

# NSW Threatened Species Scientific Committee

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## Conservation Assessment of *Bossiaea bombayensis* K.L.McDougall (Fabaceae)

Vera Wong and Gavin P. Phillips 16/05/2024

Biodiversity and Conservation Division

NSW Department of Climate Change, Energy, the Environment and Water

### ***Bossiaea bombayensis* K.L.McDougall (Fabaceae)**

*Distribution:* Endemic to NSW

*Current EPBC Act Status:* Not listed

*Current NSW BC Act Status:* Vulnerable

*Proposed listing on NSW BC Act:* Critically Endangered

Reason for change: Genuine change based on competition from weeds and loss of habitat following recent fire and repeated severe flood events.

### **Summary of Conservation Assessment**

*Bossiaea bombayensis* was found to be eligible for listing as Critically Endangered under Criterion B1ab(iii,v).

The main reasons for this species being eligible are: (1) it has a very highly restricted geographical range on the banks of the Shoalhaven River west of Braidwood (EOO is 20 km<sup>2</sup>); (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.

### **Description and Taxonomy**

*Bossiaea bombayensis* K.L.McDougall (family Fabaceae), also known as Bombay Bossiaea, is a small, wiry shrub of the legume family. *Bossiaea bombayensis* was previously included within *Bossiaea bracteosa sensu lato*, a widespread taxon occurring on the Central and Southern Tablelands and South Coast of NSW, and in Victoria and South Australia (James and Harden 2002; McDougall 2009). Taxonomic research resulted in *Bossiaea bracteosa sensu lato* being split into several new taxa, three of which occur in NSW including *B. bombayensis* (McDougall 2009). Conservation genomic work has more recently confirmed the species status of *B. bombayensis* (McMasters *et al.* 2022).

*Bossiaea bombayensis* was originally described by McDougall (2009). Thompson (2012) revised the *Bossiaea* of eastern Australia and 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.

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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 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* can be distinguished from other taxa within *Bossiaea bracteosa sensu lato* by the following features: from *B. fragrans* and *B. milesiae* by its equal to almost equal calyx lobes, from *B. bracteosa* by its much shorter, truncate leaf scales, and from *B. grayi* by its narrow, dark green cladode branches, smaller flowers and pods, alternating red and colourless staminal filaments, and general reddish appearance (of its flowers, new growth, calyx and pods) (McDougall 2009).

## Distribution and Abundance

The NSW Scientific Committee (2009) stated that “*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’ known range extends along the Shoalhaven River between the localities of Bombay and Warri.

*Bossiaea bombayensis* occurs on the traditional lands of the Yuin people who have a strong and ongoing cultural connection with their traditional lands and waters (AIATSIS 2022). Aboriginal Peoples have cared for Country for tens of thousands of years (Bowler *et al.* 2003; Clarkson *et al.* 2017).

Searches of potential habitat both upstream and downstream of the known occurrence have not led to the discovery of any further populations of *Bossiaea bombayensis* (McDougall pers. comm. March 2008 in NSW Scientific Committee 2009; Appleby 2022). Most of the potential distribution of the species has been recently surveyed except along the west bank downstream from Bombay Creek (Appleby 2022).

*Bossiaea bombayensis* is not found in any conservation reserve. It grows mostly on private land, but also on land managed by WaterNSW, Crown land and a Travelling Stock Reserve (Appleby 2022).

The distribution of *Bossiaea bombayensis* is based on 60 unique records compiled from NSW BioNet Atlas, Atlas of Living Australia (ALA), herbarium databases, and 39 records from survey results (M Appleby *in litt.* May 2022). An outlying record situated

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7 km north of Warri (ALA: CANB 875447.1) has been excluded from this data set as it is considered a misidentification and targeted searches have not found *B. bombayensis* in this area (M. Appleby pers. comm. November 2022).

## Population size and trends

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 (McDougall 2009). 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).

