Conservation Assessment of *Acacia pubifolia* Pedley (Fabaceae)

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***Acacia pubifolia* Pedley**
Distribution: NSW, Queensland
Current EPBC Act Status: Vulnerable
Current NSW BC Act Status: Endangered
Current Queensland NC Act Status: Vulnerable

Proposed listing on NSW BC Act: Endangered
No change to listing.

Summary of Conservation Assessment

Acacia pubifolia was found to be eligible for listing as Endangered under Criterion Criterion B1ab(iii,v) and B2ab(iii,v).

The main reasons for this species being eligible are (i) *Acacia pubifolia* has a highly restricted Area of Occupancy (AOO) of 100 km^2 and Extent of Occurrence (EOO) of 3,672 km^2; (ii) *Acacia pubifolia* is known from three threat-defined locations; and (iii) continuing decline has been observed and is projected to continue in the extent and quality of habitat and number of mature individuals due to the combined effects of increased frequency and duration of drought due to climate change, adverse fire regimes and grazing by domestic stock and feral goats.

Description and Taxonomy

Figure 1 - *Acacia pubifolia* in flower in Torrington SCA, October 2020. Image: Gavin Phillips

Acacia pubifolia (Velvet Wattle, Wyberba Wattle) is a conventionally accepted species (CHAH 2018) in *Acacia* section *Juliflorae* (Pedley 1978). Tindale and Kodela (2018) describe *A. pubifolia* as a "Shrub or tree to 8 m high, single-stemmed. Bark rough to 'ironbark'-type, black. Branchlets angular, brown or orange-brown, sometimes slightly pruinose, velvety-pubescent; ridges not prominent. Phyllodes narrowly elliptic, elliptic or narrowly obovate, straight, 2–10 cm long, 8–30(–35) mm wide, silvery, velvety-pubescent, later puberulous, with 1–3 slightly prominent main nerves reaching apex and base; minor nerves mostly 5–7 per mm, not anastomosing; gland 1, small, basal, hairy. Spikes almost sessile, 2–5 cm long, golden. Flowers 5-merous; calyx 0.5–0.9 mm long, truncate or dissected to c. 1/6, white-pubescent, papillose at apices; corolla 1.6–1.8 mm long, dissected to 1/2–5/8, glabrous; ovary villous. Pods linear, slightly constricted between and slightly raised over seeds, 3–8 cm long, 3–4 mm wide, chartaceous, greyish, longitudinally nerved, pubescent. Seeds longitudinal, oblong-elliptic, 4–4.5 mm long, black; pleurogram indistinct, narrowly U-shaped."

In the past, the name *Racosperma pubifolium* has been proposed for *Acacia pubifolia* to resolve taxonomic issues (Pedley 1986). This change was not accepted however, with *A. pubifolia* remaining the currently accepted name by all relevant authorities (New South Wales Flora Online 2012; CHAH 2018; Queensland Government 2022). The species has also erroneously been published in the past as *A. publifolia* (Williams 1987) and *A. pubiflora* (Tame 1992).

Acacia pubifolia is morphologically similar to four other closely related *Acacia* species. It is most similar to *Acacia pycnostachya* (Pedley 1978) which differs from *A. pubifolia*

in its flattened, pruinose and sharply angled branches, less pubescent phyllodes and larger flowers (Pedley 1964), and the two are not known to co-occur (G. Phillips pers. obs. October 2020). It also has affinities with *Acacia blakei, A. striatifolia* and *A. williamsiana,* of which it may co-occur with the latter two, but differs from all in the velvety-pubescent phyllodes and more pubescent floral parts (Pedley 1978; Hunter 1997; Tindale and Kodela 2018).

Distribution and Abundance

Acacia pubifolia is an uncommon species with a wide but patchy distribution along the western edge of the New England Tableland in northern New South Wales (NSW) to west of Stanthorpe in the Darling Downs of southeast Queensland (DCCEEW 2023). This area is within the New England Tablelands Bioregion (DAWE 2012) and on the traditional lands of the Kamilaroi, Ngarabul and Kambuwal People (Horton 1996; NPWS 2003a, 2003b; QPWS 2010).

Acacia pubifolia was initially described from plants found in the Wyberba district in the Granite Belt of southeast Queensland (Pedley 1978). More recently, sites have been confirmed around a greater area of the Granite Belt (3D Environmental 2007; Donatiu 2009; A. Pengelly *in litt.* January 2023; L. Rowley *in litt.* January 2023), including as far north as Amiens (ALA 2023). In northern NSW, stands have also been found northwest of Emmaville and in and around Warrabah National Park (Copeland and Hunter 1999; Table 1; Appendix 2).

Table 1 – Population breakdown of *Acacia pubifolia* from all known sites

Region	Subpopulation	Distance to nearest other *A. pubifolia* subpopulation	Minimum estimate of all Individuals	References
Granite Belt, Queensland	Amiens	12.1 km (Nundubbermere)	15	ALA 2023
Granite Belt, Queensland	Nundubbermere	3.8 km (Somme)	84	3D Environmental 2007; Anonymous *in litt.* February 2023
Granite Belt, Queensland	Somme	3.8 km (Nundubbermere)	122	A. Pengelly *in litt.* February 2023
Granite Belt, Queensland	Horans Gorge NR	3.3 km (Scotney)	20-100	Department of Environment and Science 2023a
Granite Belt, Queensland	Scotney/Tinkerbell NR	3.3 km (Horans Gorge)	200-300	Donatiu 2009; P. Pemberton *in litt.* January 2023.
Granite Belt, Queensland	Central Girraween NP	5.1 km (Scotney and Wyberba)	50	L. Weber *in litt.* February 2023

Granite Belt, Queensland	Wyberba	5.1 km (Scotney)	320-1600	Department of Environment and Science 2023a; ALA 2023; L. Rowley *in litt.* January 2023
Emmaville, NSW	Flagstone Creek	4.5 km (Gulf Rd)	2	Copeland 1997
Emmaville, NSW	Gulf Rd	4.5 km (Flagstone Creek)	1,159–1,409	Eco Logical Australia 2021a; Hunter 2022
Emmaville, NSW	Spring Hill	6.2 km (Gulf Rd)	2439	Copeland *et al* 2018; P. Sheringham *in litt.* January 2023
Warrabah, NSW	Warrabah	141.3 km (Spring Hill)	295	Hunter and Copeland 2007; Eco Logical Australia 2021b; P. Sheringham *in litt*. January 2023
TOTAL COUNT			**4,706–6,416**	

Distances of at least 3 km between each site mean that the 11 currently identified sites can be considered distinct subpopulations as defined by IUCN (2022). This is based on an assumption that the foraging ranges of typical *Acacia* pollinators and seed disperser species are less than 3 km, resulting in limited gene flow (Bernhardt 1987; Auld 1997; Stone *et al.* 2003; Hagler *et al.* 2011; Millar *et al.* 2013, 2014; Blythe *et al.* 2020).

