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## Notice of and reasons for the Final Determination

The NSW Threatened Species Scientific Committee, established under the *Biodiversity Conservation Act 2016* (the Act), has made a Final Determination to list the tree *Eucalyptus fracta* K.D.Hill as an ENDANGERED SPECIES in Part 2 of Schedule 1 of the Act and, as a consequence, to omit reference to *Eucalyptus fracta* K.D.Hill in Part 3 of Schedule 1 (Vulnerable Species). Listing of Endangered species is provided for by Part 4 of the Act.

### Summary of Conservation Assessment

*Eucalyptus fracta* K.D.Hill was found to be Endangered in accordance with the following provisions in the *Biodiversity Conservation Regulation 2017*: Clause 4.3(b)(d)(e i) because: 1) *Eucalyptus fracta* has a highly restricted Area of Occupancy (AOO) of 52 km<sup>2</sup> and a highly restricted Extent of Occurrence (EOO) of 233 km<sup>2</sup>; 2) *Eucalyptus fracta* is known from three threat-defined locations; and 3) continuing decline is inferred in the number of mature individuals due to adverse fire regimes, particularly increased frequency of severe wildfire.

The NSW Threatened Species Scientific Committee has found that:

1. *Eucalyptus fracta* K.D.Hill (family Myrtaceae) is a tree or mallee to 8 m tall. The bark is a hard ironbark-type to branches c. 7 cm diam., then smooth, whitish. Small branches slightly glaucous. Juvenile leaves blue-green, dull, disjunct-opposite, orbiculate, later ovate, 3–6 cm long, 2.5–3.5 cm wide; petioles 0.5–0.8 cm long. Adult leaves dull to slightly glossy grey-green, disjunct-opposite, simlifacial, lanceolate, acuminate, 7–11 cm long, 1–2.5 cm wide; petioles 0.8–1.8 cm long. Inflorescences compound, often axillary; umbellasters 7-flowered. Peduncles terete, 6–10 mm long. Pedicels terete, 1–5 mm long. Mature buds fusiform, 6–8 mm long, 2–3 mm diam. Calyptra conical, acute or apically rounded, slightly shorter than to about as long as hypanthium. Outer calyptra shed long before anthesis. Stamens irregularly flexed, all fertile. Anthers adnate, basifixed, cuboid to globoid, opening by lateral pores. Fruits cup-shaped, 3–4-locular, 5–8 mm long, 5–7 mm diam. Calyptra scar and staminophore flat, < 0.2 mm wide. Disc vertically depressed, 1–1.5 mm wide. Valves broadly triangular, acute, steeply raised, level with staminophore or slightly exserted (Hill 1997).
2. *Eucalyptus fracta* is an uncommon species endemic to ranges along the southern edge of the Hunter Valley in New South Wales (NSW). It is restricted to upper escarpments of steep sandstone ranges along the Broken Back and Hunter Ranges which form the southern edge of the Hunter Valley west of Cessnock. When the species was initially described in 1997, it was only known from the northern section of the Broken Back Range in Pokolbin State Forest (Hill 1997). More recently, sites from further northwest at Sentry Box Point in Yengo National Park and Glen Gallic Fire Trail in Wollemi National Park have been identified (Hager and Benson 2010; Bell 2019; DPE 2023).
3. The population of *Eucalyptus fracta* consists of three subpopulations. All sites around the northern part of the Broken Back Range form a single subpopulation spanning approximately 9.5 km east to west. In this area, there are large tracts of

## NSW Threatened Species Scientific Committee

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continuous habitat between recorded sightings of the species and the size of stands in the area can be quite large, with *E. fracta* often being dominant (S. Bell *in litt.* April 2023). Given this, and that no records here are more than 3 km apart, these sites are likely to have ongoing gene flow based on pollen dispersal distances reported in other eucalypts (Ashton and Sandiford 1988; Butcher *et al.* 2005; Byrne *et al.* 2008; Jones *et al.* 2008; Breed *et al.* 2015). The two outlying sites, Sentry Box Point, approximately 11.5 km northwest of Broken Back Range, and Glen Gallic, approximately 42 km further northwest, are likely to be genetically distinct given their geographic isolation. Thus, they are both considered distinct subpopulations as per the IUCN definition (IUCN 2022).

