Notice of Preliminary Determination

The NSW Threatened Species Scientific Committee, established under the *Biodiversity Conservation Act 2016* (the Act), has made a Preliminary Determination to support a proposal 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.

How to make a submission

The NSW TSSC welcomes public involvement in the assessment process and places preliminary determinations on public exhibition on the NSW TSSC pages on the Department of Planning, Industry and Environment (DPIE) website. This public exhibition provides an opportunity for the public to comment on this preliminary determination as well as provide any additional information that is relevant to the assessment.

Postal submissions regarding this Preliminary Determination may be sent to:

Secretariat
NSW Threatened Species Scientific Committee
Locked Bag 5022
Parramatta NSW 1481.

Email submissions in Microsoft Word or PDF formats may be sent to:

scientific.committee@environment.nsw.gov.au

Submissions close 15th March 2024.

What happens next?

After considering any submissions received during the public exhibition period the NSW TSSC will make a Final Determination and a notice will be placed on the DPIE website to announce the outcome of the assessment. If the Final Determination is to support a listing, then it will be added to the Schedules of the Act when the Final Determination is published on the legislation website. www.legislation.nsw.gov.au.

Privacy information

The information you provide in your submission may be used by the NSW TSSC in the assessment to determine the conservation status and listing or delisting of threatened or extinct species, threatened populations and threatened or collapsed ecological communities or to assess key threatening processes.

The NSW TSSC may be asked to share information on assessments with NSW Government agencies, the Commonwealth Government and other State and Territory governments to collaborate on national threatened species assessments using a common assessment method and to assist in the management of species and ecological communities.

If your submission contains information relevant to the assessment it may be provided to state and territory government agencies and scientific committees as part of this collaboration.

If you wish your identity and personal information in your submission to be treated as confidential you must:

- ***request your name be treated as confidential***, and
- ***not include any of your personal information in the main text of the submission or attachments so that it can be easily removed.***

Senior Professor Kristine French
Chairperson
NSW Threatened Species Scientific Committee

Public Exhibition period: 15/12/2023 – 15/03/2024

Preliminary Determination

The NSW Threatened Species Scientific Committee, established under the *Biodiversity Conservation Act 2016* (the Act), has made a Preliminary Determination to support a proposal 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) (e i, iii) because: i) it has a very highly restricted geographical range (EOO is 20 km^2); ii) all mature individuals occur within a single threat-defined location; iii) ongoing decline is inferred in habitat quality and availability because of competition from weeds, especially Scotch Broom, Blackberry, Willow and African Lovegrass; and iv) ongoing decline is projected in population size and in habitat area and quality because of increased severity of floods from climate change.

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*. Bossiaea bombayensis* is a recently described species (McDougall 2009*).* 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 than

laterals; standard to c. 8 mm long, similar in length to wings and keel, adaxially yellow with a red are, 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^{o}."

2. *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 reserve. It grows mostly on private land but also on WaterNSW land which includes the Bombay Reserve, Crown land and Travelling Stock Reserve (Appleby 2022). 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 Zimmer 2017, Appleby 2022).

3. *Bossiaea bombayensis* has a highly restricted geographic distribution with an Extent of Occurrence (EOO) of 9 km^2 and an Area of Occupancy (AOO) of 20 km^2. The AOO is based on 2 x 2 km grid cells, the scale recommended for assessing area of occupancy by IUCN (2022). The EOO is based on a minimum convex polygon enclosing all mapped occurrences of the species, the method of assessment recommended by IUCN (2022). 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 Standards and Petitions Committee 2019). As such, the EOO is also taken to be 20 km^2.

4. 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. This estimate is likely to be of low data quality as it is not based on recorded survey data. Almost all the individuals of the species are located around Bombay with a 7 km gap (or 9 km along the river banks) to a small cluster of 58 individuals located at Warri (M. Appleby and V. Wong pers. obs. November 2023). A post-fire survey, conducted in 2022, recorded over 8,000 plants, of which 498 were mature and the rest were seedlings (94%), scattered across 33 sites along a 10.5 km stretch of the river (Appleby 2022). However, there is not sufficient monitoring data to determine the proportion of the current cohort of seedlings that may survive to maturity to estimate a likely future mature population size.

5. 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 population (= 1 subpopulation for IUCN Criterion C), with the majority of individuals located on the banks of the Shoalhaven River around Bombay and a smaller cluster of individuals located 9 km to the north along the river at Warri.