The Queensland portion of the *Acacia pubifolia* population around the Granite Belt includes the substantial Wyberba subpopulation, encompassing a large area of uncleared hills on private land northwest of Wallangarra and the adjoining western edge of Girraween National Park. No quantitative data on the overall population size are available for this subpopulation, but it is noted as being large and widespread (Copeland and Hunter 1999), with the species described as 'dominant', 'frequent' or 'locally common' in the area (ALA 2023). Given the minimum single stand size in other subpopulations in the area typically ranges from 20 to hundreds of individuals depending on time since the last disturbance (Donatiu 2009; P. Pemberton *in litt.* January 2023), a minimum subpopulation size for Wyberba can be inferred. Based on 16 cleaned point records in the subpopulation, there is estimated to be 320–1,600 individuals, with each point record considered to represent a single stand. This is likely to be highly conservative, as much suitable habitat exists between the point records and the qualitative descriptions of relative abundance above indicate many more plants are likely to be in the broader area.

Smaller subpopulations of *Acacia pubifolia* are then scattered north of the Wyberba subpopulation across the Granite Belt. There is a minimum of 50 plants in Central Girraween National Park (L. Weber *in litt.* February 2023) and an estimated 200-300 plants in Scotney and Tinkerbell Nature Refuges on the northern edge of Girraween National Park (P. Pemberton *in litt.* January 2023). A single record in Horans Gorge Nature Refuge then represents another subpopulation. This record has no abundance

data (Department of Environment and Science 2023a) but is assumed to have a minimum of 20-100 plants, in line with abundances for other stands in the region.

Two more subpopulations are then located along the Severn River southwest of Stanthorpe. The first at Somme has 162 mostly mature plants on private land (A. Pengelly *in litt.* January 2023). The second straddles the localities of Nundubbermere and Fletcher and consists of a cluster of stands with a minimum of 84 mature plants (Anonymous *in litt.* February 2023), some of which are within Hillview Nature Refuge. The last and most northerly Queensland subpopulation is then located in the Amiens area and was originally known only from a specimen record collected in 1963 (T. Bean *in litt.* February 2023). The precise origin of this specimen is unknown, however a recent photographic record of a small stand of 15 plants in nearby Tumbledown Nature Refuge shows there is at least one remaining stand in the Amiens subpopulation (ALA 2023).

The NSW portion of the *Acacia pubifolia* population is split across two major areas and has been much more comprehensively surveyed, with population monitoring undertaken yearly from 2018-2021 and again in 2023 (Eco Logical Australia 2021b, 2023). Northwest of Emmaville on the western edge of the Mole Tableland are three subpopulations. The largest of these is the Spring Hill subpopulation, which is within a single private property to the west of the Beardy River containing 2,439 plants after the last census in 2018 (Copeland *et al* 2018). To the east of the Beardy River lies the Gulf Rd subpopulation, spanning an area along the southern boundary of Torrington State Conservation Area and consisting of several discrete stands with a total of 1,159–1,409 plants including 564 mature plants counted by census (Eco Logical Australia 2023; Hunter 2022). This subpopulation also includes a large, recently discovered stand that consists mostly of juveniles recovering post-fire (Hunter 2022). The third subpopulation at Flagstone Creek consists of a small, isolated stand on private land south of Torrington State Conservation Area (Copeland 1997). This subpopulation, recorded as having only two plants (Copeland 1997), has not been surveyed again since 1997, but likely persists given the area remains uncleared and fire-stimulated recruitment may have occurred following fire at the site in 2019 as seen in the recently discovered stand to the west.

The southernmost *Acacia pubifolia* subpopulation at Warrabah occurs along the Namoi River, west of Armidale. This subpopulation consists of several scattered stands, with the majority on heavily cleared private lands north of the river and a small portion within Warrabah National Park and a property under conservation covenant south of the river (Eco Logical Australia 2021b). This subpopulation has several enclosures for more detailed monitoring and protection of some stands from grazing, and the full subpopulation contains 295 individuals following the most recent surveys (Eco Logical Australia 2021b).

A long-term demographic study on *Acacia pubifolia*, showing change over time in age classes in a protected, largely undisturbed stand on the ‘Romani’ property in the Warrabah subpopulation (Eco Logical Australia 2021b) enables estimates of the number of mature individuals in other stands when the disturbance history is known. Trees of *A. pubifolia* have been recorded as being reproductively mature at around 1–

2 m height (Hunter and Copeland 2007). At the time when disturbance was minimised in the 'Romani' stand in 1999 by erecting a stock exclusion fence, around 33% of the stand was recorded as being in the 1–2 m height range or taller (Eco Logical Australia 2021b). By 2006, approximately 84% of the trees were in mature size classes, with the population still consisting of about 85% mature plants by 2018 (Eco Logical Australia 2021b). During the 2017-2020 drought, the proportion of mature individuals then increased to 94%, likely driven by increased mortality of smaller plants in the dry conditions, before dropping back to a proportion of 75% mature-sized plants in the two years following the drought (Eco Logical Australia 2021b). Given the 2017-2020 drought severely affected the full known range of *A. pubifolia* (Bureau of Meteorology 2023a), the effects of the drought on the proportion of mature plants as seen at 'Romani' could be considered indicative of all subpopulations. As such, the number of mature plants can be estimated for each subpopulation when the time since the last major disturbance (typically fire) is compared with the demographic shift over time observed at 'Romani' (Table 2).

Table 2 – Population abundance figures for *Acacia pubifolia* across all known stands.

Region	Subpopulation	Time since last fire*	Minimum estimate of all Individuals	Minimum estimate of mature individuals	References
Granite Belt, Queensland	Amiens	Long Unburnt	15	15[a]	ALA 2023
Granite Belt, Queensland	Nundubbermere	Long Unburnt	84	84[a]	3D Environmental 2007; Anonymous *in litt.* February 2023
Granite Belt, Queensland	Somme	Long Unburnt	122	122[a]	A. Pengelly *in litt.* February 2023
Granite Belt, Queensland	Horans Gorge	2021	20-100	7-33[b]	Department of Environment and Science 2023a
Granite Belt, Queensland	Scotney/Tinkerbell NR	2014	200-300	168-252[b]	P. Pemberton *in litt.* January 2023.
Granite Belt, Queensland	Central Girraween NP	2014	50	42[b]	L. Weber *in litt.* February 2023
Granite Belt, Queensland	Wyberba	Long Unburnt	320-1600	240-1200[b]	
Emmaville, NSW	Flagstone Creek	2019	2	Unknown[c]	Copeland 1997
Emmaville, NSW	Gulf Rd	2019	1,159–1,409	564[d]	Eco Logical Australia 2023; Hunter 2022
Emmaville, NSW	Spring Hill	2009	2439	2074[b]	Copeland *et al* 2018
Warrabah, NSW	Warrabah	2018 (edge of subpop only)	295	221[b]	Hunter and Copeland 2007; Eco Logical Australia 2021b

TOTAL COUNTS			**4,706–6,416**	**3,539–4,609**	

*Mapped using NPWS 2022 and Department of Environment and Science 2019.

