

NSW Threatened Species Scientific Committee

Conservation Assessment of *Leucopogon fletcheri* Maiden & Betche subsp. *fletcheri* (Ericaceae)

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Leucopogon fletcheri subsp. *fletcheri* Maiden & Betche (Ericaceae)

Distribution: Endemic to NSW

Current EPBC Act Status: Not listed

Current NSW BC Act Status: Endangered

Proposed listing on NSW BC Act: Vulnerable

Reason for change: Non-genuine change based on increased data on distribution and population size.

Summary of Conservation Assessment

Leucopogon fletcheri subsp. *fletcheri* was found to be eligible to be listed as Vulnerable under Criterion B1ab(iii,v)+2ab(iii,v).

The main reasons for *Leucopogon fletcheri* subsp. *fletcheri* being eligible are (i) the taxon has a highly restricted geographic distribution with an extent of occurrence of 2,035 km² and an area of occupancy of 88 km²; (ii) the taxon occurs in eight threat-defined locations; and (iii) it is estimated and inferred that continuing decline in the area, extent and quality of habitat, and the number of mature individuals is occurring due to the combined threats of the clearing, fragmentation, and degradation of habitat, and adverse fire regimes, particularly high frequency fire, more intense or severe fire, and changes in fire season.

Description and Taxonomy



Leucopogon fletcheri subsp. *fletcheri* in Springwood, NSW. Image: Matt Saunders.

Leucopogon fletcheri Maiden & Betche subsp. *fletcheri* is a conventionally accepted taxon in the family Ericaceae (CHAH 2023). It is described as a “densely branched shrub to 1.8 m high; branchlets scabrous. Leaves oblong-linear, 3.7–8 mm long, 1.4–3.1 mm wide; apex acute, tip pungent to 1.0 mm long; base truncate; margins entire or minutely toothed; lamina thin, convex, striate-ribbed on lower surface; petiole to 0.3 mm. Flowers pendent, mostly solitary plus rudiment, but occasionally in 2 or 3

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(particularly in the Springwood-Winmalee area), in spikes crowded at end of branches, white; recurved peduncles to 1.5 mm long; bracteoles 1.2–1.6 mm long. Sepals 3.4–4.6 mm long. Corolla tube 3.5–4.8 mm long, sparsely pubescent above middle; lobes erect at base, 2.4–3.8 mm long; ovary 1–1.9 mm long; style 5.4–7.9 mm long” (PlantNet 2023a).

Leucopogon fletcheri was first described by Maiden and Betche (1897) from material collected near Springwood by J. J. Fletcher. It was subsequently split into two subspecies by Powell and Robertson (1993), who considered the two taxa to be allopatric. *Leucopogon fletcheri* subsp. *fletcheri* has no known synonyms (CHAH 2023). PlantNet (2023b) distinguishes the nominate subspecies from *L. fletcheri* subsp. *brevisepalus* by having mostly solitary flowers, longer sepals at 3.4–4.6 mm, a longer corolla tube at 3.5–4.8 mm long, a larger ovary at 1–1.9 mm long, a longer style at 5.4–7.9 mm long, and larger fruit, which are obovoid, not ellipsoid.

Until recently, *Leucopogon fletcheri* subsp. *fletcheri* was considered to have solitary flowers. However, it was noted during recent surveys that many plants at the type locality have some peduncles with 2–3 flowers (Figs. 1–2; M Saunders pers obs. August 2023). Examination of specimens from the National Herbarium of New South Wales confirmed two-flowered inflorescences occur at multiple subpopulations (A. Orme *in litt.* August 2023; M Saunders pers obs. August 2023). Therefore, flower number alone could be misleading for identification as both subspecies can have an inflorescence with 1–3 flowers. Use of all distinguishing characteristics is needed to separate this subspecies.



Fig. 1. Examples of *Leucopogon fletcheri* subsp. *fletcheri* with 2–3 flowered inflorescences in Springwood and Winmalee, NSW. (A) from Springwood has both two- and three-flowered inflorescences; (B) a plant with a high proportion of two-flowered inflorescences in Winmalee. (C–D) examples of three-flowered *L. fletcheri* subsp. *fletcheri* in Springwood. Image: Matt Saunders.

Distribution and Abundance

Leucopogon fletcheri subsp. *fletcheri* is endemic to the Sydney Basin Bioregion (SEWPaC 2012). The taxon’s known distribution is bounded roughly by St Albans in

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the north, Springwood in the west, Kenthurst in the east, and Kentlyn in the south, occurring in the local government areas of Hawkesbury City Council, Blue Mountains City Council, The Hills Shire Council, and Campbelltown City Council. The distribution of *L. fletcheri* subsp. *fletcheri* spans the traditional lands of the Eora, Tharawal, Dharug, Gundungurra, and Kuring-gai peoples (NNTT 2013; AIATIS 2023).

Leucopogon fletcheri subsp. *fletcheri* occurs within seven subpopulations: St Albans; Blaxlands Ridge; Lower Blue Mountains; Glenbrook; Upper Blue Gum Creek; Maroota Ridge; and Kentlyn (Table 1). Subpopulations were defined by distance of separation and the potential for gene exchange via pollination. The seven subpopulations comprise clusters of records separated by more than 10 kilometres. Areas in between consist of unsuitable habitat and topography or are fragmented by non-remnant vegetation and urban infrastructure. Maximum distance of records within subpopulations is <2.5 km. A 10 km distance of separation has used to delineate subpopulations of *L. fletcheri* subsp. *fletcheri* as the taxon is insect pollinated; lacking information on maximum pollination distances of native insect pollinators, European Honeybee (*Apis mellifera*) pollination distances have been used, which have been recorded foraging up to 9.5 km from the hive (Beekman and Ratnieks 2000).

