

Notice 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 reject a proposal to list the tree *Eucalyptus benthamii* Maiden & Cabbage as an Endangered species in Part 2 of Schedule 1 of the Act and to list *Eucalyptus benthamii* Maiden & Cabbage as a Critically Endangered species in Part 1 of Schedule 1 of the Act and, to omit reference to *Eucalyptus benthamii* Maiden & Cabbage from Part 3 of Schedule 1 (Vulnerable species) of the Act. A Conservation Assessment report and Preliminary Determination for *Eucalyptus benthamii* Maiden & Cabbage as an Endangered species was published from 1st July 2022 to 1st October 2022. Following consideration of advice and submissions received, *Eucalyptus benthamii* Maiden & Cabbage is to be listed as a Critically Endangered species. Listing of Critically Endangered species is provided for by Part 4 of the Act.

Summary of Conservation Assessment

Eucalyptus benthamii Maiden & Cabbage was found to be Critically Endangered in accordance with the following provisions in the *Biodiversity Conservation Regulation 2017*: Clause 4.2 (1)(a)(2)(c). The main reasons for the listing are that the species has a suspected very large population reduction over a 3-generation period (including both past and future) and the causes of reduction may not have ceased and may not be reversible. This reduction is mainly due to extensive habitat loss and modification in the past and ongoing threats including habitat loss, altered hydrology, the effects of introduced plant and animal species, hybridisation, and an altered fire regime.

The NSW Threatened Species Scientific Committee has found that:

1. *Eucalyptus benthamii* Maiden & Cabbage is described by PlantNET (2022) as a “Tree to 40 m high; bark smooth, white, shedding in short ribbons or flakes. Juvenile leaves opposite, elliptic to ovate, dull grey-green to glaucous. Adult leaves disjunct, lanceolate, 8–12 cm long, 1.5–2 cm wide, green, dull, concolorous. Umbellasters 7-flowered; peduncle terete, 5–6 mm long; pedicels terete, 0–2 mm long. Buds ovoid or clavate, sometimes glaucous, 3–5 mm long, 2–3 mm diam., scar present, but outer calyptra not shedding cleanly; calyptra hemispherical, shorter than and narrower than or as wide as hypanthium. Fruit campanulate, 4–5 mm long, 4–5 mm diam.; disc flat or raised; valves exerted.” Brooker & Kleinig (1990) note that the bark decorticates to ground level or is retained as a small stocking of imperfectly decorticated rough bark at the base.
2. *Eucalyptus benthamii* is endemic to New South Wales (NSW) and currently known from western Sydney and the Blue Mountains in the Sydney Basin Bioregion (*sensu* SEWPaC 2012). The original habitat for the species was on the flats of the Nepean River and its tributaries (Benson 1985). Since European settlement much of the habitat has been cleared for agriculture and urbanisation or submerged beneath the waters of Warragamba Dam (Benson 1985). This includes the loss of sites along the Coxs River and a site on the Hawkesbury-Nepean River in the vicinity of

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its confluence with the Grose River (historic northern limit). Today, populations remain along the Kedumba River and some of its lower tributaries (current north-western limit); the Nattai River (southern limit); and the mid-lower Nepean River between Wallacia and Camden (eastern limit in the Camden area). The Nattai population and part of the Kedumba Valley population are within the Greater Blue Mountains World Heritage Area.