4. The population of *Eucalyptus fracta* is estimated to contain a minimum of 3,539–3,639 individuals across all three subpopulations, with this number considered to be highly conservative. All known plants are considered mature at this time, as seedling establishment appears rare and counts to date are based on mature sized and/or reproductively fertile plants (Copeland and Hunter 2005; Bell 2019; DPE 2023). Currently, at least 3,039–3,139 plants are estimated to be in the Broken Back Range subpopulation, approximately 50 plants are estimated to be in the Sentry Box Point subpopulation and the Glen Gallic subpopulation is estimated to have a minimum of 450 plants. However, the ridgetops and suitable habitat extend much further than have been currently surveyed at all sites, and so it is highly likely that many more plants will be in all subpopulations (S. Bell *in litt.* April 2023).
5. The geographic distribution of *Eucalyptus fracta* is highly restricted. The Area of Occupancy (AOO) of *E. fracta* is estimated to be 52 km<sup>2</sup> using 2 x 2 km grid cells, the scale recommended by IUCN (2022). The Extent of Occurrence (EOO) is estimated to be 233 km<sup>2</sup> and is based on a minimum convex polygon enclosing a cleaned dataset of known occurrences of the species, the method of assessment recommended by IUCN (2022).
6. When the threat of adverse fire regimes, especially increased frequency of severe wildfires, is considered, the three subpopulations of *Eucalyptus fracta* can be considered to occur at three separate threat-defined locations, as per the IUCN definition (IUCN 2022). This is due to the increased frequency of severe wildfires being the most serious plausible threat that results in the lowest number of locations for the taxon. The fire history shows that these three locations have different fire histories and are unlikely to be impacted by the same individual fire event or have the same fire regime (frequency and/or severity) now and in the future (NPWS 2022).
7. *Eucalyptus fracta* is restricted to shallow and skeletal soils along the upper ridgetops of a series of sandstone escarpments (Hill 1997; Copeland and Hunter 2005; DPE 2023). It only occurs on very steep slopes and around cliff lines where rocky boulders and exposed rock are common (S. Bell *in litt.* April 2023) and appears to favour dry, exposed northerly aspects (Copeland and Hunter 2005).
8. In the Broken Back Range, *Eucalyptus fracta* is the dominant tree along a narrow band of the upper escarpments, where it occurs most commonly with scattered individuals of *Corymbia maculata* and *Eucalyptus punctata*, with an open, sparse understorey containing *Olearia elliptica*, *Acacia parvipinnula* and *Pultenaea spinosa*, *Cleistochloa rigida*, *Plectranthus parviflorus* and *Dichondra repens* (Hill

## NSW Threatened Species Scientific Committee

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1997; S. Bell *in litt* April 2023). Where this community merges with taller forest downslope, scattered *E. fracta* can be found with more abundant *C. maculata* and *E. punctata*, along with *Eucalyptus sparsifolia* and *Angophora costata* subsp. *euryphylla* (Hill 1997; S. Bell *in litt*. April 2023). At Glen Gallic, *E. fracta* often co-occurs with *Eucalyptus sparsifolia* and *Eucalyptus punctata* as co-dominants in the canopy, with an understorey of *Daviesia acicularis*, *Bursaria spinosa*, *Acacia piligera*, *Grevillea montana* and *Macrozamia reducta* (DPE 2023).

9. *Eucalyptus fracta* has been recorded vigorously resprouting following fire (Copeland and Hunter 2005) and this is likely to be the primary response of the species following major disturbance. Eucalypts such as *E. fracta*, in which a mallee or stunted form can be derived due to environmental constraints and where a tree is the main form evident on deeper soils, employ a combination sprouting strategy when burnt (Nicolle 2006).
10. The mallee form of *Eucalyptus fracta* in exposed sites shows that it can develop substantial lignotubers (G. Phillips pers. obs. November 2019). This is likely driven by the harsh conditions experienced on the rocky escarpments, with taller, single-stemmed trees often found on deeper soils adjacent to the cliffs (DPE 2023). Stem resprouting tends to develop only in larger stem sizes in combination resprouters, with resprouting limited to basal coppicing only in plants with smaller stems (Zimmer *et al.* 2021) and this appears to also be true for *E. fracta* (DPE 2023). This points to a situation where species such as *E. fracta* could be driven to increased reliance on lignotuber resprouting following continued events that cause stem death, such as heavy drought and severe fire. In these situations, stems are not afforded sufficient time to grow to a size that can support epicormic reshooting.
11. Seedling recruitment in eucalypts is typically intermittent and rarely observed without disturbance (Keeley 1995) and this also appears true for *Eucalyptus fracta* (DPE 2023). As with other eucalypts, *E. fracta* develops an aerial seed bank where seeds can be stored for several years in the canopy, with seed being slowly released over time or *en masse* following death of a stem or branch (Tozer and Bradstock 1997; G. Phillips pers. obs. November 2019). Once released, seedling establishment and survival in eucalypts is often dependent on soil moisture availability and competition for resources when growing in nutrient poor soils (Wellington and Noble 1985; Auld *et al* 1993; Tozer and Bradstock 1997). Reduced competition, increased light levels, and nutrient influxes provided by fire are then all thought to bolster recruitment (Etchells *et al.* 2020). Little data on seedling recruitment regimes has been collected for *E. fracta* to date, but given the sparse recruitment observed on site in years away from disturbance (G. Phillips pers. obs. November 2019, November 2021) it is possible that the species requires fire to stimulate stronger germination events. This however may depend heavily on the fire regime, as limited seedling recruitment has also been observed in areas where repeat severe fires have occurred (DPE 2023).
12. Since the original listing of *Eucalyptus fracta* (NSW Scientific Committee 1999), surveys have uncovered more subpopulations (Copeland and Hunter 2005; Bell 2019) and serious threats have become apparent. These include adverse fire regimes (Copeland and Hunter 2005; A. Fawcett *in litt.* September 2018; DPE 2023), which are now considered the most serious plausible threat to the species. Of particular concern are higher frequencies of high severity wildfire, following observations of reduced resprouting vigour in the Glen Gallic subpopulation due to

