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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 shrub, *Hakea dohertyi* Haegi as a Critically Endangered species in Part 1 of Schedule 1 of the Act, and, as a consequence, to omit reference to *Hakea dohertyi* Haegi in Part 2 of Schedule 1 (Endangered species) of the Act. Listing of Critically Endangered species is provided for by Part 4 of the Act.

The NSW Threatened Species Scientific Committee is satisfied that *Hakea dohertyi* Haegi has been duly assessed by the Commonwealth Threatened Species Scientific Committee under the Common Assessment Method, as provided by Section 4.14 of the Act. After due consideration of DCCEEW (2023), the NSW Threatened Species Scientific Committee has made a decision to list the species as Critically Endangered.

Summary of Conservation Assessment

Hakea dohertyi Haegi 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)(f i) because: i) the species has a very highly restricted geographic distribution (the estimated extent of occurrence is 78 km^2); ii) the entire population occurs within one location in which the interaction between drought and fire could rapidly affect all individuals; iii) a continuing decline in the number of mature individuals, and the area, extent and quality of habitat is inferred based on the observed adverse effects of the recent drought and bushfires, which have an increasing likelihood of frequent recurrence in the future, driven by anthropogenic climate change; and iv) there is extreme fluctuation in the number of mature individuals.

The NSW Threatened Species Scientific Committee has found that:

1. *Hakea dohertyi* Haegi (family Proteaceae), commonly known as the Kowmung Hakea, is a slender erect shrub, growing to four metres. Leaves are long and filament-like with a triangular cross section when cut and a single vein running the length of the leaf, which is prominent on the underside. Clusters of up to six cream-coloured flowers grow at the base of the leaves and form large woody, beaked fruits with a warty surface (Barker *et al.* 1999).

2. *Hakea dohertyi* is endemic to New South Wales (NSW) with a natural distribution restricted to the lands of the Gundungarra and Dharug people (Horton 1996) in the southern Blue Mountains, where it is currently known to occur across three subpopulations (per the definition in IUCN 2022): (1) Kowmung River, near Sombre Dome in Kanangra-Boyd National Park; (2) Tonalli Cove, between the Tonalli River mouth and Tonalli Point in Yerranderie State Conservation Area; and (3) Tonalli Gap Trail, to the east of Yerranderie, in Yerranderie Regional Park and the southern Blue Mountains area in Blue Mountains National Park (DCCEEW 2023).

3. Prior to the 2019–2020 bushfires, the Kowmung River subpopulation was last estimated to contain approximately 7,000 *Hakea dohertyi* (comprising

~2,000 north, and ~5,000 south, of the river; Steenbeeke 1996), Tonalli Cove had fewer than 100 individuals (Offord *et al.* 2003), and Tonalli Gap Trail had 50–100 plants (DCCEEW 2023). Cursory surveys of parts of the Kowmung River subpopulation (Irrae Gowar, Hatchers Ridge, Hatchers Gully, and Willa Gowar spur) in May 2021 (*i.e*., after the bushfires) located 45 surviving adult plants, 145 one-year-old seedlings and 82 two-year-old seedlings (Lembit 2021). Additional surveys conducted in the Sombre Dome area in March 2022, recorded only 12 live seedlings (Lembit 2022). Surveys in the vicinity of the Tonalli Gap Trail in 2022 located 35 seedlings and no surviving adults (Douglas 2022). The subpopulation at Tonnalli Cove has remained inaccessible for post-burn surveys (L. Stephen *in litt*. May 2022). Overall, it is inferred that there has been a 38–57% decline from pre-fire numbers, providing a current estimate of 3,050–4,520 mature individuals (DCCEEW 2023).

4. The extent of occurrence (EOO) of *Hakea dohertyi* is estimated to be 78 km^2, based on a minimum convex polygon, the method of assessment recommended by IUCN (2022). The area of occupancy (AOO) is estimated to be 48 km^2, based on 2 km x 2 km grid cells, the scale recommended for assessing AOO by IUCN (2022). The estimates of EOO and AOO encompass the entire known historical and extant distribution of the species. They are based on a cleaned set of 68 records compiled from the Atlas of Living Australia and the NSW Bionet Atlas, including both herbarium specimens and human observations (DCCEEW 2023). The species' range is not believed to be expanding and it is unknown whether the 2019–2020 bushfires will result in permanent loss sufficient to reduce the species' EOO or AOO.

5. *Hakea dohertyi* is restricted to quartzite substrates on open, rocky slopes in dry sclerophyll forests with generally sparse canopies and understoreys (G. Steenbeeke pers. comm. August 2021). Associated species usually include *Eucalyptus punctata* (Grey Gum), *E. sieberi* (Silvertop Ash), *Persoonia linearis* (Narrow-leaved Geebung), *Allocasuarina littoralis* (Black She-oak), *Lomatia silaifolia* (Crinkle Bush) and *Stypandra glauca* (Nodding Blue Lily) (Steenbeeke 1996). The climate in the region is temperate with warm summers and no dry season (BOM 2005).