3. The geographic distribution of *Eucalyptus benthamii* is highly restricted. The area of occupancy (AOO) is estimated to be 116 km², based on the species' occupying twenty-nine 2 x 2 km grid cells, the spatial scale of assessment recommended by IUCN (2022). The extent of occurrence (EOO) is estimated to be 1207 km² using a minimum convex polygon enclosing all mapped occurrences of the species with sufficient spatial accuracy for this purpose, as recommended by IUCN (2022).
4. The population size of *Eucalyptus benthamii* is moderately low with the total number of mature individuals estimated to be 4,500-10,200. A large percentage (c.88%) of this estimate is within the Kedumba Valley within the Blue Mountains National Park. Along the Nepean River, *E. benthamii* sites are dominated by adult trees with very low recruitment as there is little regeneration due to agricultural practices and competition with weeds (England 2016) along with hybridisation and low seed viability and germination rates (Butcher *et al.* 2005). The population size of the Nattai NP occurrence remains largely unknown, although the area of suitable habitat along the Nattai River is restricted.
5. *Eucalyptus benthamii* occurs on riverbanks and alluvial flats in tall open forest. It is known to occur in 'River-Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions' threatened ecological community (TEC) (NSW Scientific Committee 2011). Associated species of the largest population in the Kedumba Valley include *E. crebra*, *E. deanei*, *E. punctata*, *Leptospermum polygalifolium*, *Acacia filicifolia* and *Pteridium esculentum* and at the Bents Basin site include *Eucalyptus elata*, *E. bauerina*, *E. amplifolia*, *E. deanei*, *Angophora subvelutina*, *Bursaria spinosa*, and *Pteridium esculentum* (DPE 2022). *Eucalyptus benthamii* is a long-lived tree likely to live more than 250 years (Benson 1985) though other studies have shown some species of long-lived eucalypts can be at least 300-400 years old (Brookhouse 2006). The primary juvenile period is not known but thought to be approximately 6-10 years (Benson 1985) for some plants and probably 10-20 years for most plants (following the pattern identified in *Eucalyptus delegatensis* by Doherty *et al.* 2017). Plants can likely produce fruit for 250-350 years after the primary juvenile period. Generation length for *E. benthamii* is estimated to be 263 to 376 years (Douglas and Scott 2023). Seed is dispersed locally by wind and seedling recruitment follows flood or soil disturbance and requires open sites. Benson (1985) noted that significant seedling recruitment following fire did not occur and seedlings were outcompeted by other local species, including weeds. Following fire, *Eucalyptus benthamii* resprouts by producing epicormic shoots along the trunk and major branches and/or resprouting from the base of the trunk (Benson 1985). Severe fire, as seen in 1997 at Bents Basin, may lead to the death of some trees of all sizes (particularly small ones measuring <20 cm diameter at breast height) and for some larger trees, the bole may be structurally weakened (Benson 1985).

6. The main threats to *Eucalyptus benthamii* are habitat loss and fragmentation (land clearing, urban development, proposed raising of the Warragamba Dam wall and construction of other smaller dams), changed hydrology (flood mitigation and proposed raising of the Warragamba Dam wall), weed invasion, and inappropriate fire regimes (Benson *et al.* 1996, cited in Butcher *et al.* 2005; Gardiner 2004; DPE 2022; DoE 2014). Other threats include habitat degradation caused by feral animals, mowing (Barker 2017), inbreeding depression and hybridisation with *Eucalyptus viminalis* (Manna Gum) (Butcher *et al.* 2005). These threats have led to loss of *E. benthamii* and associated habitat and remnant populations are now isolated within an extensively modified and fragmented habitat (NSW NPWS 2000). These threats, often in combination, have led to limited recruitment of *E. benthamii* and associated habitat species. Anthropogenic climate change is likely to exacerbate these existing threats and lead to an increased likelihood of drought and changes to disturbance regimes such as fire and floods (OEH 2014).
7. Habitat loss and fragmentation: Vegetation clearing has occurred in the past and is ongoing for *Eucalyptus benthamii*. Clearing of riparian habitat in western Sydney was evident in the early 1800s, while much of the urbanisation of the area occurred in the past 140 years (Benson and Howell 1990). Extensive habitat loss has occurred in the past due to clearing of floodplain and riparian forest for timber and agriculture, and later for mining of soil, sand and gravel in some areas (see for e.g., Benson 1985; Butcher *et al.* 2005; England 2016). Further losses are possible due to infrastructure creation associated with increasing urbanisation (e.g., additional or wider road and rail bridges, water pipelines, and powerlines) and apparently likely due to continuing or expanding 'sand mining' at the locality of Elderslie (BioNet Atlas records from GS LLS 2015). Further urbanisation of catchments containing the species is also predicted for all but the Kedumba Valley, with the Nepean sites likely to be most affected. Habitat loss in the Kedumba Valley is likely due to the proposed raising of the Warragamba Dam wall (see below). 'Clearing of native vegetation' is listed as a Key Threatening Process under the Act.
8. Altered Hydrology: The Warragamba Dam built in 1960 led to the inundation and loss of large areas of habitat of *Eucalyptus benthamii* (SMEC 2021). Further loss of habitat will occur if the proposal to raise the height of the Warragamba Dam wall by 14m proceeds. "The *E. benthamii* habitat in the upstream and downstream study areas [of the dam raising project] has been assessed as critical habitat because it is important for dispersal, the long-term maintenance of the species and for maintaining genetic diversity. The Project could potentially adversely affect this habitat through the direct removal of vegetation, increasing the presence of invasive species, erosion and deposition, and modifying hydrology and the fire regime." (SMEC 2021). Annual Exceedance Probability (AEP) describes the probability of a flooding event being equalled or exceeded in a given year; and is used in SMEC (2021) as an indicator of flooding frequency associated with raising the Warragamba dam wall. "The Project could potentially impact (modify or destroy) up to 107.39 hectares of [*E. benthamii*] habitat within the upstream 1% AEP and 10.73 hectares within the 20% AEP." (SMEC 2021). The population of *E. benthamii* in the Kedumba Valley is the largest and least disturbed population of the species and the modification and/or destruction of the habitat is expected to cause the