Table 1. Population breakdown of *Leucopogon fletcheri* subsp. *fletcheri*.

Subpopulation	Tenure	Estimated number of individuals	current mature	References
St Albans	NPWS	20–200		RBGDT 2021
Maroota Ridge	Council, freehold	229		James 2012; Anne Clements and Associates 2013; DCS 2023a
Blaxlands Ridge	NPWS; freehold	633–1,165		Barker 2017, Barker 2019b, Barker 2021; DCS 2023a
Lower Blue Mountains	Freehold; NPWS; public reserve; council; Crown land;	45,943–46,674		BMCS 2018; UBM Ecological Consultants 2018; P. Ridgeway <i>in litt.</i> May 2022; S. Chew <i>in litt.</i> July 2022; BioNet 2023; M. Saunders pers. obs. August 2023
Glenbrook	NPWS	144		K. Wilkins <i>in litt.</i> 2023
Upper Blue Gum Creek	Freehold; council; Crown land	200–600		RBGDT 2021; ANHSIR 2023; Bionet 2023; DCS 2023a
Kentlyn	Crown land	500–1000		M. Misdale pers. comm. 2022; DCS 2023b
Population total		47,669–50,012		

The St Albans subpopulation is the northernmost subpopulation of *Leucopogon fletcheri* subsp. *fletcheri*, occurring in Yengo National Park between St Albans and Fernances to the north of Sydney. It occurs on shallow sandy soils in dry sclerophyll forest on a ridgetop of Hawkesbury sandstone (RBGDT 2021). Analysis of satellite

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imagery indicates this subpopulation occurs in contiguous bushland in proximity to a fire trail at elevations ranging from 250–280 m. Four wildfires have occurred at this site in the past 20 years: 1994, 1998, 2002, and 2020 (NPWS 2023).

The Maroota Ridge subpopulation is located in South Maroota, on council-maintained road reserve and private land (James 2012). This subpopulation occurs predominantly along one broad ridgetop and its upper slopes, on skeletal sandy soils in open dry sclerophyll forest on flats, rock terraces, and rock platforms at elevations ranging from 80–130 m (RBGDT 2021; BioNet 2023, M. Saunders pers. obs. August 2023). This subpopulation last burnt in 2004 (James 2012).

Blaxlands Ridge supports another large subpopulation, comprising 11 sites distributed between Wollemi National Park and non-reserved lands in predominantly contiguous bushland (Barker 2017, Barker 2019b; ANHSIR 2023). These sites are restricted to exposed ridgetops and upper slopes in shrubby dry sclerophyll woodland and open woodland on skeletal to shallow sandy soils, often with outcropping Hawkesbury sandstone, and are primarily situated on northwest to northeast aspects (Barker 2017). Elevations range from approximately 70–140 m. Six sites in the Blaxlands Ridge subpopulation were fully or partially burnt by a hazard reduction burn undertaken in 2018 (Barker 2017, Barker 2019b; NPWS 2023). A further three sites, including one which was partially burnt in 2018, occur within the mapped burn area of a hazard reduction burn undertaken in 2021 (NPWS 2023). The southernmost site at this subpopulation was last recorded in 1985 and so the status of this site is unknown (ANHSIR 2023).

The Lower Blue Mountains subpopulation is the westernmost subpopulation and occurs in the lower Blue Mountains in the townships of Springwood, Winmalee, Faulconbridge, and Yellow Rock. This is the most significant subpopulation of *Leucopogon fletcheri* subsp. *fletcheri* in both abundance and extent, comprising at least 14 large sites over an area of approximately 10.01 km². In addition, there are numerous small sites, scattered occurrences, and records lacking information on abundance or extent. Some of these sites occur in contiguous bushland while others are disjunct, fragmented by urbanisation. The largest sites occur predominantly on Local Council managed land (PCO 2023a) and private tenures, with a small proportion located within Blue Mountains National Park (Fig. 3). Sites within this subpopulation occur on ridges, slopes, and valley floors, on skeletal to moderately deep sandy soils frequently associated with rock outcrops and small cliffs, in open woodland to heathy shrubland (BMCS 2018; RBGDT 2021; BioNet 2023; M. Saunders pers. obs. August 2023). Elevations range from 180–380 m with sites typically situated on northerly or westerly aspects. Recent surveys found a total of 11,534 mature individuals across 13 sites (M. Saunders pers. obs. August-September 2023). Based on survey data and predicted habitat extent (Fig. 3), it is estimated 44,185 mature individuals occur within these sites. The predicted habitat extent of 50.21 ha was determined by a combination of field validation and analysis of satellite imagery. As surveys were not systematic, an average density per hectare was derived by buffering GPS survey tracks to 3 m in ArcMap to create polygons of the area surveyed, which were then clipped to the predicted habitat extent, resulting in an average of 880 mature individuals/ha. Most sites in this subpopulation last burnt in 2013, with the remaining sites having last burnt in 1993 (NPWS 2023).

The Glenbrook subpopulation comprises a single site near Red Hands Cave in Blue Mountains National Park. This site is situated near the top of a ridge on a gentle south

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facing slope on shallow white sand over sandstone in open woodland (BioNet 2023) at elevations from approximately 165–185 m. This site last burnt in 2002 (NPWS 2023).

The Upper Blue Gum Creek subpopulation occurs as 11 sites spread out in Kenthurst, Annangrove, Glenhaven, and North Kellyville. These sites occur on private property and remnant bushland associated with Blue Gum Creek in an area heavily fragmented and modified by urbanisation, with some sites potentially already having been lost to urban development. Sites within this subpopulation occur on shallow lateritic soils with sandstone and shale influences on sandstone ridges in dry sclerophyll forest and are frequently situated on disturbance margins (RBGDT 2021; BioNet 2023). Sites range from 70–110 m in elevation and are typically situated with northerly and westerly aspects. No recent surveys have been undertaken at this subpopulation, as most sites occur on private properties. There are few historical fires recorded within this subpopulation. One site may have been affected by a fire in 2023 (ABC 2023).