## NSW Threatened Species Scientific Committee

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this mechanism (DPE 2023). Physical disturbance due to land uses including timber harvesting, firewood collection and track maintenance activities may also have adverse effects on the species (OEH 2019), though these threats may be minimised as rock outcrops and areas of skeletal soils are protected in Pokolbin State Forest and do not support species likely to be affected by timber harvesting (NSW EPA 2018). '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 Act.

13. Continuing decline is inferred in the number of individuals of *Eucalyptus fracta* due to the increasing frequency of severe wildfires. *Eucalyptus fracta* stands have been burnt by wildfire up to three times in the past 44 years (NPWS 2022). However, recent surveys in the Glen Gallic subpopulation have revealed that significant structural change may be underway following two severe wildfires within seven years (DPE 2023). Higher intensity wildfire can alter stand structure and understorey species competition, as well as increase mortality of dominant eucalypts (Etchells *et al.* 2020). Death of above-ground stems in a combination resprouter species like *Eucalyptus fracta* pushes the species to rely more on basal coppicing alone to regenerate, as larger stems capable of epicormic regrowth are eliminated in hotter fires (Zimmer *et al.* 2021). This pattern is enhanced if intense fires become more frequent, further limiting the species' ability to coppice and reducing the chance of escape from subsequent fires (Zimmer *et al.* 2021). This process appears to now be underway in the Glen Gallic subpopulation, where a significant portion of trees were observed to have been burnt at high severity in the February 2020 Kerry Ridge wildfire following a similar high severity wildfire in November 2013 (DPE 2023). While no complete mortality was observed during systematic surveys analysing post-fire effects following the 2020 fire, approximately three years post-fire, coppicing has become the dominant response, with limited epicormic regrowth (DPE 2023). Additionally, the coppice growth of *E. fracta* remained on average only 1-1.5 m in height, much lower than expected compared to previous surveys, and was in overall poor health (DPE 2023).
14. Given the Hunter Region in which *Eucalyptus fracta* occurs is predicted to become hotter, more hot days over 35°C annually, and an increase in average and severe fire weather by 2079 (CSIRO and BOM 2022; AdaptNSW 2023) and that fire weather is predicted to become harsher and the time spent in drought is predicted to increase on the East Coast through the 21<sup>st</sup> century (CSIRO 2023), it is highly plausible that more frequent severe fires driven by these changes in climate will impact the *E. fracta* population in the future. Other populations affected by severe wildfires in 2019/20, such as in the Broken Back Range and Sentry Box Point subpopulations, are therefore at increased risk if another severe fire occurs given the observations of lowered coppice vigour at the Glen Gallic site following the repeat severe fires there (DPE 2023). Thus, continuing decline is inferred in the number of mature individuals of *E. fracta* given this threat is likely to continue to increase into the future, exacerbating and expanding the processes of structural change and increased mortality risk observed at Glen Gallic.
15. *Eucalyptus fracta* K.D.Hill is not eligible to be listed as a Critically Endangered species.

# NSW Threatened Species Scientific Committee

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16. *Eucalyptus fracta* K.D.Hill is eligible to be listed as an Endangered species as, in the opinion of the NSW Threatened Species Scientific Committee, it is facing a very high risk of extinction in Australia in the near 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:** Endangered under Clause 4.3(b)(d)(e i).

**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: Endangered under Clause 4.3(b)(d)(e i)**

<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,

## NSW Threatened Species Scientific Committee

	(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: Not met.**

<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

# NSW Threatened Species Scientific Committee

	(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: Not met.

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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Senior Professor Kristine French  
Chairperson  
NSW Threatened Species Scientific Committee

### Supporting Documentation:

Phillips G.P. (2023) Conservation Assessment of *Eucalyptus fracta* K.D.Hill (Myrtaceae). NSW Threatened Species Scientific Committee.

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## NSW Threatened Species Scientific Committee

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## NSW Threatened Species Scientific Committee

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