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population of *E. benthamii* in the Kedumba Valley to decline (SMEC 2021). 'Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands', is listed as a Key Threatening Process under the Act.

9. Weeds: Recruitment of *Eucalyptus benthamii* and associated habitat species at a number of sites is affected by growth of dense weeds, for example *Gleditsia triacanthos* (Honey Locust), *Olea europaea* subsp. *cuspidata* (African Olive), *Ligustrum* spp. (Privet), *Acer negundo* (Box Elder), *Opuntia* spp. (Cactus), *Cardiospermum* spp. (Balloon Vine), *Asparagus asparagoides* (Bridal Creeper), *Rubus* spp. (Blackberry) and exotic grasses such as *Cynodon* spp. (Couch) and *Paspalum* spp. (DPE 2022). The Nepean sites have the worst areas of weed infestations often leading to areas of dense shade and competition that are likely to prevent the germination of *E. benthamii* and associated habitat species. The Bents Basin area has *Olea europaea* (African Olive), *Ligustrum sinense* (Small-leaved Privet), *Ligustrum lucidum* (Large-leaved Privet), *Lantana camara* (Lantana), *Cardiospermum* spp. (Balloon Vine), *Lonicera japonica* (Japanese Honeysuckle), *Solanum seaforthianum* (Climbing Nightshade), *Asparagus asparagoides* (Bridal Creeper), and *Tradescantia fluminensis* (Wandering Spiderwort) as problem species (Barker 2017). The Kedumba population is considered to have relatively low levels of weed species (Butcher *et al.* 2005) but is nonetheless at risk given part of the valley was used for farming until it was added to the National Park in relatively recent history, and that the headwaters of the Kedumba River include urban areas of the higher Blue Mountains in which weed species are well-established. Weed species are likely to occur within suitable habitat for *E. benthamii* in the Nattai River system near the location of the two records of the species. That catchment receives runoff from urban, commercial and rural areas, and sewerage treatment plants in the Southern Highlands. 'Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall ex G. Don) Cif.', 'Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants' and 'Invasion and establishment of exotic vines and scramblers' are listed as a Key Threatening Processes under the Act.

10. Changed fire regime: Altered fire frequency and high fire severity can impact *Eucalyptus benthamii*. High severity fire is known to damage the canopy of the species (Fairley 2004), kill seedlings and saplings and cause damage to tree boles in large individuals (Benson 1985). Around 30-54% of the distribution of *E. benthamii* overlapped with the spatial extent of the 2019/2020 fires (Gallagher 2020), particularly the Kedumba Valley and Nattai populations. Most mature trees survived by resprouting from epicormic buds or basal sprouts, but seedlings and saplings experienced high rates of mortality. The population at Bents Basin State Conservation Area experiences planned and unplanned fires. Benson (1985) noted damage to and death of some individuals, especially where combustible flood debris had accumulated around trunk bases, leading to fire of high severity. Benson (1985) also noted the relationship between altered flood regimes and excessive accumulation of flammable debris. Other known populations are generally subject to infrequent fire as they occur in highly modified riparian or managed parkland contexts where fire is now absent or extremely rare. Sites along the Nepean River and The Oaks are within extensively cleared land with rural or urban land use and

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with extensive mesophyll weed invasion. The lack of fire in these areas may impede recruitment of *E. benthamii* because fire may have been advantageous to germination by removing or thinning competing vegetation (including weeds) and providing an exposed ash bed to allow rapid seedling establishment.