The Kentlyn subpopulation is the southernmost subpopulation. Individuals within this subpopulation occur on finer silts with a clay underlayer on the rocky margins of broad sandstone slopes with flow accumulation (M. Misdale pers. comm. June 2022). Elevations range from 50–110 m with site aspects ranging from southwest to northeast. The northern portion of this site was subjected to a hazard reduction burn in 2016 (L. Robinson *in litt.* 2022). Seedling recruitment has been observed consistently 5–6 m apart in the burnt area, but no counts have been conducted (M. Misdale pers. comm. June 2022).

Extent of occurrence and area of occupancy

The extent of occurrence (EOO) was calculated at 2,035 km² and is based on a minimum convex polygon enclosing all mapped occurrences of the species, the method of assessment recommended by IUCN (2022). The area of occupancy (AOO) is estimated to be 88 km² and was calculated using 2 x 2 km grid cells, the scale recommended by IUCN (2022). Both EOO and AOO were calculated using ArcGIS (Esri 2015), enclosing all confirmed survey records, and cleaned spatial datasets.

EOO and AOO were calculated based on occurrence records drawn from BioNet, Atlas of Living Australia, herbarium specimen records, the Global Biodiversity Information Facility; Campbelltown City Council, recent monitoring reports, and recent survey data (BMCS 2014; Barker 2017; BMCS 2018; Barker 2019a, Barker 2019b, Barker 2020, Barker 2021; GBIF 2021; RBGDT 2021; ANHSIR 2023; BAM-C 2023; BioNet 2023; K. Wilkins *in litt.* August 2023; M. Misdale pers. comm. June 2022; M. Saunders pers obs. August 2023).

Population size and trends

Population size of *Leucopogon fletcheri* subsp. *fletcheri* is estimated to range from 47,669–50,012 mature individuals (Table 1), based on extrapolated survey data from St Albans (20–200 mature individuals), Maroota Ridge (229 mature individuals), Blaxlands Ridge (633–1,165 mature individuals), Lower Blue Mountains (45,943–46,674 mature individuals), Glenbrook (144 mature individuals), Upper Blue Gum Creek (200–600 mature individuals), and Kentlyn (500–1,000 mature individuals).

Accurately estimating the number of mature individuals of *Leucopogon fletcheri* subsp. *fletcheri* is difficult, as data vary in age, abundance estimates frequently lack

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demographic information, and several subpopulations have likely been burnt since the last surveys. Estimates of mature individuals were therefore calculated by combining estimates derived from the primary juvenile period, average fire survivorship rates (Barker 2017, Barker 2019a; BMCS 2014, BMCS 2018) and predicted seedling survivorship rates (Ooi 2019) with recent survey data.

Number of Locations

Leucopogon fletcheri subsp. *fletcheri* occurs at eight threat-defined locations as per the IUCN definition (IUCN 2022). Each of the seven subpopulations in Table 1 is considered to occur in an individual threat-defined location, except for the Lower Blue Mountains subpopulation, which occurs in two threat-defined locations. The most serious plausible threats resulting in the lowest number of locations for the taxon are adverse fire regimes, particularly high frequency fire, more intense or severe fire, and changes in fire season, and the clearing, fragmentation, and degradation of habitat. Historical wildfire extent has been used as the primary determinant of locations. Subpopulations located in relatively small areas of contiguous fire-prone bushland lacking fire history have been assigned location on based the plausible threat of fire affecting the entire area. One subpopulation, located in a highly modified landscape, is more threatened by clearing, fragmentation, and degradation of habitat, and has therefore been assessed under this threat.

Ecology

Habitat

Leucopogon fletcheri subsp. *fletcheri* typically occurs in dry eucalypt woodland or shrubland (NSW Scientific Committee 1999; OEH 2023) on skeletal to moderately deep sandstone soils with minor shale and laminite influences. It is found on a range of geologies derived from the Mittagong Formation, Hawkesbury Sandstone, and Narrabeen Group Sandstone, which collectively comprise a mix of interbedded shale, laminite, fine to coarse grained quartz and quartz lithic sandstone, siltstone, and claystone (SALIS 2023). *Leucopogon fletcheri* subsp. *fletcheri* occurs on the Lucas Heights, GyMEA, Faulconbridge, Hawkesbury, Watagans, and Warragamba soil landscapes, which range from shallow to moderately deep soils (SALIS 2023).

Leucopogon fletcheri subsp. *fletcheri* occurs on ridges, gentle to steep rocky slopes, rock outcrops and cliff edges, and valleys floors (M. Saunders pers. obs. August 2023). Historically, *L. fletcheri* subsp. *fletcheri* was considered to be restricted to flat and gently sloping terrain along ridges and spurs (NSW Scientific Committee 1999). However, recent surveys have found the taxon occurs on a broader range of landforms than previously thought. To date, the largest known site occurs from a ridgetop continuously down a steep rocky slope into the valley floor below, where it extends into the margins of the riparian community (M. Saunders pers. obs. August 2023).

Leucopogon fletcheri subsp. *fletcheri* occurs at elevations ranging from 50–380 m above sea level and appears to prefer cooler, wetter areas, with average annual rainfall of 1,050–1,150 mm and average temperatures of 11–24°C (BMCS 2014, BMCS 2018).