6. *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 (McDougall 2009).

7. *Bossiaea bombayensis* is a fire sensitive obligate seeder, with adults killed by fire followed by mass recruitment of seedlings (Appleby 2022). In December 2019 a fire burnt 78% of the known habitat, including all of its known distribution except a 1km section of the river and a patchy burn in some areas. This fire killed mature adults and triggered mass recruitment of seedlings. Unburnt monitoring plots at Bombay have seedlings accounting for 16% of the total individuals counted (Appleby 2022). In burnt monitoring areas, 57% of the total number of individuals were seedlings that established in the years following the first post-fire germination event (Appleby 2022).

8. *Bossiaea bombayensis* can reproduce sexually from seeds or asexually from root suckers (McMaster *et al.* 2022). It flowers in September and October with yellow and red pea flowers 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.* 2016). *Bossiaea bombayensis* has small seeds with an aril (Thompson 2012), suggesting ants may contribute to dispersal. Ants have been found to disperse seeds mostly less than 2m and rarely over 4 m (Westoby 1991). For this riparian species, floodwaters may also be important for seed dispersal, and in scarification (McDougall 2009).

9. The main threat to *Bossiaea bombayensis* and its habitat continues to be competition from weeds which results in the full population of the species being considered as occurring in one threat defined location as defined by the IUCN (2022). Increased severity of floods as a result of climate change, high frequency fire, disturbance from visitors and road maintenance, feral pigs and disease are also threats to *B. bombayensis.*

10. Weed invasion and competition, especially by Scotch Broom *Cytisus scoparius*, Willows *Salix* spp., Blackberry *Rubus discolor* spp. agg and African Lovegrass *Eragrostis curvula* (Appleby 2022; NSW Scientific Committee 2009), is the main threat to *Bossiaea bombayensis*. Since an extensive wildfire in 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 riverbanks 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. Ongoing decline is inferred in the population size from competition from weeds. Occasional weed control is conducted by the Queanbeyan-Palerang Regional Council at the small Bombay Reserve (M. Appleby *in litt.* June 2023), but it does not address weeds in the majority of the species' habitat area.

11. Increased severity of floods as a result of climate change is projected to cause continuing decline in the population and habitat quality of *Bossiaea bombayensis*. 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 through 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 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 intensity with climate change (BOM 2022).

12. The *Bossiaea bombayensis* population is susceptible to high frequency fires and should another fire occur in the next couple of years before the current cohort of seedlings matures, population reductions are likely to occur. Short time intervals between fires in obligate seeders can disrupt 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 history of fire prior to the 2019 fire (Department of Planning and Environment 2023b). As such, frequent recurrent fire in habitat of *B. bombayensis* is highly unlikely under projected changes to fire conditions under ongoing climate change (Abatzoglou *et al*. 2019; Bowman *et al*. 2020). However, fire risk may be increased by camping and/or campfires at Warri and in the Bombay Reserve (M. Appleby *in litt.* June 2023).

13. *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 Critically Endangered under Clause 4.3 (a) (d) (e i, 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) (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: Vulnerable under Clause 4.4 (c)(e i, 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:			
	(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.

Senior Professor Kristine French
Chairperson
NSW Threatened Species Scientific Committee

Supporting Documentation:

Wong V (2023) Conservation Assessment of *Bossiaea bombayensis* K.L.McDougall (Fabaceae*)*. NSW Threatened Species Scientific Committee.

References:

Abatzoglou JT, Williams AP, Barbero R (2019) Global emergence of anthropogenic climate change in fire weather indices. *Geophysical Research Letters* **46**, 326–336.

Appleby M (2022) '*Bossiaea bombayensis* 2022 Post-fire Survey.' Unpublished report to the Department of Planning and Environment, Sydney.

Beekman M, Ratnieks FLW (2000). Long-range foraging by the honey-bee, *Apis mellifera* L. *Functional Ecology*, **14(4)**, 490–496.

Bengsen AJ, Gentle M.N, Mitchell JL, Pearson HE, Saunders GR (2014) Impacts and management of wild pigs *Sus scrofa* in Australia. *Mammal Review*, **44(2),** 135–147.

Bradbury D, Tapper SL, Coates D, Hankinson M, McArthur S, Byrne M (2016) How does the post-fire facultative seeding strategy impact genetic variation and phylogeographical history? The case of *Bossiaea ornata* (Fabaceae) in a fire-prone, mediterranean-climate ecosystem. *Journal of Biogeography*, **43(1),** 96–110.