[a] Estimate based on site counts and photographic evidence of maturity

[b] Estimate based on demographic studies in Eco Logical Australia (2021b)

[c] Unable to be estimated due to lack of recent data and unknown recruitment mode post-fire

[d] Count provided through census data including maturity levels

The population of *Acacia pubifolia* is therefore estimated to contain a minimum of 3,539–4,609 mature individuals, with this number considered to be highly conservative. Many stands in the Queensland portion of the distribution are poorly surveyed and remain unrecorded on biodiversity databases (A. Pengelly *in litt.* January 2023; L. Rowley *in litt.* January 2023) and new stands are still being found even after years of monitoring in heavily surveyed subpopulations (Eco Logical Australia 2021a, 2021b; Hunter 2022). Furthermore, a number of recently burnt stands currently consist of large numbers of juveniles that will progress to mature age classes in coming years (Eco Logical Australia 2021a, 2021b, 2023; Hunter 2022). Thus, it is likely that the true *A. pubifolia* population size is substantially larger than 3,539–4,609 and this range is therefore considered precautionary for this assessment.

Area of Occupancy and Extent of Occurrence

The Area of Occupancy (AOO) of *Acacia pubifolia* was estimated to be 100 km^2 using 2 x 2 km grid cells, the scale recommended by IUCN (2022). The Extent of Occurrence (EOO) was estimated to be 3,672 km^2 and is based on a minimum convex polygon enclosing all mapped occurrences of the species, the method of assessment recommended by IUCN (2022). Both EOO and AOO were calculated using ArcGIS (Esri 2015), enclosing all confirmed survey records and cleaned spatial datasets. Based on these estimates, *A. pubifolia* has a highly restricted AOO and EOO.

Number of Locations

When the threat of increased frequency and duration of drought due to climate change is considered, the eleven subpopulations of *Acacia pubifolia* can be considered to occur across three threat-defined locations, as per the IUCN definition (Appendix 2; IUCN 2022). This is due to increased frequency and duration of drought being the most serious plausible threat that results in the lowest number of locations for the taxon, and the effects of this threat are likely to differ in magnitude and effect across the three major regions of the Granite Belt, Emmaville and Warrabah in all but the most significant drought events.

While the Granite Belt subpopulations are separated by a minimum distance of 54 km from the Emmaville subpopulations and both are within the Border Rivers catchment area (MDBA 2022a), the Emmaville subpopulations are around 100–200 m lower in mean elevation and receive over 100 mm less mean rainfall annually (Clarke *et al.* 1997; Bureau of Meteorology 2023b). This means that the climate experienced by both areas is already different in nature as is typical across the Border Rivers (MDBA 2022b), and hence the occurrence and impact of drought is likely to vary between these regions. The Warrabah subpopulation is then approximately 141 km further

south from the next closest stands in the Emmaville region, and is within the Namoi River catchment, which has very different climatic conditions to the northern subpopulations (MDBA 2022a). Thus, the Warrabah subpopulation is likely to experience differing drought regimes again. This means that all three regions can be considered separate threat-defined locations.

Ecology

Habitat

The habitat of *Acacia pubifolia* is characterised by rocky granite hillsides with coarse, sandy soils covered by *Eucalyptus-Callitris* dominated forests and woodlands (Hunter and Copeland 2007; Tindale and Kodela 2018). While outcropping boulders and/or exposed rock pavements are a regular occurrence at many sites (3D Environmental 2007; Donatiu 2009; RBGDT 2023a), there are also records of the species on heavier clay soils (RBGDT 2023a) and on underlying metamorphic geology (Hunter and Copeland 2007), indicating that soil preferences may be wider than previously realised.

Acacia pubifolia can form almost pure stands in some areas similar to the 'wattle scrub' communities in southern NSW (Hunter 2005). Such thickets are evident at the Gulf Rd subpopulation in Torrington State Conservation Area and stands in Girraween National Park (Hunter 2005). However, it also commonly co-occurs with other species including *Eucalyptus prava, E. dealbata, E. laevopinea, E. caleyi* subsp. *caleyi, Callitris endlicheri, Angophora floribunda, Acacia neriifolia, Leptospermum brevipes, Leucopogon muticus, Jacksonia scoparia, Calytrix tetragona, Dillwynia sericea* and *Cheilanthes sieberi* subsp. *sieberi* (3D Environmental 2007; Hunter and Copeland 2007; RBGDT 2023a).

In NSW, *Acacia pubifolia* has been confirmed in the plant community types (PCT) Torrington Granite Shrub Forest (PCT 4124), Western New England Rocky Granite Low Woodland (PCT 3855) and Western New England White Pine-Tumbledown Gum Woodland (PCT 3511) (G. Phillips pers. obs. December 2018, November 2021; DPE 2022a, 2022b). The species is almost certainly not restricted to these PCTs though and may be found within other PCTs given the still poorly understood floristics in the areas in which *A. pubifolia* occurs (DPE 2022b).

In Queensland, *Acacia pubifolia* has been recorded in Regional Ecosystems 13.12.5 (*Eucalyptus youmanii* woodland on igneous rocks), 13.12.2 (*Eucalyptus andrewsii, E. youmanii* woodland on igneous rocks) and 13.12.6 (Shrubland and/or heath with areas of bare/lichen covered rocks +/- emergent Eucalypts on igneous rocks) (3D Environmental 2007; Department of Environment and Science 2023b). The species may not be restricted to these ecosystem types.

Life History

Previously, *Acacia pubifolia* has been considered an obligate seeder, reliant on seedling recruitment alone for post-disturbance recovery (Clarke *et al.* 1997). However, records of the species reshooting post-fire in the Wyberba subpopulation

and recent observations of extensive suckering in the NSW subpopulations mean that the species more likely has a variable response to disturbances such as fire, depending on the intensity and severity of past disturbance events (Hunter and Copeland 2007; Eco Logical Australia 2021a). Indications of mass emergence following fire in the more northerly Queensland stands in the absence of many mature stems pre-fire (P. Pemberton *in litt.* January 2023) also point to the fact that the primary response – through reshooting/suckering or by seedlings – may differ between subpopulations or even between stands.