In December 2019 a fire burnt 78% of the known habitat of *Bossiaea 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 these events recorded over 8,000 plants scattered across 33 sites along a 10.5 km stretch of the river (Appleby 2022). Excluding two of the largest sites with 'estimated individuals numbering thousands' of plants, this survey counted 498 mature plants having survived the fire and floods and approximately 1,820 post-fire seedlings that were already reproductively mature and bearing buds and flowers (Appleby 2022). Overall, approximately 57% of the counted individuals consisted of seedlings yet to reach reproductive maturity (Appleby 2022), meaning that the total 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 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). Observations from one monitoring site post-2019 suggest that the species was recorded over a slightly greater extent pre-fire than post-fire, but numbers were not documented (Appleby 2022). However, the total number of mature individuals is inferred to have declined as a result of competition from weeds and loss of streambank habitat from scouring from repeated major flood events.

Based on the potential for pollination and seed dispersal by floodwaters to occur over many kilometres, and on genetic information (McMasters *et al.* 2022), all records of *Bossiaea 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.

## Extent of Occurrence and Area of Occupancy

The Area of Occupancy (AOO) is 20 km<sup>2</sup> 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 km<sup>2</sup> 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 km<sup>2</sup>. The calculated EOO (9 km<sup>2</sup>) is slightly lower than previous estimates (NSW Scientific Committee 2009) of 25-55 km<sup>2</sup>, which is a reflection of record accuracy, rather than a population decline.

## Number of Locations

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). This is due to the current effects of weeds being largely consistent across the full range of the species, and could plausibly further affect any or all of the population following future flood or fire events.

## Ecology

*Bossiaea bombayensis* is a wiry shrub that 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 has been observed, suggesting that recruitment is occurring more or less continuously and is not reliant on fire or other mass disturbance event (McDougall 2009).

*Bossiaea bombayensis* occurs in shrubland vegetation and rarely extends into neighboring dry sclerophyll woodland (McDougall 2009). Associated species include *Callitris endlicheri*, *Grevillea arenaria*, *Lomandra longifolia*, *Micrantheum hexandrum*, *Pomaderris andromedifolia* and *Leptospermum polygalifolium* (McDougall 2009). The species is found in, but not restricted to, the Plant Community Type Southeast Tableland Rocky Riparian Scrub (PCT 4083) (Department of Planning and Environment 2023a).

*Bossiaea bombayensis* can reproduce from seeds or from 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.* 20014). Cross pollination can occur over many kilometres in species pollinated by bees (Beekman and Ratrieks 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. 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 to enable germination (McDougall 2009).

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*Bossiaea bombayensis* is a fire sensitive obligate seeder, with adults killed by fire followed by mass recruitment of seedlings (Appleby 2022). Fire is not strictly required for regeneration however, with seedling germination appearing to be a regular event (McDougall 2009; Appleby 2022). Recruitment is thought to be continuous as stands of mixed age classes have been recorded both pre- and post-fire (McDougall 2009; Appleby 2022). Following the December 2019 fire, it was also noted that seedling germination appeared to be ongoing, with small numbers of seedlings apparent from each subsequent year in the majority of burnt sites (Appleby 2022), which may indicate a breakdown of seed dormancy over time helping to create mixed-aged stands.

This species appears well-adapted to low soil moisture, with leaves reduced to cladodes and its ability to grow in rocky crevices and sandy lenses exposed to light and heat with very little soil volume (Appleby 2022). The species did not appear to be affected by the 2017–2019 drought: no drought-related mortality or other long-term effects were recorded in unburnt monitoring plots following the December 2019 fire (Appleby 2022).

A 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).

*Bossiaea bombayensis* has been observed to reach maturity in 2-4 years (Appleby 2022). The longevity of individual plants is unknown and generation length has not been calculated.

## Threats

The main threat to *Bossiaea bombayensis* and its habitat continues to be competition from weeds, especially scotch broom (*Cytisus scoparius*), willows (*Salix* spp.), blackberry (*Rubus anglocandicans*) and African lovegrass (*Eragrostis curvula*) (Appleby 2022; NSW Scientific Committee 2009). The threat of weed competition is also being exacerbated by the increased frequency and severity of floods and fires as a result of climate change, and these threats themselves have been noted to cause continuing declines by destroying standing plants and removing the soil seedbank.

