing, lifting in flakes, with cladodes dark green or grey-green. Scales 1–1.5(–2) mm long, c. 0.5 mm wide from midrib to margin, brown, with venation obscure, with base sometimes minutely cordate. Inflorescences: axes contracted; scales 4 or 6, with largest 1.5–2 mm long, 1–1.5 mm wide; scale cluster 2–2.5 mm long; bract mostly caducous at anthesis, 2–3 mm long, c. 1.3 mm wide, strongly convex; pedicel 1.5–3 mm long, glabrous, not exceeding scale cluster or exceeding by up to 1 mm; bracteoles caducous before anthesis, c. elliptic, 2.5–3.2 mm long, with l:w ratio 1.5–2, appressed, inserted near base, strongly convex, with venation obscure, glabrous, brown. Calyx 3.5–4.5 mm long, glabrous, with tube longer than lobes; upper lobes triangular, 1–1.5 mm long, 1–1.2 mm wide, slightly acuminate, chartaceous distally; sinus 1–1.5 mm deep; lower lobes 1.5–2 mm long, chartaceous distally; lateral lobes 1 mm wide, at except for distal median ridge; median lobe slightly longer, wider and more convex

NSW Threatened Species Scientific Committee

than laterals; standard to c. 8 mm long, similar in length to wings and keel, adaxially yellow with a red area, abaxially largely suffused red but streakily pale medially and yellow towards lateral margins; wings 2.5 mm wide, brownish-red proximally, but largely yellow; keel 3.5 mm wide, grading from pale to pink to red; anthers c. 0.6 mm long post-dehiscence; ovary glabrous, 6–8-ovulate; style 3.5–4 mm long. Pods: stipe 1–2.5 mm long; body narrow-oblong, 20–26 mm long, 4–6 mm wide; upper margin 0.7–1 mm wide, at or with a fine sutural ridge to c. 0.3 mm high; valves with transverse venation obscure. Seeds 2–2.5 mm long, 1.3–1.5 mm wide; aril c. 1 mm long, c. 0.5 mm high, with base 0.6–0.8 mm long, with lobe curving c. 90°."

- Bossiaea bombayensis* is currently only known from the banks of the Shoalhaven River, west of Braidwood in the South Eastern Highlands Bioregion (Thackway and Creswell 1995). The species' range extends along the river between the localities of Bombay and Warri. *Bossiaea bombayensis* is not found in any conservation reserves. Searches of potential habitat both upstream and downstream of the known occurrences have not led to the discovery of any further populations of *B. bombayensis* (McDougall pers. comm. March 2008 in NSW Scientific Committee 2009; Appleby 2022).
- The Area of Occupancy (AOO) of *Bossiaea bombayensis* is 20 km² based on 2 x 2 km grid cells, the scale recommended for assessing area of occupancy by IUCN (2024). The Extent of Occurrence (EOO) is calculated to be 9 km² based on a minimum convex polygon enclosing all mapped occurrences of the species, the method of assessment recommended by IUCN (2024). However, where EOO is less than 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 2024). As such, the EOO is also estimated to be 20 km².
- McDougall (2009) estimated the number of mature individuals of *Bossiaea bombayensis* as approximately 4,000-6,000 plants, based on field reconnaissance in the Shoalhaven Gorge. In December 2019 a fire burnt 78% of the known habitat of *B. bombayensis*, covering all of the known distribution except a 1 km section of the river and some areas that burnt more patchily. This fire killed mature adults and triggered mass recruitment of seedlings. However, a severe flood in February 2020, two months after the fire, uprooted and washed away an unknown number of unburnt mature adult plants, as well as soil containing seeds (Appleby 2022). Subsequent repeated severe flood events in 2020-22 washed away more mature *B. bombayensis* plants and many seedlings (Appleby 2022).
- A survey in 2022 following multiple fire and flood events recorded over 8,000 plants scattered across 33 sites along a 10.5 km stretch of the river (Appleby 2022). Overall, approximately 57% of the counted individuals consisted of seedlings yet to reach reproductive maturity (Appleby 2022), meaning that the total number of mature individuals is currently estimated at approximately 3,440 assuming that 43% of the total population consists of reproductively mature plants, inclusive of the two large sites not included in the 2022 census. There is not sufficient monitoring data to determine the proportion of the current cohort of seedlings that are yet to reach reproductive maturity and that may survive to maturity to accurately estimate a likely future mature population size. As such, the current population size

NSW Threatened Species Scientific Committee

is considered to be 3,440-6,000 mature individuals. The lower bound of this range represents mature plants that survived the 2019 fire and reproductively mature plants from the cohort of post-fire seedlings recorded in 2022 (Appleby 2022), with the upper bound represented by the maximum estimate for a mature population in McDougall (2009).