Commonly co-occurring species include *Eucalyptus sparsifolia*, *Eucalyptus haemastoma*, *Corymbia gummifera*, *Corymbia eximia*, *Angophora costata*,

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Leptospermum trinervium, *Banksia spinulosa*, *Dillwynia retorta*, *Grevillea phyllicoides*, *Micromyrtus ciliata*, *Leucopogon setiger*, and *Epacris pulchella* (RBGDT 2021; M. Misdale pers. comm. 2022; BioNet 2023; M. Saunders pers. obs. 2023). Co-occurring threatened species listed on the *Biodiversity Conservation Act 2016* include *Leucopogon exolasius*, *Hibbertia puberula* subsp. *puberula*, *Darwinia biflora*, *Acacia bynoeana*, *Grevillea parviflora* subsp. *supplicans*, *Hibbertia superans*, *Kunzea rupestris*, *Micromyrtus blakelyi*, and *Tetratheca glandulosa* (James 2012; RBGDT 2021; M. Misdale pers. comm. 2022; BioNet 2023).

Fire and disturbance ecology

Leucopogon fletcheri subsp. *fletcheri* is an obligate seeding species, generally killed outright by fire and not known to reproduce vegetatively (BMCS 2014, BMCS 2018), although partially burnt plants may occasionally survive (Barker 2019a). While the taxon appears to flower and produce seed regularly and prolifically, drought has been observed to cause the mass abortion of flowers (BMCS 2014, BMCS 2018).

Survey data indicate a strong preference for track edges and disturbed sites (BMCS 2018). While *Leucopogon fletcheri* subsp. *fletcheri* may respond positively to fire through the regeneration of a persistent soil seedbank, fire is not required for recruitment (BMCS 2018). This is consistent with the idea that *Leucopogon* species are gap recruiters that tolerate fire rather than being specifically adapted to it (Ooi *et al.* 2006a). Surveys along Springwood Ridge Trail indicate that although plants are abundant along track edges, higher densities can be present in remnant vegetation not close to tracks (M. Saunders pers. obs. August 2023).

Reproductive and seed ecology

Leucopogon fletcheri subsp. *fletcheri* flowers from August to October (PlantNet 2023b) and fruit is likely to ripen from November to December (Ooi *et al.* 2006b). *Leucopogon* species have relatively unspecialised flowers which are insect pollinated (Keighery 1995). A diverse range of moth, butterfly, bee, and fly species have been observed visiting *L. fletcheri* subsp. *fletcheri* flowers (BMCS 2014, BMCS 2018), including frequent visitation by the European honeybee (*Apis mellifera*) (Fig. 4; M. Saunders pers. obs. August 2023). Fertilised flowers result in the development of a drupe (OEH 2023), typically containing a single seed per fruit (Maiden and Betche 1897).



Fig. 4. European Honeybee (*Apis mellifera*) visitation of *Leucopogon fletcheri* subsp. *fletcheri* flowers in South Maroota (A–B) and Springwood (C). Image: Matt Saunders.

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Juveniles are typically found within 1–10 m of mature plants (BMCS 2018; M. Saunders pers. obs. August 2023). BMCS (2014, 2018) state that myrmecochory (ant-dispersal) is not considered likely for this taxon; however, closely related congeneric species have been shown to be dispersed by ants (Ooi 2019). It is likely seeds are also dispersed by birds, as birds have been observed taking fruit from other *Leucopogon* species (Ooi 2007), which would explain how the taxon occurs on crests and spurs separated by expanses of unsuitable habitat. Water is a probable dispersal agent in steep or rocky habitat (M. Saunders pers. obs. August 2023).

It is possible that humans were a historical dispersal agent of *Leucopogon fletcheri* subsp. *fletcheri*. *Leucopogon* fruit are generally sweet, succulent, and edible (Clarke 1998; Robinson 2003). It is well documented that fruit of *L. parviflorus* were eaten by Aboriginal peoples in Victoria (Ngume and Donkor 2020) and the fruit of several other Ericaceae genera were also utilised as a food resource. Fruit from several species of *Styphelia* were commonly eaten along the east coast (Mason and Whiteside 2001), as were the fruit of *Acrothamnus hookeri* (Argue 1995). The fruit of *Lissanthe sapida* are also known to be edible (Kohen *et al.* 1984).

Seedling emergence of *Leucopogon fletcheri* subsp. *fletcheri* is slow, beginning 12 months after fire and peaking at four years (BMCS 2018). This delay is likely due to a morphophysiological dormancy which has been shown to be present in closely related congeners (Ooi *et al.* 2006b). Morphophysiological dormancy typically requires seasonal temperature stratification or after-ripening to overcome physiological dormancy, coupled with the need for underdeveloped embryos to grow to a species-specific length, which delays germination and results in seasonal germination (Ooi 2019; Ooi *et al.* 2004, 2006b). In other *Leucopogon* species, primary dormancy has been shown to be unaffected by fire cues, although once primary dormancy has been broken, smoke can enhance germination (Ooi *et al.* 2006b). Seedling emergence may also be delayed by almost 12 months by winter fires, resulting in higher mortality and slower growth compared with post-summer fire cohorts (Ooi 2010).

It is also likely that *Leucopogon* species are gap recruiters, in which recruitment is facilitated by the formation of gaps in the canopy (Ooi *et al.* 2006a, Ooi *et al.* 2006b, Ooi *et al.* 2007). While seed dormancy has been shown to be broken by burial, germination appears to be triggered by increased temperature amplitude through the formation of canopy gaps after fire or tree fall (Ooi *et al.* 2007).

Seed viability and seedbank persistence of *Leucopogon fletcheri* subsp. *fletcheri* are unknown; however, studies of congeners have found seed viability ranges from approximately 60–92% and estimated seedbank half-lives range from 3.47–5.45 years (Ooi *et al.* 2007).