Acacia pubifolia is known to produce new stems via suckering from the rootstock, with this appearing to be the main regenerative response to fire and other disturbance in the NSW subpopulations (Eco Logical Australia 2021a, 2021b) and at Wyberba (DCCEEW 2023). Following fire in the Gulf Rd subpopulation in November 2019, many previously mature stems have been replaced by root suckers, with some plants appearing to produce multiple new stems from a single rootstock (Eco Logical Australia 2021a). It appears that suckering is not only confined to being a post-fire response, with root suckers also confirmed to be the primary source of smaller size-class plants in long unburnt stands in Warrabah National Park and in the fenced enclosures at 'Romani' in post-drought recovery (Hunter and Copeland 2007; Eco Logical Australia 2021b).

Clonal reproduction as a method of reliable reproduction and long-term survivability is known to become more prevalent over sexual reproduction in other threatened species with highly disjunct or relict subpopulations that are exposed to differing disturbance regimes and fragmentation of habitat (Rossetto *et al.* 2004; Gross and Caddy 2006; He *et al.* 2011). This shift to clonal reproduction is also known from several other highly cleared and fragmented *Acacia* species that grow in dry environments (Auld 1993; Croft *et al.* 2010; Johnson *et al.* 2016). Thus, a dependence on suckering for the majority of reproduction is theorised to have become apparent in stands of *Acacia pubifolia* to allow them to persist within fragmented and modified landscapes (Hunter and Copeland 2007). Clonality may also be naturally derived due to limitations in soil nutrients and regular fire frequencies in open, shrubby ecosystems to enable persistence in harsh ambient conditions (He *et al.* 2011; Tsakalos *et al.* 2022) and this may also be true for *A. pubifolia* given the similarities in habitat preference.

Seedlings appear to be more frequently observed in the northerly Queensland subpopulations in more intact landscapes. Observations of hundreds of recruits coming up in disturbed areas where only low numbers of mature plants had previously existed, demonstrates that recruitment from the soil seedbank may be the primary response mechanism in subpopulations such as Scotney/Tinkerbell Nature Refuge and Nundubbermere (P. Pemberton *in litt.* January 2023; Anonymous *in litt.* February 2023). The southern subpopulations do produce viable seeds, though it is sporadic in production between individuals and year to year (G. Phillips pers. obs. December 2018, November 2020). Seed collections made from the Wyberba, Spring Hill, Gulf Rd and Warrabah subpopulations indicate that plants do produce reasonable quantities of viable seed in years with favourable environmental conditions, with all subpopulations sampled having high germination rates of over 90% (RBGDT 2023b).

Thus, a lack of conditions conducive to seedling establishment or high seed predation rates may be contributing to their absence in these subpopulations.

Lifespan and Generation Length

Acacia pubifolia is assumed to have a similar generation length to other large wattles which live up to 35 years (Hunter 2005; Hunter and Copeland 2007). Other dryland *Acacia* species such as *A. harpophylla* which predominantly reproduce through suckers can also live for 30-40 years before senescing (Johnson *et al.* 2016). Given this, individual *A. pubifolia* stems are estimated to have a lifespan of approximately 35 years.

The secondary juvenile period for *Acacia pubifolia* is estimated to be seven years. This is based on demographic studies showing progression of individuals through size classes to be greater than 1 m tall (Eco Logical Australia 2021b) and studies on the growth rates of individual juveniles in the Gulf Rd subpopulation (Mitchell-Williams 2022). *Acacia harpophylla* are also known to reach 1 m average height around 7–8 years of age (Johnson *et al.* 2016). Based on observations of what are assumed to be seedlings in Queensland, the primary juvenile period is also estimated to be approximately 6 to 7 years (P. Pemberton *in litt.* January 2023).

Given the varying recruitment strategies shown by *Acacia pubifolia,* it is possible to estimate the generation length in two ways. Where plants largely reproduce by suckering, generation length can be estimated using the age of first reproduction + *z* * length of reproductive period (IUCN 2022), where *z* is a constant between 0 and 1 calculated using survivorship and the relationship between fecundity and age. Using the above lifespan estimate of 35 years, a value for *z* of 0.21 comparable to other small, partially clonal tree species (Fung and Waples 2017), and a secondary juvenile period of seven years as a proxy for development of underground storage organs, the generation length of *A. pubifolia* is therefore estimated to be approximately 14 years using this method.

Alternatively, where *Acacia pubifolia* recruits via a soil seedbank, generation length can be calculated by primary juvenile period + half-life of seeds in the seedbank (IUCN 2022). Given an average half-life of seeds of approximately 10-18 years found in other *Acacia* species (Auld 1986; Holmes and Newton 2004), the generation length is estimated to be approximately 17-25 years using this method. Given *A. pubifolia* appears to be partially clonal, with 60–80% of known individuals in subpopulations appearing to only reproduce via root suckers, a weighted average generation length is required (IUCN 2022) and this is estimated to be approximately 14.6-18.4 years.

Pollination Ecology

Acacia pubifolia flowers from September to November (Tindale and Kodela 2018), with fruit maturing from December to January (RBGDT 2023a). The flowers are initially female before becoming functionally male, with the stigma being receptive prior to anther dehiscence (Kenrick 2003). This, along with asynchronous flowering over individual plants and within individual inflorescences, helps to promote outcrossing in

most *Acacia* (Kenrick 2003; Stone *et al.* 2003). This means that most species are highly self-incompatible (Bernhardt 1987; Kenrick 2003).

Acacia species predominantly rely on insects for the bulk of pollination with the most important of these being bees and wasps, with flies, beetles, and to a lesser extent, birds also involved (Bernhardt 1987; Stone *et al.* 2003; Gibson *et al.* 2011). Insects are drawn to the flowers to forage on the large pollen loads, with the pollen packaged into compounds consisting of multiple grains called polyads, which are particularly attractive to smaller native bee species and introduced honeybees (*Apis mellifera*) (Stone *et al.* 2003; Gibson *et al.* 2011). Pollination by birds such as honeyeaters, enabling occasional long-distance pollination, has also been postulated for some *Acacia* species (Vanstone and Paton 1998; Stone *et al.* 2003) This pollination mode is possible in *A. pubifolia* given the presence of a small gland on the phyllode which may act as an extrafloral nectary attractive to birds (Stone *et al.* 2003). In *Acacia pycnantha,* the exclusion of honeyeaters from these extrafloral nectaries resulted in much lowered production of fruit (Vanstone and Paton 1988) and so these birds may also affect pollination in *A. pubifolia* in a similar manner.