6. Genomic study of *Bossiaea bombayensis* found extremely low genetic diversity, suggesting this species is unlikely to be resilient to climate events or disease and may be prone to inbreeding depression (McMasters *et al.* 2022). Based on the potential for pollination and seed dispersal by floodwaters to occur over many kilometers, and on genetic information (McMasters *et al.* 2022), all records of *B. bombayensis* are considered to be part of a single subpopulation as per the IUCN (2024) definition. The majority of individuals are located on the banks of the Shoalhaven River around Bombay, with a smaller cluster of individuals located 9 km to the north along the river at Warri.
7. *Bossiaea bombayensis* has only been found over a 16 km stretch of the Shoalhaven River in a steeply incised valley on sandy and rocky slopes and terraces above the frequent flood line of the river (McDougall 2009). It generally occurs in a narrow (<30m) strip between the riverbank and rocky slopes to the crest of the riparian area, although a few plants have been found above the crest just north of Bombay Bridge (Appleby 2022). A range of plant sizes have been observed, suggesting that recruitment is occurring more or less continuously and is not strictly reliant on fire or other mass disturbance event (McDougall 2009).
8. *Bossiaea bombayensis* is a fire sensitive obligate seeder, with adults killed by fire followed by mass recruitment of seedlings (Appleby 2022). *Bossiaea bombayensis* can reproduce sexually from seeds or asexually via root suckers (McMaster *et al.* 2022). It flowers in September and October and the fruits dehisce by mid-December (McDougall 2009, Thompson 2012). Like most other members of the genus, flowers are pollinated by bees, wasps, beetles, and other insects (Bradbury *et al.* 2015; Stock 2019; Toon *et al.* 2014). Cross pollination can occur over many kilometers in species pollinated by bees (Beekman and Ratnieks 2001; Greenleaf *et al.* 2007; Smith *et al.* 2017). *Bossiaea bombayensis* has small seeds with an aril (Thompson 2012), suggesting ants may contribute to dispersal. For this riparian species, floodwaters may also be important for seed dispersal, and in scarification to enable germination (McDougall 2009).
9. The main threats to *Bossiaea bombayensis* are competition from weeds, and the increased frequency and severity of floods and fires as a result of climate change. Additionally, disturbance from visitor recreation and road maintenance, habitat degradation from feral pigs and Sambar deer, and disease including *Phytophthora cinnamomi* infection are all considered to be contributing to localised declines in the species. 'Anthropogenic climate change', 'Invasion and establishment of Scotch Broom (*Cytisus scoparius*)', 'Invasion of native plant communities by exotic perennial grasses', 'Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants', 'High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition', 'Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa* Linnaeus 1758', 'Herbivory and

NSW Threatened Species Scientific Committee

environmental degradation caused by feral deer', and 'Infection of native plants by *Phytophthora cinnamomi*' are listed as Key Threatening Processes in the Act.

10. When the most serious plausible threat of increased weed competition following fire and/or flood events is considered, the sole subpopulation of *Bossiaea bombayensis* can be considered a single threat-defined location, as per the IUCN definition (IUCN 2024).
11. Continuing decline is inferred in the quality and extent of habitat available for *Bossiaea bombayensis* due to weed invasion, especially by scotch broom (*Cytisus scoparius*), willows (*Salix* spp.), blackberry (*Rubus anglocandicans*) and African lovegrass (*Eragrostis curvula*) (NSW Scientific Committee 2009; Appleby 2022). Since the fire of 2019 and subsequent repeated major floods, the impact of weeds on the population of *B. bombayensis* has changed. Weed infestations on the banks of the Shoalhaven River in and adjacent to the known habitat of *B. bombayensis* are severe and extensive (Appleby 2022; V. Wong pers. obs. November 2022). Dense thickets, tens to hundreds of metres long and 5 to 30 m wide along the river banks, of predominantly scotch broom and blackberry, grow adjacent to known *B. bombayensis* habitat, preventing the species from colonising these areas (M. Appleby and V. Wong pers. obs. November 2022). Less dense, but spreading, invasions of these weeds occur in rockier areas, causing a considerable ongoing decline in the quality and availability of habitat.
12. Continuing decline in the number of mature individuals and the quality and extent of habitat of *Bossiaea bombayensis* is inferred from increased severity of floods due to climate change. While floods are a regular feature of the habitat of *B. bombayensis*, the timing of repeated severe flood events just over two months after the 2019 fire and again in the following months has killed unburnt adult plants, scoured away a large amount of riverbank soil (and presumably seeds and seedlings), deposited localised large piles of flood debris, and covered other areas in mud and sand (Appleby 2022). The repeated large floods have eroded the width of the banks within the river corridor (M. Appleby *in litt.* April 2022). As such, bank erosion, in combination with dense *Acacia* regrowth up slope from the river in areas affected by fire, has driven population reductions and effectively limited the extent of post-fire establishment and habitat of *B. bombayensis* (M. Appleby 2022). The intense La Nina events of 2020-22 highlight the vulnerability of the species to major repeated flood events, which are predicted to increase in frequency and severity with climate change (BOM 2022). As such, continuing decline in the species is inferred from increased severity of floods due to climate change.
13. The *Bossiaea bombayensis* population is susceptible to high frequency fires, and if another fire should occur in the next couple of years before the current cohort of seedlings matures, population reductions might occur. Short time intervals between fires in obligate seeders can kill standing plants before they are able to produce seeds, disrupting the replenishment of seed banks, which are essential to post-fire recruitment and population persistence (Enright *et al.* 2015; Gallagher *et al.* 2020; Zimmer *et al.* 2021). However, *B. bombayensis* grows in an area where there is no recorded history of fire prior to 2019 (Department of Planning and Environment 2023), and this could indicate that the species would be sensitive to any increase in fire, particularly severe fire. Such fires are increasingly likely in

NSW Threatened Species Scientific Committee

south-eastern Australia under projected changes to fire conditions due to climate change (Abatzoglou *et al.* 2019; Bowman *et al.* 2020; AdaptNSW 2023). Fire risk may also be increased by camping and/or campfires at Warri and in the Bombay Reserve (M. Appleby *in litt.* June 2023).

14. *Bossiaea bombayensis* K.L.McDougall 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: *Bossiaea bombayensis* was found to be Critically Endangered under Clause 4.3(a)(d)(ei,iii)

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 under Clause 4.3(a)(d)(ei,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,	

NSW Threatened Species Scientific Committee

	(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: Vulnerable under Clause 4.4(c)(ei,ii(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: Not met

The total number of mature individuals of the species is:

NSW Threatened Species Scientific Committee

	(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: Vulnerable under Clause 4.7**

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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Supporting Documentation:

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NSW Threatened Species Scientific Committee

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NSW Threatened Species Scientific Committee

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