BMCS (2014, 2018) state that seedling growth of *Leucopogon fletcheri* subsp. *fletcheri* has been observed at approximately 5 cm/year. Similar growth rates have been observed on post-fire seedlings at Blaxlands Ridge (Barker 2020, Barker 2021). However, growth rates may change as the plants mature. Many individuals off Springwood Ridge Trail within 2–3 m of trees with significant stem char are >1 m, with some as tall as 1.8 m, despite the last fire occurring only 10 years ago (Fig. 5; M. Saunders pers. obs. August 2023). With these plants located in dense shrubby woodland, it is unlikely they were present pre-fire and escaped being burnt. As *L. fletcheri* subsp. *fletcheri* is considered fire-sensitive, this is highly suggestive that these

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plants germinated post-fire and have attained heights of up to 1.8 m in under 10 years, far exceeding a growth rate of 5 cm/year. It is possible that soil or landform plays a role in growth rates, with the plants at the top of the Springwood Ridge site occurring on a wide, flat ridge with deeper soils capable of supporting relatively large trees (M. Saunders pers. obs. August 2023).



Fig. 5. A 1.7 m *Leucopogon fletcheri* subsp. *fletcheri* surrounded by trees with substantial stem char. This individual was only 2–3 m from trees last burnt in 2013. Image: Matt Saunders.

Lifespan and generation length

Leucopogon fletcheri subsp. *fletcheri* has a primary juvenile period of 4–6 years (BMCS 2018; P. Ridgeway *in litt.* August 2023b); however, seed production at this age is low and it may take >10 years for peak fecundity to be achieved (BMCS 2018). The maximum longevity of the taxon is unknown. However, the closely related *L. ericoides* and *L. esquamatus* are estimated to live for 5–20 years, both of which have a similar, although slightly shorter, primary juvenile periods, relative to *L. fletcheri* subsp. *fletcheri* (Benson and McDougall 1995). With a primary juvenile period of 4–6 years, it is probable that maximum longevity of *L. fletcheri* subsp. *fletcheri* is not less than 20 years.

The generation length of *Leucopogon fletcheri* subsp. *fletcheri* is estimated to be 6.5–8.5 years. Given that *L. fletcheri* subsp. *fletcheri* is an obligate seeder which retains a soil seedbank, generation length may be estimated by using the juvenile period + either the half-life of seeds in the seed bank or the median time to germination, whichever is known more precisely (IUCN 2022). Seedling emergence of *L. fletcheri* subsp. *fletcheri* begins at 12 months and peaks four years post-fire (BMCS 2018). Seedlings have been observed emerging six years post-fire (P. Ridgeway *in litt.* August 2023); however, it is not possible to determine whether these seedlings were from the pre-fire seedbank or from the newly maturing cohort. Therefore, the median time to germination is considered to be 2.5 years. Consequently, generation length can be calculated by using a primary juvenile period of 4–6 years and a median time until germination of 2.5 years.

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Threats

Leucopogon fletcheri subsp. *fletcheri* is threatened by the clearing, fragmentation, and degradation of habitat, resulting from urban development, unrestricted public access, recreational activities, adverse fire regimes, particularly high frequency fire, but also high intensity and high severity fires, and out of season fires. A substantial proportion of the population occurs on non-reserved lands, with varying degrees of threat from development and inappropriate land use. Drought may be a threat to the taxon, although evidence for this is limited. 'High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition', 'Clearing of native vegetation', and 'Anthropogenic Climate Change' are listed as a Key Threatening Processes under the *Biodiversity Conservation Act 2016*. 'Fire regimes that cause declines in biodiversity', 'Land clearance', and 'Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases' are listed as a Key Threatening Processes under the *Environment Protection and Biodiversity Conservation Act 1999*.

Clearing, fragmentation, and degradation of habitat

Approximately three quarters of the sites at which *Leucopogon fletcheri* subsp. *fletcheri* occurs are fully or partially on non-reserved lands, and are threatened by land clearing, fragmentation, and degradation, with substantial evidence of continuing decline occurring from this threat already available.

The majority of the Lower Blue Mountains subpopulation occurs on non-reserved land. Although a large proportion of the sites occur in land zoned as *C2 Environmental Conservation*, clearing, fragmentation, and degradation continues to be an issue. Sites have been heavily fragmented by illegal mountain bike trails (Fig. 6; M. Saunders pers. obs. August 2023) and significant clearing has already been undertaken for subdivisions (B. Heterick *in litt.* August 2023; BMCC 2023).



Fig. 6. Clearing for illegal mountain bike tracks in Winmalee. A–E: examples of the network of mountain bike tracks that have been developed at this site. Note the *Leucopogon fletcheri* subsp. *fletcheri* plant at the bottom left of inset E. The ‘islands’ of vegetation in B and D both had numerous *L. fletcheri* subsp. *fletcheri* individuals growing in them, indicating that these tracks ran through significant habitat. F–G: associated clearing and infrastructure adjacent to the site. H: an example of digging within core habitat that has been undertaken to build the jumps on the tracks. Image: Matt Saunders.

The major Springwood Ridge to Springwood Creek site is subject to fire trail maintenance along its eastern edge, with plants observed to have been damaged at the edges of the trail (M. Saunders pers. obs. August 2023). Other sites have plants growing directly in the corridor of vehicle tracks, which are threatened by vehicular use (M. Saunders pers. obs. August 2023). Plants in this subpopulation are also threatened by urban encroachment and development, including underscrubbing and illegal land clearing resulting in direct loss of individuals (Peak Land Management 2016).