Furthermore, several minor threats may also be contributing to localised declines in *Bossiaea bombayensis*. There is noted human disturbance from visitors at a small recreation reserve at Bombay, a camping area at Warri (Appleby 2022) and a large sand quarry 1.5 km upstream from Warri, all of which add to habitat disturbance and the ability for weeds to spread and establish. The maintenance of trails to these areas and the trampling by feral animals such as pigs and deer also physically disturbs the plants, and *Phytophthora cinnamomi* is considered likely to be contributing to disease within the population.

## Competition from weeds

The main threat to *Bossiaea bombayensis* is 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). In addition, local occurrences of serrated tussock (*Nassella trichotoma*), Gorse (*Ulex europaeus*), exotic pines (*Pinus* spp.), fleabane (*Conyza* spp.), mullein (*Verbascum* spp.), plaintain (*Plantago* spp.), purpletop (*Verbena bonariensis*), spear thistle (*Cirsium vulgare*) and cats ears (*Hypochaeris radicata*) may also threaten the species (Appleby 2022; NSW Scientific Committee 2009).

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Scotch broom, blackberry, African lovegrass, serrated tussock and gorse have been identified as Weeds of National Significance, because of their invasiveness, potential for spread, and economic and environmental impacts (Department of Primary Industry 2023).

In its 2009 Final Determination, the NSW Scientific Committee (2009) stated that “These weeds are widespread but, at present, rarely dominate the local vegetation in this area” and that “Although parts of the habitat are affected, weeds are not currently considered to be causing decline in *Bossiaea bombayensis* (K. McDougall pers. comm. March 2008).” 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. Continuing decline is inferred in the population size also due to this strong competition from weeds.

Conversely, weeds such as African Lovegrass tussocks can act as a nursery for emerging *Bossiaea bombayensis* seedlings, providing shelter and a moist-micro habitat (M. Appleby 2022). This means that any increase in control of these weeds may inadvertently result in the loss of individuals of *B. bombayensis* over time as well. 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 presently address weeds in the majority of the species’ habitat area.

‘Invasion and establishment of Scotch Broom (*Cytisus scoparius*)’, ‘Invasion of native plant communities by exotic perennial grasses’ and ‘Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants’ are listed as Key Threatening Processes under the *Biodiversity Conservation Act 2016*.

## Increased frequency and severity of floods as a result of climate change

While floods are a regular feature of the habitat of *Bossiaea 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. ‘Anthropogenic climate

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change' is listed as a Key Threatening Process under the *Biodiversity Conservation Act 2016*.

## High Frequency Fire

If another fire should occur in the next couple of years before the current cohort of *Bossiaea bombayensis* seedlings matures, population reductions might occur. *Bossiaea bombayensis* is considered to be an obligate seeder, with mass germination triggered by disturbances (including fire). 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 history of fire prior to the 2019 fire (Department of Planning and Environment 2023b), and this could indicate that the species would be sensitive to any increase in fire, particularly severe fire. Such fires are increasingly likely in 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).

'High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition' is listed as a Key Threatening Process under the *NSW Biodiversity Conservation Act 2016*.

## Disturbance from visitor recreation and road maintenance

The Shoalhaven River at Bombay Reserve is a significant place of recreation for local residents (McDougall 2009) and *Bossiaea bombayensis* is at higher risk of being trampled and disturbed at this site. Several mature plants were recently killed during maintenance works on the road adjacent to this reserve also (Appleby 2022). Recent survey of the very small Warri site also showed disturbance from campers and caravanners (Appleby pers. obs. November 2022).

## Habitat degradation from feral pigs and deer

Feral pigs (*Sus scrofa*) and Sambar Deer (*Rusa unicolor*) are a potential ongoing threat to *Bossiaea bombayensis*. Feral pigs and Sambar Deer have a particular affinity for wet areas of the landscape, which they use for feeding and wallowing (Bengsen *et al.* 2014; Forsyth *et al.* 2009). Domestic stock, feral cattle, feral deer and feral pigs can cause damage to riverbanks including vegetation removal, soil disturbance and increased turbidity. Trampling by pigs was observed during recent surveys in habitat of *B. bombayensis* (Appleby 2022).

'Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa* Linnaeus 1758' and 'Herbivory and environmental degradation caused by feral deer' are both listed as Key Threatening Processes under the *Biodiversity Conservation Act 2016*.

## Disease

Recent surveys found that adult plants and seedlings were discoloured and showing signs of disease in several patches and dead unburnt plants were noted in some sites (Appleby 2022). While the cause of the dieback is unknown, *Bossiaea bombayensis* may be susceptible to the introduced pathogen *Phytophthora cinnamomi*, as other *Bossiaea* species are strongly suspected to be adversely affected (NSW Scientific

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Committee 2003). *Phytophthora cinnamomi* has had a devastating effect on plant communities world-wide, causing catastrophic dieback in many species. The risk of *Phytophthora* is increased by visitation at Bombay Reserve and Warri and potentially could be introduced from upstream sources.

'Infection of native plants by *Phytophthora cinnamomi*' is listed as a Key Threatening Process on the *Biodiversity Conservation Act 2016*.

## Damming of the Shoalhaven River

Although not currently in planning, damming of the Shoalhaven River (such as the currently shelved Welcome Reef proposal) may pose a future threat to *Bossiaea bombayensis*, and could affect about 80% of suitable habitat for the species (K. McDougall pers. comm, in NSW Scientific Committee 2009).

## **Assessment against IUCN Red List criteria**

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

### *Criterion A Population Size reduction*

#### Assessment Outcome: Data Deficient

Justification: To be listed as threatened under Criterion A the species must have experienced a population reduction of  $\geq 30\%$  over three generations or 10 years (whichever is longer). There is insufficient data to assess *Bossiaea bombayensis* against this criterion because the generation time is unknown and there is no long-term monitoring data to inform any population reductions, especially as current seedling cohorts mature.

### *Criterion B Geographic range*

#### Assessment Outcome: Critically Endangered under Criterion B1ab(iii, v)

Justification: *Bossiaea bombayensis* has a very highly restricted geographic range with both the Extent of Occurrence (EOO) and Area of Occupancy (AOO) estimated to be 20 km<sup>2</sup>. *Bossiaea bombayensis* meets the EOO threshold for Critically Endangered (<100 km<sup>2</sup>) under Criterion B1. The AOO meets the threshold for Endangered (<500 km<sup>2</sup>) under Criterion B2 but is above the threshold for Critically Endangered (<10 km<sup>2</sup>).

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),  $\leq 5$  (EN) or  $\leq 10$  (VU) locations.

Assessment Outcome: Met for Critically Endangered due to having one threat-defined location.

Justification: *Bossiaea bombayensis* is found at one threat-defined location when considering the most serious plausible threat of increased weed competition following fire and/or flood events is considered.



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*Bossiaea bombayensis* is not considered severely fragmented as all individuals are found in a large, non-isolated subpopulation and the subpopulation is considered viable.

- 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: Met for (iii) area, extent and/or quality of habitat and (v) number of mature individuals.

Justification: Continuing decline is inferred in the quality of habitat from competition from weeds, particularly scotch broom, blackberry, willow and African lovegrass, particularly after disturbance events such as severe fire and floods. The first two of those species have been identified as Weeds of National Significance, because of their invasiveness, potential for spread, and economic and environmental impacts (Department of Primary Industry 2023). Continuing decline in habitat area and quality is also inferred from increasing severity of floods as a result of climate change causing loss of areas of riverbank. Continuing decline in the number of mature individuals has in turn been observed as a result of the physical removal of plants and the washing away of the soil seedbank following repeat severe floods, and the resulting competition from weeds which suppress subsequent germination.

- c) Extreme fluctuations.

Assessment Outcome: Data Deficient.

Justification: Currently there is no available data to assess the likelihood of extreme fluctuations in *Bossiaea bombayensis*.

## Criterion C *Small population size and decline*

Assessment Outcome: Vulnerable under Criterion C2a(ii)

Justification: The estimated population size of *Bossiaea bombayensis* is 3,440-6,000 plants (NSW Scientific Committee 2009; Appleby 2022), which meets the threshold for Vulnerable (<10,000 mature individuals) but exceeds the threshold for Endangered (<2500 mature individuals). In addition, 100% of mature individuals occur in one subpopulation.