Seed Ecology

The pods of *Acacia pubifolia* twist spirally upon opening (G. Phillips pers. obs. December 2018; Eco Logical Australia 2021a), a trait known to eject seeds a small distance from the parent plant in other *Acacia* species (Auld 1997). Ants are then presumed to further move the seeds by up to several metres (Hughes and Westoby 1992), as the ants are attracted to the lipid-rich elaiosome attached to the end of the seed (Auld 1997) and this is relatively well-developed in *A. pubifolia* (Tame 1992). This movement and burial in the upper soil layers by ants is also known to play a role in predator avoidance and germination of *Acacia* species by protecting the seeds from the direct heat of a fire and providing heating conditions more favourable to the breaking of seed dormancy and germination (Beaumont *et al.* 2018).

Acacia species are generally considered to have persistent soil seedbanks, able to stay viable in the ground long-term as high levels of seed dormancy are present at peak fruit maturity (Auld 1997). This dormant portion of the seedbank requires the hard seed coat to be broken down or abraded in order for germination to occur, and this may occur by heat shock during the passage of fire or by physical abrasion (Tame 1992; Auld and Denham 2006). Germination tests on *Acacia pubifolia* show that it too possesses such a physical dormancy, requiring scarification to achieve high germination rates (RBGDT 2023b). A portion of the seedbank may also have either lowered levels of dormancy or no dormancy at all and the proportion of such seeds produced may vary between subpopulations, with this used as a strategy to diversify risk and ensure germination in unpredictable or variable fire and disturbance regimes (Liyanage and Ooi 2015).

Threats

Previously, the primary threats identified for *Acacia pubifolia* included adverse fire regimes, grazing by domestic stock and feral goats (*Capra hircus*), and clearing and fragmentation from agriculture and infrastructure development (Department of

Environment, Water, Heritage and the Arts 2008; OEH 2020). Monitoring in recent years has also now identified severe drought as adversely affecting *A. pubifolia* (Eco Logical Australia 2021a, 2021b) and this may now amount to the greatest driver of decline into the future with climate change. The only long-term demographic monitoring of the species in the Warrabah subpopulation shows a steady decline in the overall number of plants over the past 24 years (Eco Logical Australia 2021b), with other subpopulations also showing contemporary evidence of similar declines as a result of drought (Eco Logical 2021a; ALA 2023).

Increased frequency and duration of drought due to climate change

Increased frequency and duration of drought is contributing to continuing decline in the *Acacia pubifolia* population and is strongly inferred to do so into the future. In the Warrabah subpopulation, significant numbers of older, large individuals of *A. pubifolia* were observed to die off along with a stalling of recruitment and flowering/fruiting through both the Millennium Drought of 1997–2009 and the 2017–2019 drought (Table 3; Hunter and Copeland 2007; Eco Logical Australia 2019, 2020, 2021b), with subsequent numbers never appearing to recover back to pre-drought estimates. Over a 24-year period encompassing these two major drought events, the abundance within an experimental enclosure set up to protect an intact stand of *A. pubifolia* on the 'Romani' property saw the numbers of *A. pubifolia* drop from 95 in 1999 to 83 in 2006 during the Millennium Drought. By 2018, as the 2017-2019 drought took hold, the number had again dropped to 48, with this trend continuing throughout the drought with only 29 plants recorded in 2019 and 2020. By 2021, after the drought had abated, the number had slightly recovered back to 33 (Eco Logical Australia 2021b). While it is thought that some of the trees may recover through resprouting in time and this is already underway in some stands (Eco Logical Australia 2021a, 2021b, 2023), the survey data from 2006 and 2018 shows a still sizeable decline in total abundance. This is despite the intervening years having favourable climatic conditions, the plants remaining protected within the fenced enclosure and being unaffected by fire throughout this time (NPWS 2022; Bureau of Meteorology 2023a).

Table 3 – Change in abundance of mature individuals since 1999 in the 'Romani' site within the Warrabah subpopulation (Eco Logical Australia 2021b). Drought information sourced from Bureau of Meteorology 2023a).

Survey Date	Observer	Total Plants	Year on year change	Cumulative Change	Drought Year	Notes
3/05/1999	P. Metcalfe	95	-	-	Yes	Onset of Millennium Drought
4/10/2006	L. Copeland	83	-13%	-13%	Yes	Drought conditions eased 2003-2006, so some recovery is likely accounted for in the total plants counted this season

20/02/2018	L. Copeland	48	-42%	-49%	Yes	2017-2019 Drought
29/05/2019	L. Copeland	29	-40%	-69%	Yes	2017-2019 Drought
21/04/2020	L. Copeland	29	0%	-69%	No	4 months post-drought
15/09/2021	L. Copeland	33	14%	-65%	No	19 months post-drought

These observations are also in line with monitoring data in the broader Warrabah and Gulf Rd subpopulations of *Acacia pubifolia*, with the overall number of stems at both subpopulations seen to steadily decline due to constant mortality of mature trees during the 2017-2020 drought (Eco Logical Australia 2019, 2020, 2021a). The Warrabah subpopulation declined by 23% from 425 to 326 individuals from 2018 to 2020, having already declined from a minimum of 500 in 2007 resulting in an overall loss of approximately 28%, with limited post-drought recruitment evident by 2021 (Hunter and Copeland 2007; Eco Logical Australia 2021b). The Gulf Rd subpopulation similarly declined by 15% from 838 to 711 individuals from 2017 to 2021 (Eco Logical Australia 2021a), though heavy post-fire suckering growth has again boosted overall stem numbers to 909 at last count due to a large flush of juveniles (Eco Logical 2023). In both cases however, the mortality of mature plants was significant, and it is currently unknown if recent recruitment will replenish pre-drought mature numbers (Eco Logical Australia 2021a, 2021b, 2023). Given these common declines in the more heavily surveyed subpopulations through the drought, it is highly likely that similar declines have occurred in other subpopulations given the wide-ranging impacts of both the Millennium and 2017–2020 droughts (Bureau of Meteorology 2023a). Records of decreased flowering/fruiting (P. Pemberton *in litt.* January 2023) and poor plant health (ALA 2023) over this time in the Queensland subpopulations indicates these trends may be occurring in those subpopulations also.