The site along Blue Gum Swamp Fire Trail in Winmalee, while predominantly within Blue Mountains National Park, has been subjected to repeated slashing. In 2013, the edges of the trail were slashed for fire management purposes, resulting in the loss of at least 61 plants, and possibly up to 200 (BMCS 2014). This was repeated in 2019 during fire suppression operations, which resulted in approximately 800 plants being slashed to 20–30 mm above the ground (Monahan 2021).

The Upper Blue Gum Creek subpopulation is unsecured (BMCS 2018) and occurs as several small sites scattered between Kenthurst, Annangrove, and Glenhaven. With

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the exception of the site in Annangrove Park Reserve, which is Crown land, the entire distribution of the taxon within this subpopulation occurs on freehold land subject to extensive development for agriculture and residential purposes (PCO 2023b). These sites occur on both private property and in remnant bushland surrounded by development. Sites on private property are at greater risk of vegetation clearing and habitat modification, while sites on Crown land or currently unused land are more at risk of habitat degradation from unrestricted access and recreational activities (OEH 2023). Two sites appear to have already been destroyed by development, based on analysis of satellite imagery.

A subdivision on Paulls Road in South Maroota is likely to have resulted in the direct loss of *Leucopogon fletcheri* subsp. *fletcheri* (Anne Clements and Associates 2013). Construction activities from the subdivision are encroaching on the road reserve, with direct impacts to plants observed (M. Saunders pers. obs. August 2023).

Clearing is also a threat to some sites in the Blaxlands Ridge subpopulation. There is evidence that habitat recently cleared along Warrigal Road previously supported *Leucopogon fletcheri* subsp. *fletcheri*, while management tracks in the area are subjected to overuse from 4WDs and trail bikes (Barker 2020).

Habitat clearing, fragmentation, and degradation continues to be a serious threat contributing to the continuing decline of *Leucopogon fletcheri* subsp. *fletcheri*. 'Clearing of native vegetation' is listed as a Key Threatening Process under the *Biodiversity Conservation Act 2016*. 'Land clearance' is listed as a Key Threatening Process under the *Environment Protection and Biodiversity Conservation Act 1999*.

Adverse fire regimes

Leucopogon fletcheri subsp. *fletcheri* is particularly at risk of high frequency fire. Decreases in inter-fire intervals result in interval squeeze and increase plant "immaturity risk", in which obligate seeding species have less time to reach reproductive maturity before the next fire (Enright *et al.* 2015). The taxon is fire-sensitive, killed outright by fire and with stand replacement reliant upon recruitment from the stored soil seedbank (BMCS 2018; Barker 2019a), a life-history trait shared with other obligate seeding *Leucopogon* species (Ooi 2002; Ooi *et al.* 2006a; Swab *et al.* 2012). Fire frequencies sufficient to kill recruits prior to maturity threaten obligate seeders with ongoing decline and local extinction (Bowman *et al.* 2014; von Takach Dukai *et al.* 2018; McColl-Gausden *et al.* 2022). Despite the taxon having a primary juvenile period of 4–6 years (BMCS 2018; P. Ridgeway *in litt.* August 2023b), it has been suggested the minimum inter-fire interval for the taxon is 10 years, as fecundity is low when plants first mature (BMCS 2018).

Changes in fire season, high severity fires, and high intensity fires also pose a risk to *Leucopogon fletcheri* subsp. *fletcheri*. Studies of closely related *Leucopogon* species indicate that winter fires delay seedling emergence, reducing seedling survival and growth rates and lengthening the primary juvenile period, thereby exacerbating the risk posed by high frequency fires and interval squeeze (Ooi 2010, Ooi 2019; Ooi *et al.* 2004). Fire intensity is inversely correlated with burn patchiness, with a higher proportion of plants killed with decreased burn patchiness (Ooi 2006a).

Monitoring at the SoS site along Blue Gum Swamp Fire Trail in Winmalee indicates that although *Leucopogon fletcheri* subsp. *fletcheri* is killed outright by fire, post-fire recruitment rapidly leads to the recovery of sites (BMCS 2014; P. Ridgeway *in litt.* May

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2022). Therefore, it is recurring fires at short time intervals that is likely to lead to genuine declines.

Climate change projections indicate a future trend of increased fire weather and more frequent fires (Abatzoglou *et al.* 2019; Dowdy *et al.* 2019; Jones *et al.* 2022). The Sydney Basin is projected to become hotter, have fewer cold nights under 2°C, have more hot days over 35°C, have more dangerous fire weather days, and have a longer fire season by 2079 (BOM and CSIRO 2022; AdaptNSW 2023). Regionally, it is predicted with high confidence that climate change will result in a harsher fire-weather climate in the future (CSIRO 2023). It is plausible that these changes will lead to more frequent, intense, and severe fires, and changes in fire season, which will in turn adversely affect the *L. fletcheri* subsp. *fletcheri* population in the future. Should high frequency fires become a feature of the Lower Blue Mountains subpopulation, there is a possible risk of significant decline, as this subpopulation supports an estimated 93.33–96.38% of the mature population. Despite the size of this subpopulation, individual historical fires have affected almost the entire range of the taxon at this locality, indicating that future fires at this locality have the capacity to rapidly affect a large proportion of the population.

‘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 *Biodiversity Conservation Act 2016*. ‘Fire regimes that cause declines in biodiversity’ is listed as a Key Threatening Process under the *Environment Protection and Biodiversity Conservation Act 1999*.