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 generation (whichever is longer) (CR); 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 is insufficient data to assess *Bossiaea bombayensis* against this subcriterion.

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

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## Assessment Outcome: Met

Justification: Continuing decline is inferred in the number of individuals from competition from weeds, particularly scotch broom, blackberry, willow and African lovegrass and from loss of habitat resulting from the removal of plants, soil and soil seedbanks due to the increased frequency and severity of floods as a result of climate change.

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

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

## Assessment Outcome: Not met

Justification: The species is considered to occur in a single population of 3,440 to 6,000 mature individuals, which does not meet the threshold of  $\leq 1,000$  to be listed using this Subcriterion.

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

## Assessment Outcome: Met for Vulnerable

Justification: 100% of the mature individuals of *Bossiaea bombayensis* are within one subpopulation.

- b. Extreme fluctuations in the number of mature individuals

## Assessment Outcome: Data deficient

Justification: Currently there is no available data to assess the likelihood of extreme fluctuations in *Bossiaea bombayensis*.

## *Criterion D Very small or restricted population*

### Assessment Outcome: Vulnerable under Criterion D2

Justification: *Bossiaea bombayensis* has a population size of 3,440-6,000 mature individuals. However, it also has an AOO of 20 km<sup>2</sup> and occurs at one threat-defined location, rendering it prone to the effects of human activities and stochastic events that may rapidly drive the species to extinction in a very short time period.

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: Not met.

Justification: The total number of mature *Bossiaea bombayensis* individuals is estimated to be 3,440-6,000.

- D2. Population with a very restricted area of occupancy (typically less than 20 km<sup>2</sup>) or number of locations (typically five or fewer) such that it is prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and is thus capable of becoming CR or even EX in a very short time period.

## Assessment Outcome: Vulnerable under Criterion D2

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Justification: *Bossiaea bombayensis* has an AOO of 20 km<sup>2</sup> and occurs at a single threat-defined location. Increased competition from long-lived and aggressive weeds in combination with increased disturbance due to more frequent and severe fire and flood events are already apparent at this location, and therefore present a plausible threat that can drive *B. bombayensis* to become Critically Endangered or Extinct in a very short time period.

*Criterion E Quantitative Analysis*

Assessment Outcome: Data Deficient

Justification: Currently there is not enough data to undertake a quantitative analysis to determine the extinction probability of *Bossiaea bombayensis*.

## Conservation and Management Actions

*Bossiaea bombayensis* is currently listed on the NSW *Biodiversity Conservation Act 2016* and a conservation project has been developed by the NSW Department of Climate Change, Energy, the Environment and Water under the Saving our Species program. The conservation project identifies priority locations, critical threats and required management actions to ensure the species is extant in the wild in 100 years. *Bossiaea bombayensis* sits within the Site Management stream of the SoS program and the conservation project can be viewed here:

<https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=20125>

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## Expert Communications

Appleby, Mary. Species expert and consulting ecologist, NSW.

Brinkley, Erin. Upper Shoalhaven Landcare Coordinator, NSW.

Roper, Erika. Former Threatened Species Officer, Southeast Ecosystems and Threatened Species Branch, Department of Planning and Environment, Wollongong, NSW.

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## APPENDIX 1

### 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**

<b>(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:</b>			
	(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.
<b>(2) - The determination of that criteria is to be based on any of the following:</b>			
	(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)**

<b>The geographic distribution of the species is:</b>			
	(a)	for critically endangered species	very highly restricted, or
	(b)	for endangered species	highly restricted, or
	(c)	for vulnerable species	moderately restricted,
<b>and at least 2 of the following 3 conditions apply:</b>			
	(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,

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		(iii)	the number of locations in which the species occur or of populations of the species.
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**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))**

<b>The estimated total number of mature individuals of the species is:</b>			
	(a)	for critically endangered species	very low, or
	(b)	for endangered species	low, or
	(c)	for vulnerable species	moderately low,
<b>and either of the following 2 conditions apply:</b>			
	(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**

<b>The total number of mature individuals of the species is:</b>			
	(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**

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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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