11. Feral animals: Deer and goats may destroy seedlings and saplings by browsing, which in some cases includes stripping bark from trunks, promoting disease entry, or even ring-barking the tree. Deer are noted to be abundant in Bents Basin SCA (and presumably environs) by DPIE (2014), with evidence of deer damaging trees in *Eucalyptus benthamii* habitat (Barker 2017). Livestock grazing is also recognised as a threat (Han *et al.* 2020). Feral Pigs (*Sus scrofa* Linnaeus 1758) are likely to be a problem at most occurrences of the species because they share a preference for riparian habitats (NSW SC 2004). Feral Pigs are likely to destroy seedlings/saplings through digging (NSW SoS 2022) and may also promote weed invasion. 'Herbivory and environmental degradation caused by feral deer', and 'Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa* Linnaeus 1758' are listed as a Key Threatening Processes under the Act.
12. Habitat modification and disturbance from mowing or slashing is likely to be common on parts of rural and rural-residential properties that support the species and may also prevent or limit the extent of recruitment, and increasingly confine the species to unmown areas such as riparian zones. Barker (2017) reported detrimental effects of mowing and slashing in planted and some natural occurrences within a part of Bents Basin SCA.
13. *Eucalyptus benthamii* has undergone and is likely to undergo a very large reduction in population size. There is a suspected population reduction of greater than 80% over a 3-generation period in the past based on habitat quality and the causes of reduction may not have ceased and may not be reversible. This reduction is based on the loss of vegetation types (that *E. benthamii* is associated with) since European settlement: with estimated declines across the Sydney Basin of 80-95% for Cumberland Riverflat Forest (Tozer *et al.* 2010) and 75-95% for Cumberland Swamp Oak Riparian Forest (OEH 2013). Assuming that *E. benthamii* underwent declines similar to those experienced by the vegetation types with which it is associated, there is a suspected population reduction of greater than 80% over a 3-generation period in the past based on habitat quality. Future decline from tree mortality, lack of recruitment, loss of habitat and habitat degradation across the species range due to increased urbanisation and weed impacts, in addition to the declines that would result from the proposed raising of the Warragamba Dam wall, is projected in the next 20-50 years. Note that some 88% of the remaining total population for the species occurs in the Kedumba Valley and SMEC (2021) states that the proposal to raise the Warragamba Dam wall will lead to the modification and/or destruction of habitat and is expected to cause the population of *E. benthamii* in the Kedumba Valley to decline. When combined, past habitat loss and future reduction is >80% over 3 generations. Consequently, there is a suspected population reduction of greater than 80% over a 3-generation period (including both past and future) based on habitat quality and the causes of reduction may not have ceased and may not be reversible.

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14. *Eucalyptus benthamii* Maiden & Cabbage 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 4.2 (1)(a)(2)(c)

**Clause 4.2 – Reduction in population size of species
(Equivalent to IUCN criterion A)**

Assessment Outcome: Critically Endangered under Clause 4.2 (1)(a)(2)(c)

(1) - The species has undergone or is likely to undergo within a time frame appropriate to the life cycle and habitat characteristics of the taxon:			
	(a)	for critically endangered species	a very large reduction in population size, or
	(b)	for endangered species	a large reduction in population size, or
	(c)	for vulnerable species	a moderate reduction in population size.
(2) - The determination of that criteria is to be based on any of the following:			
	(a)	direct observation,	
	(b)	an index of abundance appropriate to the taxon,	
	(c)	a decline in the geographic distribution or habitat quality,	
	(d)	the actual or potential levels of exploitation of the species,	
	(e)	the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.	

**Clause 4.3 – Restricted geographic distribution of species and other conditions
(Equivalent to IUCN criterion B)**

Assessment Outcome: Endangered under Clause 4.3 (b) (d) (e i, ii, iii, iv).

The geographic distribution of the species is:			
	(a)	for critically endangered species	very highly restricted, or
	(b)	for endangered species	highly restricted, or
	(c)	for vulnerable species	moderately restricted.
and at least 2 of the following 3 conditions apply:			
	(d)	the population or habitat of the species is severely fragmented or nearly all the mature individuals of the species occur within a small number of locations,	
	(e)	there is a projected or continuing decline in any of the following:	
		(i)	an index of abundance appropriate to the taxon,
		(ii)	the geographic distribution of the species,
		(iii)	habitat area, extent or quality,

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	(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 Clause C)

Assessment Outcome: Vulnerable under Clause 4.4 (c) (d, iii)

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: Clause 4.5 is 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.

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Clause 4.6 – Quantitative analysis of extinction probability (Equivalent to IUCN criterion E)

Assessment Outcome: Data Deficient

The probability of extinction of the species is estimated to be:			
	(a)	for critically endangered species	extremely high, or
	(b)	for endangered species	very high, or
	(c)	for vulnerable species	high.

Clause 4.7 – Very highly restricted geographic distribution of species– vulnerable species (Equivalent to IUCN criterion D2)

Assessment Outcome: Clause 4.7 is Data Deficient.

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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