6. The primary juvenile period of *Hakea dohertyi* is estimated to be 4–7 years. Lifespan is unknown, but individuals have been observed up to an age of 60 years and may live up to 100 years, based on estimates of annual growth patterns (Steenbeeke 1996; Douglas and Haegi 2020). The seedbank is held within the canopy for upwards of 10 years with a possible maximum of around a third the age of the plant (*i.e.*, up to 33 years; Steenbeeke 1996). The half-life of seeds is approximately 17 years, and based on this, and the range of juvenile periods documented for the species, generation length is estimated to be 21–24 years.

7. *Hakea dohertyi* flowers from August to mid-September (Steenbeeke 1996). Pollinators of this species are unknown, but likely to be insects, as is the case for other *Hakea* species (Steenbeeke 1996). The species appears highly fecund, with fecundity increasing with age, and individuals observed to bear 500–2,000 follicles (*i.e.*, fruits; Steenbeeke 1996). The seeds have high viability (approximately 100%), which remains high for at least seven years (Steenbeeke 1996). They possess no

dormancy mechanisms, and 100% germination has been observed within 14 days when incubated at temperatures of 15°C (Offord *et al.* 2003). In their experiments, Offord *et al*. (2003) found that higher temperatures (20–25°C) slowed the rate of germination, while at 30°C, fewer than 5% of seeds had germinated within 28 days. There is little seed predation believed to occur while seeds are stored within the follicle (Steenbeeke 1996).

8. As the seeds of *Hakea dohertyi* are winged, seed dispersal is likely wind assisted. However, dispersal distances are likely quite short; *Hakea* species with seed weights comparable to the *H. dohertyi* (approximately 14 g) have only been observed to disperse up to 20 m from the parent plant, including due to secondary dispersal via wind blowing seeds across the ground (Groom 2010).

9. Climate change is driving shifts in rainfall and temperatures across the range of *Hakea dohertyi*, increasing the likelihood of the severe droughts and fires (Abram *et al.* 2021) that cause mortality in this species (see details below). 'Anthropogenic Climate Change' and 'High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition' are listed as Key Threatening Processes under the Act.

10. The extent of the 2019–2020 bushfires overlapped with 97% of known records of *Hakea dohertyi* (DPE 2020) and burnt an estimated 89% of the species' modelled range (Gallagher 2020). In addition, the entire range of this species was subject to a severe and prolonged drought from 2017–2019. This period was the driest 36 months on record in the region (BOM 2024) and was a major contributing factor in the extent and severity of the 2019–2020 bushfire season (Abram *et al.* 2021). Given these events, the interaction between drought and fire is the greatest serious plausible threat capable of rapidly affecting all individuals of *H. dohertyi*. Consequently, with respect to this threat, the species' entire distribution is considered a single location.

11. Although *Hakea dohertyi* possesses traits and occurs in a landscape that suggests it is tolerant of drier conditions, the 2017–2019 drought resulted in widespread dieback events across a range of species generally considered tolerant of dry conditions (Nolan *et al.* 2020). Observations of *H. dohertyi* in the Kowmung River subpopulation noted high levels of mortality in apparently unburnt sites where still living adult plants occurred alongside apparently drought-killed plants (G. Steenbeeke pers. comm. August 2021). Time spent in drought is projected, with medium confidence, to increase over the course of the century (CSIRO 2022) and it is inferred that this will contribute to a continued decline of *H. dohertyi*.

12. *Hakea dohertyi* is a serotinous obligate seeder that germinates and recruits readily in the post-fire environment (G. Steenbeeke pers. comm. August 2021). However, plants are killed by exposure to any fire, and exposure to temperatures during fires of > 300°C, or prolonged fires (greater than three minutes), will kill and/or consume seeds in the follicle (Steenbeeke 1996; G. Steenbeeke pers. comm. August 2021). Few seedlings were observed in the areas that were burnt in 2019–2020, compared to the unburnt areas that were affected by drought alone (G Steenbeeke pers. comm. August 2021). This indicates that the canopy seedbank was largely killed during these bushfires, leading to recruitment failure. This failure, combined with

the mortality of mature plants and the canopy seedbank, represents a net decline in total population size, and will result in extreme fluctuation in the number of mature individuals (IUCN 2022). High severity fires are likely to have occurred in the past but are projected to become more frequent in the future (Nolan *et al.* 2020) and it is inferred that this will contribute to a continued decline of *H. dohertyi*.

13. Although *Hakea dohertyi* has a relatively short primary juvenile period, high frequency fire has the capacity to adversely affect the population by interrupting recruitment or limiting the time available for the canopy seedbank to develop and accumulate. Historically, the vegetation this species occurs in had generally quite long fire-free periods. However, climate change is increasing the likelihood of more frequent fire. It is inferred that further population decline is likely if any part of the species' range is burnt again within the next 10–15 years (*i.e.*, before maturation and accumulation of a canopy seedbank; Steenbeeke 1996)

14. *Hakea dohertyi* Haegi 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 4.3 (a)(d)(e i, iii)(f i)

Clause 4.2 – Reduction in population size of species
(Equivalent to IUCN criterion A)
Assessment Outcome: Endangered under Clause 4.2 (1)(b)(2)(a)

(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)(f i)

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 Clause C)
Assessment Outcome: Vulnerable under Clause 4.4 (c)(d iii)(e i, ii(B)(C))

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:

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