While it is acknowledged that some stands may be senescing due to a lack of fire given the fire stimulated recruitment seen in other previously senescent stands such as Gulf Rd (Eco Logical Australia 2021a, 2023), the observed loss of mature individuals and stalling of recruitment during drought is still considered to represent an ongoing threat to the population of *Acacia pubifolia*. Drought is likely to increase in frequency and magnitude in the future due to widely accepted projections of increased air temperatures (Nicholls 2004; Reichstein *et al.* 2013; Trenberth *et al.* 2013). While predicting the effects of future droughts and how they affect individual species is difficult (Cook *et al.* 2018; De Kauwe *et al.* 2020), the observed mortality in *A. pubifolia* across multiple drought events highlights that drought has an overall adverse effect on the species. Indeed, these projected changes are already becoming more consistent with increased reports of severe drought affecting forest and woodland ecosystems across eastern Australia (Fensham *et al.* 2009; Allen *et al.* 2015; De Kauwe *et al.* 2020) as well as species closely related to *A. pubifolia* such as *A. williamsiana* (Croft *et al.* 2007). As such, it can be strongly inferred that future mortality-inducing events due to prolonged and severe drought in *A. pubifolia* are likely to become more common.

Under future climate scenarios, the New England and Southern Downs regions in which *Acacia pubifolia* occurs are predicted to become hotter, have fewer colder nights under 2°C annually, and more hot days over 35°C annually by the 2070s (AdaptNSW 2023, State of Queensland 2023). These shifts will not only exacerbate the mortality of *A. pubifolia* during droughts, but will further expose the population to increased risk from other threats that interact with drought to enhance decline such as adverse fire regimes and herbivory. Thus, recovery potential following each drought episode will likely be reduced, further amplifying the already observed declines as has been noted already in other suckering *Acacia* species on the New England Tableland such as *A. williamsiana* (Croft *et al.* 2007). 'Anthropogenic Climate Change' is listed as a Key Threatening Process under the *NSW Biodiversity Conservation Act 2016.*

Adverse fire regimes

Adverse fire regimes may cause decline in the population of *Acacia pubifolia* if severe fires were to affect the population more frequently into the future, particularly if such fires were to follow on from times of drought. Currently, stands of *A. pubifolia* are exposed to a variety of fire regimes with a mixture of long unburnt and recently burnt stands (Table 2; Department of Environment and Science 2019; NPWS 2022). When burnt, stands appear to undergo intense recruitment (at least at some sites after some fires), with numerous root suckers and/or seedlings replacing burnt mature individuals which may have been in very low numbers or in poor health immediately prior to the fire (Eco Logical Australia 2021a, 2023; Hunter 2022; P. Pemberton *in litt.* January 2023). As such, suitable fire regimes for *A. pubifolia* need to allow for recovery or resprouting ability in subpopulations that display a reliance on clonal reproduction, as well as the replenishment and germination of soil seedbanks, and this may vary between sites depending on the primary recruitment method. Previously, a minimum return fire interval of 5 years and a maximum interval of 30 years was recommended (OEH 2020). However, a 5-year minimum may now be adverse once drought interactions are also considered, with a 15-year minimum return interval more recently recommended (DPE 2023).

Croft *et al.* (2010) showed that stands of *Acacia williamsiana,* a close relative of *A. pubifolia* which also reproduces almost exclusively through root suckers, could be locally extirpated in a single 10-year cycle of fire-drought-fire-drought. It was found that after an initial wildfire followed by drought, a stand was still able to resprout in a limited manner but another fire-drought cycle 5 to 10 years following the initial wildfire then results in the complete death of all reshoots and no further reshooting or recruitment was recorded (Croft *et al.* 2010). Given the close ecological similarities of these species, it is considered that *A. pubifolia* is similarly affected by too frequent fire, with the repeated disturbances greatly depleting the species' ability to reshoot within a few disturbance cycles once drought is included (Croft *et al.* 2007).

Drought-fire interactions have not yet been directly observed to be causing continuing decline in *A. pubifolia* as subpopulations recently burnt in 2019 following severe drought are currently recovering well enough to replenish pre-fire numbers through strong suckering growth (Eco Logical Australia 2021a, 2023; Hunter 2022). However, there remains a high risk that another drought-fire cycle in these subpopulations could

rapidly induce such a decline as demonstrated by Croft *et al.* (2010). Additionally, the lack of seedling recruitment observed in the Gulf Rd stands following wildfire in 2019 may be due to a depleted soil seedbank, given the previous wildfire was only 10 years prior in 2009 (NPWS 2022). Thus, a projected continuing decline is considered likely in the population of *A. pubifolia* due to increased fire frequency as the conditions conducive to such events are predicted to increase in frequency into the future in the New England Tableland and Southern Downs regions (AdaptNSW 2023; State of Queensland 2023). '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 NSW *Biodiversity Conservation Act 2016* and 'Fire regimes that cause declines in biodiversity is listed as a Key Threatening Process under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Adverse fire regimes may also affect the population of *Acacia pubifolia* if fire is kept out of the landscape for too long by reducing recruitment events that may replenish senescent stands. Given the hard seed coat that must be breached for maximum germination to occur in *A. pubifolia* (RBGDT 2023b), the passage of wildfire at suitable intervals may be required to stimulate large recruitment events from seed. Subpopulations that have come to rely on asexual reproduction through suckering are also typically reliant on regular fire to stimulate new suckering growth given clonality is dependent on regular fire to maintain competitive advantages (He *et al.* 2011) and large increases in suckers are apparent following hot fires in *A. pubifolia* (Eco Logical Australia 2021a, 2023; Hunter 2022). The very poor health of plants seen in intact, yet long unburnt stands such as at Amiens (ALA 2023), and the constant decline of mature individuals in more fragmented and cleared stands such as at Warrabah (Hunter and Copeland 2007; Eco Logical Australia 2021b), may therefore be due to a prolonged absence of suitable hot fires to stimulate germination of seeds to maintain stand diversity or the mass emergence of suckers to regenerate older underground storage organs.

Clearing of habitat for agricultural and infrastructure development

The clearing of habitat for agricultural development has been noted to have caused the loss of individuals of *Acacia pubifolia* in the past in some subpopulations, notably at Warrabah (Hunter and Copeland 2007) and Gulf Rd (G. Phillips pers. obs. January 2019). On the private lands within the Warrabah subpopulation, it has been noted that the landscape in which the stands of *A. pubifolia* occur are highly modified and not representative of the original vegetation (Hunter and Copeland 2007) and so there is a high probability that individuals have been historically cleared and that intra-stand isolation has ensued. The lands around Warrabah National Park were first cleared for agricultural development in the 1830s (NPWS 2003b), so it is possible that stands have been fragmented since this time. Historical clearing has affected the Gulf Rd subpopulation also, with stands immediately adjacent to heavily cleared pastoral lands having had a proportion of their original extent cleared in earlier times of European settlement (G. Phillips pers. obs. January 2019). The full extent of a population reduction due to this historical clearing is not known for either subpopulation but it is likely to have been non-trivial in magnitude at both, and has at a minimum reduced the

quality and extent of habitat available to *A. pubifolia*. However, clearing appears to have abated in modern times with sympathetic management (DPE 2023).