Bowman DM, Kolden CA, Abatzoglou JT, Johnston FH, van der Werf GR, Flannigan M (2020) Vegetation fires in the Anthropocene. *Nature Reviews Earth & Environment* **1(10)**, 500–515.

Bureau of Meteorology (BOM) (2022) State of the Climate 2022. Available at: http://www.bom.gov.au/state-of-the-climate/ (accessed on 17 March 2023).

Department of Planning and Environment (2023b) NPWS Fire History – Wildfire and Prescribed Burns. Available at: https://datasets.seed.nsw.gov.au/dataset/fire-history-wildfires-and-prescribed-burns-1e8b6 (accesse4d 12 July 2023).

Enright NJ, Fontaine JB, Bowman DMJS, Bradstock RA, Williams RJ (2015) Interval squeeze: Altered fire regimes and demographic responses interact to threaten woody species persistence as climate changes. *Frontiers in Ecology and the Environment* **13(5)**, 265–272.

Forsyth DM, McLeod SR, Scroggie M, White MD (2009) Modelling the abundance of wildlife using field surveys and GIS: non-native sambar deer (*Cervus unicolor*) in the Yarra Ranges, south-eastern Australia. *Wildlife Research*, **36(3)**, 231–241.

Gallagher RV, Allen S, Mackenzie BD, Yates CJ, Gosper CR, Keith DA, Auld TD (2021) High fire frequency and the impact of the 2019–2020 megafires on Australian plant diversity. *Diversity and Distributions* **27(7)**, 1166–1179.

Greenleaf SS, Williams NM, Winfree R, Kremen C (2007) Bee foraging ranges and their relationship to body size. *Oecologia* **153(3)**, 589–596.

IUCN Standards and Petitions Subcommittee (2022) Guidelines for Using the IUCN Red List Categories and Criteria, Available at: http://www.iucnredlist.org/documents/RedListGuidelines.pdf (accessed on 24 April 2022)

McDougall KL (2009) Four new species related to *Bossiaea bracteosa* F.Muell. ex Benth. in south-eastern Australia. *Telopea*. **12**, 347–360.

McMaster ES, Yap J-YS, Rossetto M (2022) Conservation genomics of *Bossiaea* species in South-eastern Australia in support of management. Australian Institute of Botanical Science.

NSW Scientific Committee NSW (2003) Infection of native plants by *Phytophthora cinnamomi* – key threatening process listing. Available at: https://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/nsw-threatened-species-scientific-committee/determinations/final-determinations/2000-2003/infection-of-native-plants-by-phytophthora-cinnamomi-key-threatening-process-listing (accessed 29 April 2022).

NSW Scientific Committee (2009) Final determination to list the shrub *Bossiaea bombayensis* K.L.McDougall as a VULNERABLE SPECIES. Available at: http://www.environment.nsw.gov.au/determinations/bossiaeabombayensisFD.htm (accessed 24 April 2023)

Smith JP, Heard TA, Beekman M, Gloag R (2017) Flight range of the Australian stingless bee *Tetragonula carbonaria* (Hymenoptera: Apidae). *Austral Entomology*, **56(1)**, 50–53.

Stock S (2019) Divergence in floral morphology and pollinator interactions in two sympatric Australian pea plants. *Field Studies in Ecology*, **2(1)**

Thackway R, Cresswell ID (1995) 'An Interim Biogeographic Regionalisation for Australia: A Framework for Setting Priorities in the National Reserves System Cooperative Program.' Australian Nature Conservation Agency, Canberra.

Toon A, Cook LG, Crisp MD (2014) Evolutionary consequences of shifts to bird-pollination in the Australian pea-flowered legumes (Mirbelieae and Bossiaeeae). *BMC Evolutionary Biology*, **14(1)**, 1–11.

Westoby M, French K, Hughes L, Rice B, Rodgerson L (1991) Why do more plant species use ants for dispersal on infertile compared with fertile soils? *Australian Journal of Ecology*, **16(4)**, 445–455.

Zimmer H (2017) Conservation Assessment for *Bossiaea bombayensis* K.L.McDougall (Fabaceae). Threatened Species Scientific Committee.

Zimmer H, Allen J, Smith R, Gibson R, Auld T (2021) Post-fire recruitment and resprouting of a threatened montane eucalypt. *Australian Journal of Botany*, **69**, 21–29.