Publication date: 24/05/2024

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 *Hakea macrorrhyncha* W.R.Barker as an Endangered species in Part 2 of Schedule 1 of the Act. Listing of Endangered species is provided for by Part 4 of the Act.

The NSW Threatened Species Scientific Committee is satisfied that *Hakea macrorrhyncha* W.R.Barker 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 Endangered.

Summary of Conservation Assessment

Hakea macrorrhyncha W.R.Barker was found to be Endangered in accordance with the following provisions in the *Biodiversity Conservation Regulation 2017*: Clause 4.3 (b)(d)(e i)(f i) because: i) the species has a highly restricted geographic distribution with an Area of Occupancy estimated at 124 km^2; ii) it is known from fewer than five threat-defined locations; iii) continuing decline in the number of mature individuals is estimated and inferred due to adverse fire regimes and increased frequency of drought due to climate change; and iv) the species is susceptible to extreme fluctuations in the number of mature individuals.

The NSW Threatened Species Scientific Committee has found that:

1. *Hakea macrorrhyncha* W.R.Barker (family Proteaceae) is an erect, single-stemmed or forked close to base, shrub or small tree, 1.8–6 m high. Branchlets are densely white-tomentose, with hairs persistent until flowering. Leaves are terete, often grooved below, (3–)4.5–9 cm long, 0.9–1.5 mm wide, initially white-tomentose, quickly glabrescent and smooth. The apex is porrect, with mucro 0.8–1.5 mm long. Inflorescence is an axillary umbel of *c*. three or four flowers. The rachis is knob-like, 0.5–0.7 mm long, white woolly-pubescent. Pedicels are 4–5.5 mm long, moderately densely white short-tomentose. Perianth is 3–3.8 mm long, cream-white, moderately to densely white short-tomentose. The pistil is 6.5–8 mm long, recurved. Fruit laterally broad ovate, 35–45 mm long, 21–25(–30) mm wide, rugose-reticulate. The beak long-triangular, smooth but for small dense round pusticules, decurrent down one side for much of length, very shortly down other; apiculum ± absent; horns obscure. Seed 30–34 mm long, 9–13 mm wide; wing decurrent 1/2–3/4 way down one side of body only, black throughout. Seed body is flanged on pale wood side. The bases of the leaves of *H. macrorrhyncha* are deep pink-red; the pollen presenter is also pink-red from bud stage (Barker 1996).

2. *Hakea macrorrhyncha* occurs in New South Wales (NSW) and Queensland (Qld). The species is known from four main subpopulations: Girraween National Park (Qld) and Bald Rock National Park (NSW) (same contiguous subpopulation), the

Torrington area of the Northern Tablelands of NSW, Gibraltar Range/Washpool National Parks (NSW), Maryland National Park (NSW), as well as a few isolated records from near "The Springs" to the west of Torrington State Conservation Area.

3. The species' distribution is well known, and survey effort is considered adequate to capture the extent of the distribution accurately. However, there have not been sufficient targeted surveys of *Hakea macrorrhyncha* to accurately estimate population size. Based on the records for this species, the most extensive subpopulations appear to be those in the Torrington area and Gibraltar Range/Washpool National Parks. Relatively minor contributions to the known individuals are from the remaining three subpopulations. Based on available information, including a considerable degree of uncertainty in estimating the number of mature individuals post 2019–20 bushfire season, the total number of mature individuals across all populations is considered likely to be greater than 2,500 and less than 10,000.

4. The Torrington subpopulation of *Hakea macrorrhyncha* was surveyed after the 2019–20 bushfires between October 2020 and May 2021 (NSW DPIE 2021). There was observed to be considerable decline in the number of mature individuals with levels of recruitment insufficient to replace lost plants (J. Hunter pers. comm. December 2021). This is based on post-fire survey results where only five of the 57 sites surveyed had live mature individuals, and all mature plants were recorded as dead at the remaining 52 of the 57 sites (NSW DPIE 2021). There were 19 sites with dead adults recorded and no signs of recruitment via seedlings. The surveys were approximately one year after fire and a recruitment response for *Hakea* spp. would typically be expected by then. There were between 350 and 650 live individuals found in total within the survey area, 20 of which were mature, with the remainder juvenile (NSW DPIE 2021). Between 500 and 1800 dead adult individuals were recorded. Similar observations that indicate decline following the 2019-20 fires have also been made in the Gibraltar Range/Washpool subpopulation, with one area noted as being a mix of dead and alive mature plants with many seedlings growing, and another had 10 live mature individuals remaining of an estimated population of >100 pre-fire, along with 100–200 seedling recruits.