Drought

There is evidence that drought is a threat to *Leucopogon fletcheri* subsp. *fletcheri*. Most of the flowers on plants in the Blue Gum Swamp Trail site in Winmalee were observed to abort during drought conditions (BMCS 2018), suggesting drought could lead to declines in the soil seedbank. The Kentlyn subpopulation, which occurs on broad sandstone slopes susceptible to drying and changes to rainfall, was observed to have suffered during drought, although it has since recovered with seedling recruitment (M. Misdale pers. comm. June 2022). However, the abundance of plants in all age classes at the recently surveyed sites in Springwood suggest that there was no substantial mortality during the 2017–2019 drought (M. Saunders pers. obs. August 2023). It is likely that plants at the edge of the taxon’s range or in marginal habitat would be disproportionately affected by drought, while plants on deeper soils and in more optimal habitat may be buffered from the effects of drought to some extent. On average, cool season rainfall is predicted to continue to decrease across many regions of eastern and southern Australia, which will likely lead to more time in drought (BOM and CSIRO 2022). Over the distribution of *Leucopogon fletcheri* subsp. *fletcheri*, time spent in drought is projected, with medium confidence, to increase over the course of the century (CSIRO 2023). ‘Anthropogenic Climate Change’ is listed as a Key Threatening Process under the *Biodiversity Conservation Act 2016*. ‘Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases’ is listed as a Key Threatening Process under the *Environment Protection and Biodiversity Conservation Act 1999*.

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Assessment against IUCN Red List criteria

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

Criterion A Population Size reduction

Assessment Outcome: Data Deficient.

Justification: There are insufficient data to estimate, infer or project the magnitude of past or future reductions in the population size of *Leucopogon fletcheri* subsp. *fletcheri*. As, such, under a three-generation timespan, a population size reduction of $\geq 50\%$ for reversible, understood, and ceased causes (A1) or $\geq 30\%$ for continuing, not understood, or irreversible causes (A2, A3 and A4) has not been observed, nor is it predicted with confidence to occur up to 19.5–25.5 years (a three-generation timeframe) into the future.

Criterion B Geographic range

Assessment Outcome: Vulnerable under Criterion B1ab(iii,v)+2ab(iii,v)

Justification: *Leucopogon fletcheri* subsp. *fletcheri* has a highly restricted geographic distribution with an extent of occurrence (EOO) calculated at 2,035 km², within the threshold of <5,000 km² for Endangered, and an area of occupancy (AOO) calculated to be 88 km², within the threshold of <500 km² for Endangered. However, with eight threat-defined locations, *L. fletcheri* subsp. *fletcheri* only qualifies for Vulnerable.

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), ≤ 5 (EN) or ≤ 10 (VU) locations.

Assessment Outcome: Met for Vulnerable due to having eight threat-defined locations.

Justification:

As a fire-sensitive obligate seeder killed outright by fire, adverse fire regimes are considered a serious plausible threat operating on *Leucopogon fletcheri* subsp. *fletcheri*, particularly high frequency fire, more intense or severe fire, and changes in fire season. Six of the seven subpopulations are considered primarily threatened by fire: St Albans; Blaxlands Ridge; Glenbrook; Lower Blue Mountains; Maroota Ridge; and Kentlyn. Each of these subpopulations is considered to occur in individual threat-defined locations, except for the Lower Blue Mountains subpopulation, which occurs in two threat-defined locations. Adverse fire regimes have been used to determine locations due to being the threat which results in the smallest number of locations, as per the IUCN Guidelines (2022). Historical wildfire extent has been used as the primary determinant of locations. Subpopulations located in relatively small areas of contiguous fire-prone bushland lacking fire history have been assigned their locations based on the plausible threat of fire affecting the entire area.

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The Upper Blue Gum Creek subpopulation is primarily threatened by habitat clearing, fragmentation and degradation. The IUCN Red List Guidelines (2022) state that “where the most serious plausible threat is habitat loss that occurs gradually and cumulatively via many small-scale events a location can be defined by the area over which the population will be eliminated or severely reduced within a single generation or three years, whichever is longer”. As all sites in this subpopulation occur on non-reserved lands, this subpopulation is considered to occur in a single threat-defined location, based on the threat of habitat clearing, fragmentation and degradation from development, recreation, and urban encroachment.

Therefore, *Leucopogon fletcheri* subsp. *fletcheri* is considered to occur in eight threat-defined locations.

Leucopogon fletcheri subsp. *fletcheri* is not considered to be severely fragmented as subpopulations are not isolated and all subpopulations are large enough to be 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: Condition met for continuing decline in (iii) area, extent and/or quality of habitat and (v) number of mature individuals.

Justification: It is estimated and inferred that continuing decline in the (iii) area, extent and quality of habitat, and (v) number of mature individuals is occurring due to the combined effects of the clearing, fragmentation, and degradation of habitat, and adverse fire regimes, particularly high frequency fire, more intense or severe fire, and changes in fire season.

There is ample evidence that clearing, fragmentation, and degradation of habitat are contributing to ongoing decline of *Leucopogon fletcheri* subsp. *fletcheri*, and it is expected this will continue due to the large proportion of the population occurring on non-reserved lands. Several sites have experienced adverse effects from habitat clearing and fragmentation in the recent past (Anne Clements and Associates 2013; BMCS 2014; Peak Land Management 2016; Barker 2020; Monahan 2021; B. Heterick *in litt.* August 2023) and there is evidence of this continuing to occur (M. Saunders pers. obs. August 2023). Habitat clearing which occurs for urban development or illegal tracks and trails is inferred to result in a decline in the number of mature individuals through a reduction in available habitat extent. Although disturbance may facilitate the recruitment of the species at the edges of such areas, the complete clearance of large swathes of habitat which support high densities of *L. fletcheri* subsp. *fletcheri* for residential developments is considered likely to result in a net loss in the number of mature individuals, even when factoring in enhanced recruitment resulting from disturbance. Given that higher densities of *L. fletcheri* subsp. *fletcheri* have been observed in undisturbed remnant bushland than along track edges (M. Saunders pers. obs. August 2023), the positive effects of clearing on the number of mature individuals is likely to be minimal.