Adverse impacts on *Acacia pubifolia* due to infrastructure maintenance and development are also apparent in the Gulf Rd, Warrabah and Nundubbermere subpopulations. At Gulf Rd, grading along the road which bisects the largest stand damaged and killed a number of plants as recently as 2018 (DPE 2023). Track maintenance has also been noted to have damaged some plants in the Warrabah subpopulation due to them overhanging a major fire trail into which suckers were recruiting (G. Phillips pers. obs. November 2020). Decline from this work is considered trivial in magnitude however, with numbers of impacted plants being very low at each site, the damage localised in nature. While further damage is now mitigated against through protective measures in the NPWS managed land (DPE 2023), some further damage at the Gulf Rd subpopulation may still occur with the proposed erection of a stock fence (P. Sheringham *in litt.* March 2023) and so the magnitude of this threat may also change into the future.

Loss of habitat for infrastructure development may still occur in the Nundubbermere subpopulation as substantial suitable habitat for *A. pubifolia* may be inundated for a proposed dam, though no *A. pubifolia* plants were themselves mapped in the inundation area (3D Environmental 2007). Damage to identified *A. pubifolia* individuals mapped as possibly being affected by associated dam infrastructure has also been avoided by re-routing planned road and pipeline easements to avoid stands (3D Environmental 2007; State of Queensland 2014). Thus, while clearing for agriculture and infrastructure has occurred in the past, the only current impacts from this threat on the population of *A. pubifolia* are considered trivial in magnitude or only constitute future plausible threats to the extent of available habitat. Therefore, clearing of habitat is not considered to be contributing to continuing decline as per the IUCN definition (2022) at this time. 'Clearing of native vegetation' is listed as a Key Threatening Process on the *Biodiversity Conservation Act 2016*.

Grazing by domestic stock and feral goats

Grazing by livestock and feral goats (*Capra hircus*) is ongoing at the Warrabah and Gulf Rd subpopulations and are contributing to continuing decline in the quality of habitat for *Acacia pubifolia* at both these sites, with similar impacts likely in other subpopulations. In the Warrabah subpopulation, most known plants exist within land managed for grazing and plants outside of fenced enclosures have been noted to sustain damage from grazing animals (Hunter and Copeland 2007). Similarly, at the Gulf Rd site, plants in the southernmost part of the subpopulation exist within paddocks managed for livestock and recruitment is severely limited in these stands due to recruits being constantly grazed, limiting opportunities to recolonise historically cleared ground (G. Phillips pers. obs. January 2019). Thus, continued livestock grazing is contributing to continuing decline in the quality of habitat at these two major subpopulations by limiting recruitment opportunities, and this is exacerbated by feral goat issues (Eco Logical Australia 2023).

Feral goats are known to impact *Acacia pubifolia* through their over-grazing and erosion of soils (DPE 2021), especially in times of drought and they have been noted

to have a minor effect on the species (Eco Logical Australia 2023). Active management of goats is undertaken at the Gulf Rd and Warrabah subpopulations (DPE 2023). However, such control is not undertaken on all properties adjacent to these sites, which means they remain a threat to the broader subpopulations (G. Phillips pers. obs. January 2019). The Flagstone Creek subpopulation is also known to occur on private property with a high density of goats due to past farming practices (G. Phillips pers. obs. January 2019). Goats are also a concern within Girraween National Park, especially for outcrop vegetation (QPWS 2010). This means that although the current impacts are minor in nature (Eco Logical Australia 2023), several *A. pubifolia* subpopulations are likely to see continuing decline in habitat quality due to goat browsing, and this decline may be significantly amplified in times of drought. 'Competition and habitat degradation by feral goats (*Capra hircus*)' is listed as a key threatening process under the NSW *Biodiversity and Conservation Act 2016* and 'Competition and land degradation by unmanaged goats' is listed as a key threatening process under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

Assessment against IUCN Red List criteria

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

Criterion A *Population size reduction*

Assessment Outcome: Data deficient

Justification: *Acacia pubifolia* has suffered a population reduction in the past due to the combined effects of increased frequency and duration of drought due to climate change and clearing of habitat for agricultural and infrastructure developments. However, this reduction is not able to be quantified across the full population and/or occurred outside of a three-generation timeframe and therefore precludes listing under Criterion A. Within the three-generation timeframe of 43.8-55.2 years, reductions in the overall number of individuals of approximately 28% in the Warrabah subpopulation and 15% in the Gulf Rd subpopulations have been recorded due to drought (Hunter and Copeland 2007; Eco Logical Australia 2021a, 2021b). However, recent post-drought recruitment events, especially following fire at Gulf Rd (Eco Logical Australia 2023), make overall reductions difficult to quantify to the present and into the future, even though they are certain to be occurring given the large mortality in mature stems at both sites since 2017 (Eco Logical Australia 2021a, 2021b, 2023; P. Sheringham *in litt.* March 2023). No similar demographic or monitoring data are available for any other subpopulations over the required timeframe to enable calculation of reductions in these sites. Furthermore, while past land clearing for agricultural development has certainly resulted in a loss of mature individuals in the Warrabah and Gulf Rd subpopulations, this clearing was predominantly undertaken prior to the three-generation timeframe of 43.8-55.2 years and is of unknown magnitude (NPWS 2003b; G. Phillips pers. obs. January 2019). Given these data issues, assessment under Criterion A is not able to be presently undertaken.

Criterion B *Geographic range*

Assessment Outcome: Endangered under Criterion B1ab(iii,v) + B2ab(iii,v)

Justification: *Acacia pubifolia* has a wide but patchy distribution, giving it a highly restricted Area of Occupancy (AOO) and Extent of Occurrence (EOO). The AOO has been calculated as 100 km^2, meeting the threshold for Endangered. The EOO has been calculated as 3,672 km^2, also meeting the threshold for Endangered.

In addition to these thresholds, at least two of three other conditions must be met to qualify for listing under Criterion B. 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 Endangered due to having three threat-defined locations.

   Justification: *Acacia pubifolia* is found at three threat-defined locations when considering the most serious plausible threat of increased frequency and duration of drought due to climate change. This is due to increased frequency and duration of drought being the most serious plausible threat that results in the lowest number of locations for the taxon, and the effects of this threat are likely to differ in magnitude and effect across the three major regions of the Granite Belt, Emmaville and Warrabah in all but the most significant drought events.