5. *Hakea macrorrhyncha* is confined to shrubland heathland, layered open forest, and closed shrubby woodland on granite. Associated species/vegetation includes *Eucalyptus andrewsii* (New England Blackbutt), *E. bancroftii* (Orange Gum), and *Callitris endlicheri* (Black Cypress Pine) low closed woodland (Barker 1996). The Granites lookout site in Washpool National Park is a rocky site with *E. planchoniana* (Needlebark Stringybark), *Leptospermum trinervium* (Flaky-barked Tea-tree), *Kunzea bracteolata, Callistemon flavovirens* (Green Bottlebrush)*, Hovea pedunculata*, *Pseudanthus pauciflorus* and *Pultenaea pycnocephala* (Dense-head Bush-pea) (P. Sheringham pers. comm. July 2022).

6. *Hakea macrorrhyncha* is an obligate seeder (Clarke *et al.* 2009), meaning it does not resprout and relies on recruitment from seed for population persistence through successive fires. Its seed is stored in a canopy seed bank (serotinous). The primary juvenile period of individuals is known to vary across its range (Clarke *et al.* 2009). In the higher rainfall region of Gibraltar Range the primary juvenile period is estimated at four years, whereas in populations in the Torrington area it is

approximately seven years (Clarke *et al*. 2009). Lifespan is unknown but other NSW species of Hakea are varied but moderately long-lived (e.g., *H. dactyloides* (Finger Hakea) approximately 15–20 years, *H. dohertyi* (Kowmung Hakea) 100+ years, *H. salicifolia* (Willow-leaved Hakea) approximately 20–30 years, *H. sericea* (Needlebush) 15–20 years; Benson and McDougall 2000).

7. Flowering occurs from August to September (Clarke *et al.* 2009; though only based on two records). The species' pollinators are not well known, but most *Hakea* species with small, white and cream flowers are insect-pollinated (Hanley *et al.* 2008). Pollinated flowers form tough woody capsules (follicles) typically containing one to two seeds which are held in the canopy for an unknown period of time until the follicles dry out or dehisce due to age or fire. Upon release, the seeds are wind-dispersed. While dispersal distances have not been studied in *Hakea macrorrhyncha,* localised dispersal up to eight metres is known in other *Hakea* species (Hammill *et al.* 1998). Dispersal could occur less commonly over larger distances, depending on updrafts (Keith *et al.* 2020).

8. Following severe fires, the serotinous seed bank of *Hakea macrorrhyncha* is exhausted at the same time as the death of parent plants, meaning that a decline in mature individuals represents a decline in the total number at this time. In such taxa, extreme fluctuations of mature individuals can arise from stochastic variation in post-fire seedling establishment. Therefore, *H. macrorrhyncha* is prone to extreme fluctuations in the number of mature individuals (IUCN 2022).

9. The major threats to *Hakea macrorrhyncha* are adverse fire regimes, in particular higher frequency and higher severity fires, and increased frequency of drought due to climate change. 'High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition' and 'Anthropogenic climate change' are listed as Key Threatening Processes under the Act.

10. Based on the threat of adverse fire regimes, *Hakea macrorrhyncha* has five or fewer threat-defined locations. The estimated maximum number of locations (five) is the same as the estimated subpopulations given the relative geographic isolation of each subpopulation. The minimum number (two) is based on the assumption that another significant fire event, like the 2019–20 bushfire season, may occur in which up to three populations are impacted at once which gives a minimum of two locations.