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Fire has been shown to kill *Leucopogon fletcheri* subsp. *fletcheri* outright (BMCS 2014; Barker 2019a, Barker 2019b). With the Sydney Basin projected to become hotter, have fewer cold nights under 2°C, have more hot days over 35°C, have more dangerous fire weather days, and have a longer fire season by 2079 (BOM and CSIRO 2022; AdaptNSW 2023), it is plausible that these changes will lead to more frequent, intense, and severe fires, and changes in fire season, which will in turn adversely affect the *Leucopogon fletcheri* subsp. *fletcheri* population in the future.

Therefore, it is estimated and inferred that continuing decline in the area, extent and quality of habitat, and number of mature individuals is occurring due to the combined effects of clearing, fragmentation, and degradation of habitat, and adverse fire regimes, particularly high frequency fire, more intense or severe fire, and changes in fire season.

c) Extreme fluctuations.

Assessment Outcome: Not met.

Justification: There is no evidence to suggest *Leucopogon fletcheri* subsp. *fletcheri* undergoes extreme fluctuations. While fires can cause mass mortality of mature individuals, the presence of a persistent seedbank negates this scenario being considered an extreme fluctuation.

Criterion C Small population size and decline

Assessment Outcome: Not met.

Justification: *Leucopogon fletcheri* subsp. *fletcheri* has an estimated population size of 47,067–49,410 mature individuals, exceeding the threshold for Vulnerable.

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: While there is evidence of ongoing decline in the number of mature individuals, the available data are insufficient to quantify the percentage or rate of decline.

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

Assessment Outcome: Met.

Justification: It is estimated and inferred that continuing decline in the area, extent and quality of habitat, and number of mature individuals is occurring due to the combined effects of clearing, fragmentation, and degradation of habitat, and adverse fire regimes, particularly high frequency fire, more intense or severe fire, and changes in fire season.

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

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

Assessment Outcome: Not met.

Justification: Several subpopulations exceed 1,000 mature individuals, exceeding the threshold for Vulnerable.

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

Assessment Outcome: Met for Critically Endangered.

Justification: The Lower Blue Mountains subpopulation is estimated to support 93.33–96.38% of the mature individuals of *Leucopogon fletcheri* subsp. *fletcheri*, meeting the threshold for Critically Endangered.

- b. Extreme fluctuations in the number of mature individuals

Assessment Outcome: Not met.

Justification: There is no evidence to suggest *Leucopogon fletcheri* subsp. *fletcheri* undergoes extreme fluctuations. While fires can cause mass mortality of mature individuals, the presence of a persistent seedbank negates this scenario being considered an extreme fluctuation.

Criterion D Very small or restricted population

Assessment Outcome: Not met.

Justification: *Leucopogon fletcheri* subsp. *fletcheri* has an estimated population size of 47,067–49,410 mature individuals.

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 population size of *Leucopogon fletcheri* subsp. *fletcheri* is estimated to range from 47,067–49,410 mature individuals, exceeding the threshold required to meet this subcriterion.

- D2. Restricted area of occupancy (typically < 20 km²) or number of locations (typically < 5) with a plausible future threat that could drive the taxon to CR or EX in a very short time.

Assessment Outcome: Not met.

Justification: *Leucopogon fletcheri* subsp. *fletcheri* has an area of occupancy of 88 km² and occurs in eight threat-defined locations and there are no plausible threats that could rapidly drive the species to CR or EX in a short amount of time.

Criterion E Quantitative Analysis

Assessment Outcome: Data Deficient

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Justification: No quantitative analysis has been undertaken to assess the extinction probability of this species and there are currently insufficient data to undertake one.

Conservation and Management Actions

Leucopogon fletcheri subsp. *fletcheri* is currently listed on the NSW *Biodiversity Conservation Act 2016* and a conservation project has been developed by the NSW Department of Planning and Environment 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. *Leucopogon fletcheri* subsp. *fletcheri* sits within the Site-managed species management stream of the SoS program and the conservation project can be viewed here: <https://www.environment.nsw.gov.au/sosapp/#/project/237>

Activities to assist *Leucopogon fletcheri* subsp. *fletcheri* currently recommended by the SoS program (OEH 2023b) include:

Habitat loss, disturbance and modification

- Keep species records and known/predicted fire regime requirements up to date in all appropriate databases.
- Ensure that fire planning documents stipulate a minimum 10-year inter-fire period. Instead of fire use alternate mechanical hazard reduction treatments when necessary.
- Install signage where the species occurs to prevent damage to plants.
- Determine slashing exclusion period and erect "Significant Roadside Vegetation" signs.
- Educate Branch plant operators and Area staff about the species and requirement to protect individuals during maintenance activities.
- Maintain close links with Branch plant crew and local Area staff to ensure sites vulnerable to damage during fire management are protected.

Survey and monitoring

- Regular monitoring of species abundance, extent and condition on the site will be conducted to determine population trends through time.
- Assess size and age structure of population and the operation of threats.
- Monitor species recruitment and adult condition immediately post fire event and subsequently every six months for three years (some sites) or annually for 15 years (Winmalee site)
- Pre- and post-burn monitoring of plants in established quadrats.
- Install permanent plots and count individuals within them.
- Monitor target weed density using methodologies outlined in the monitoring manual for bitou bush control and native plant recovery.
- Survey main fire trails for the species and undertake trailside protection works and works to minimise erosion.

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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: *Leucopogon fletcheri* subsp. *fletcheri* was found to be Vulnerable under Clause 4.3(c)(d)(e i,iii)

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: Vulnerable under Clause 4.3(c)(d)(e i,iii)

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,

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	(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 C)

Assessment Outcome: Not met

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)

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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.
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