11. Adverse fire regimes have been estimated and are inferred to be causing continuing decline in the number of mature individuals of *Hakea macrorrhyncha.* The two largest known subpopulations of *H. macrorrhyncha* were burnt in the 2019–20 bushfires (DPIE 2020a). Only one of these subpopulations (Torrington SCA) has been systematically surveyed since, between October 2020 and May 2021, during which it was noted as experiencing a "major reduction in size with minimal recruitment" (J. Hunter pers. comm. December 2021). Given the primary juvenile period of four to seven years across its range, and although rates of seed bank accumulation over subsequent years are yet to be quantified, another fire within the next decade may kill plants before they have matured and replenished the canopy stored seed bank. Consequently, this species is particularly vulnerable

to another fire over the next decade, which could eliminate populations before they replenish their seed banks (DAWE 2022). The limited recruitment observed in Torrington SCA following the 2019–20 bushfires may be in part due to high fire frequency. In particular, the northeast of Torrington SCA has experienced four fires in the last 20 years alone that have impacted many of the sites where the species has been recorded in that area.

12. Severe fire in 2019–20 severely impacted the Torrington subpopulation of *Hakea macrorrhyncha* (J. Hunter pers. comm. December 2021) with some adult plants surviving partial canopy scorch but the majority being killed. Although high severity fires have been known to destroy canopy-held seed in small-fruited *Hakea* species (Bradstock *et al.* 1994), large-fruited species similar to *H. macrorrhyncha* were more likely to survive, with high levels of mortality only occurring at extreme temperatures that may occur in some crown fires. Crown fire was recorded at 8 of the 57 Torrington sites, with juvenile recruitment only occurring at three of these eight extreme-severity fire sites (NSW DPIE 2021), suggesting high severity crown fire may be contributing to these declines.

13. Severe drought is inferred to be contributing to continuing decline in the number of mature individuals of *Hakea macrorrhyncha*. Severe drought can influence seed release (and plant mortality), diminishing the ability of *Hakea macrorrhyncha* to adequately replenish its seedbank between disturbance events (Richards *et al*. 1997; Enright and Goldblum 1999), e.g., droughts may lead to seed release from canopy stored fruits reducing the size of the seed bank. Additionally, droughts may interact with fire regimes to create a cumulative pressure on *H. macrorrhyncha* by promoting more frequent and more severe fires. Interactions between fire and drought limit the capacity of populations to regenerate after fire (DAWE 2022). Enright *et al*. (2015) describes a detrimental interaction between fire and climate change induced drought, termed interval squeeze, where woody species such as *Hakea* produce fewer seeds and experience lower seedling survival under drought, requiring longer fire-free periods to reach reproductive maturity and produce seeds to ensure self-replacement. However, climate projections suggest increased fire frequency in many regions, shortening fire-free periods. Preceding drought and frequent fire history may have contributed to declines seen in recruitment post-fire in the 2021 Torrington survey. Droughts are also expected to increase in extent and severity due to climate change (Head *et al*. 2014), potentially increasing pressure on *H. macrorrhyncha*.

14. The limited recruitment observed in Torrington SCA following the 2019-20 fires (JT Hunter pers. comm. December 2021) means that the population will be markedly reduced in the generation after the 2019–20 bushfires and the risk of another fire impacting the species before recovery after the 2019–20 bushfires has occurred is high. This, taken with other threats the species is facing, means the likelihood of further declines is considerable in the future, and estimated continued decline in the number of mature individuals is likely to continue.

15. *Hakea macrorrhyncha* W.R.Barker is not eligible to be listed as a Critically endangered species

16. *Hakea macrorrhyncha* W.R.Barker 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)(f i)

Clause 4.2 – Reduction in population size of species
(Equivalent to IUCN criterion A)
Assessment Outcome: Data deficient.

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

Clause 4.3 – Restricted geographic distribution of species and other conditions
(Equivalent to IUCN criterion B)
Assessment Outcome: Endangered under Clause 4.3 (b)(d)(e i)(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)(e i, ii(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: 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.

Senior Professor Kristine French
Chairperson
NSW Threatened Species Scientific Committee

Supporting Documentation:

DCCEEW (Department of Climate Change, Energy, the Environment and Water) (2023). Conservation Advice for *Hakea macrorrhyncha* (tall needle bush). Australian Government, Canberra, ACT.

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