   Acacia pubifolia is not considered severely fragmented. Most subpopulations could be considered isolated given the distances between subpopulations, the species' localised seed dispersal, typical pollinator foraging ranges and gene flow patterns observed in other *Acacia* species (Bernhardt 1987; Auld 1997; Stone *et al.* 2003; Hagler *et al.* 2011; Millar *et al.* 2013, 2014; Blythe *et al.* 2020). However, most subpopulations are of substantial size (i.e. >1000 individuals) and/or show positive recruitment either asexually or sexually after disturbance and are thus considered currently viable, not satisfying the IUCN (2022) definition of severe fragmentation.

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: Met for continuing decline observed, inferred and projected for (iii) area, extent and quality of habitat and (v) number of mature individuals

   Justification: Decline has been observed and is strongly inferred to continue in the extent and quality of habitat and number of mature individuals of *Acacia pubifolia* due to the combined effects of increased frequency and duration of drought due to climate change, adverse fire regimes and grazing by domestic stock and feral goats. In the Warrabah subpopulation, significant numbers of older, large individuals of *A. pubifolia* were observed to die off along with a stalling of recruitment and flowering/fruiting through both the Millennium

Drought of 1997–2009 and the 2017–2019 drought (Hunter and Copeland 2007; Eco Logical Australia 2019, 2020, 2021b), with subsequent numbers never appearing to recover back to pre-drought estimates. These observations are also in line with observations in the Gulf Rd subpopulation, with the overall number there seen to steadily decline due to constant mortality of mature trees during the 2017-2019 drought (Eco Logical Australia 2019, 2020, 2021a). Recruitment is now underway, particularly in the Gulf Rd subpopulation following fire in 2019 (Eco Logical Australia 2023), however this is uncertain to replenish pre-drought mature numbers given the long-term decline noted at Warrabah between the Millennium and 2017-2019 droughts (Eco Logical Australia 2021b). Given these common declines in the more heavily surveyed subpopulations, it is highly likely that similar declines have occurred in other subpopulations given the wide-ranging impacts of both the Millennium and 2017–2020 droughts (Bureau of Meteorology 2023a). Records of decreased flowering/fruiting (P. Pemberton *in litt.* January 2023) and poor plant health (ALA 2023) through the 2017-2019 drought in the Queensland subpopulations indicate these trends are likely to be occurring in those subpopulations also. Under projected future climate conditions for the region in which *A. pubifolia* occurs, drought is expected to increase in frequency and magnitude (Nicholls 2004; Reichstein *et al.* 2013; Trenberth *et al.* 2013; Allen *et al.* 2015; AdaptNSW 2023; State of Queensland 2023). Therefore, it can be reasonably inferred that future drought-induced mortality events in *A. pubifolia,* such as that seen in the Millennium and 2017-2019 droughts, will become more common, exacerbating observed declines. Droughts can also interact with adverse fire regimes to contribute to decline through the elimination of stems capable of resprouting, depletion of soil seedbanks and increased mortality of mature individuals if severe fires were to become more frequent, as seen in other closely related *Acacia* species (Croft *et al.* 2007, 2010). Conversely, too infrequent fire may limit recruitment episodes required to replenish senescing stands as clonal shrubs are dependent on regular fire to maintain competitive advantages (He *et al.* 2011) and the soil seedbank requires disturbance such as from fire in order to germinate (Tame 1992; Auld and Denham 2006). Additionally, a number of subpopulations are actively grazed and/or impacted by feral goat browsing through overgrazing and erosion of soils and this is exacerbated during drought (Hunter and Copeland 2007; QPWS 2010; DPE 2021; Eco Logical Australia 2021b). Combined, these threats mean that the extent and quality of habitat and the number of mature individuals of *A. pubifolia* are likely to remain under pressure, with currently observed declines strongly inferred to continue into the future.

c) Extreme fluctuations.

Assessment Outcome: Not met.

Justification: *Acacia pubifolia* is a relatively long-lived species and is unlikely to undergo extreme fluctuations.

Criterion C Small population size and decline

Assessment Outcome: Not met.

Justification: The current population for *Acacia pubifolia* includes an estimated minimum number of 3,539–4,609 mature individuals, meeting the threshold for Vulnerable. In addition to this threshold, one of at least two other conditions must be met to qualify for listing under Criterion C. These conditions 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: *Acacia pubifolia* is undergoing continuing decline due to the combined effects of increased frequency and duration of drought due to climate change, adverse fire regimes and grazing by domestic stock and feral goats. However, insufficient data are available to estimate the rate of this decline across the whole population of *A. pubifolia*, and hence this subcriterion cannot be evaluated.

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

Assessment Outcome: Not met.

Justification: Decline has been observed and is strongly inferred to continue in the area, extent and quality of habitat and number of mature individuals of *Acacia pubifolia* due to the combined effects of increased frequency and duration of drought due to climate change, adverse fire regimes and grazing by domestic stock and feral goats, however at least 1 of the following 3 conditions also must be met:

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

Assessment Outcome: Not met.

Justification: The population of *Acacia pubifolia* consists of 11 subpopulations, with the largest (Spring Hill) containing approximately 2,074 mature individuals.

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

Assessment Outcome: Not met.

Justification: *Acacia pubifolia* has a spread of different sized subpopulations (Table 2), with the largest (Spring Hill) currently estimated to possess approximately 58% of known mature individuals.

b. Extreme fluctuations in the number of mature individuals

Assessment Outcome: Not met.

Justification: *Acacia pubifolia* is a relatively long-lived species and is unlikely to undergo extreme fluctuations.

Criterion D Very small or restricted population

Assessment Outcome: Not met.

Justification: *Acacia pubifolia* is currently estimated to have a population of 3,539–4,609 mature.

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 current estimated population for *Acacia pubifolia* is a minimum of 3,539–4,609 mature individuals.

D2. Restricted area of occupancy (typically <20 km^2) 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: *Acacia pubifolia* has an estimated AOO of 100 km^2 and only occurs at three threat-defined locations. However, it is not subject to future plausible threats that could rapidly drive the species to EX or CR in a very short time.

Criterion E Quantitative Analysis

Assessment Outcome: Data deficient.

Justification: Currently there is insufficient data to undertake a quantitative analysis to determine the extinction probability of *Acacia pubifolia.*

Conservation and Management Actions

Acacia pubifolia 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. *A. pubifolia* sits within the site-managed management stream of the SoS program.

Activities to assist this species currently recommended by the SoS program (OEH 2020; DPE 2023) include:

Habitat loss, disturbance and modification

- Manage fire to encourage regeneration of *Acacia pubifolia* by implementing a fire interval of between 15 and 30 years, and not during current or projected dry periods.
- Fence off known subpopulations to protect from grazing stock and maintain existing stock fences.
- Protect individuals during road and other infrastructure maintenance activities.
- Protect areas of dry shrubby woodland habitat, especially known populations, from further clearing and fragmentation.
- Expand and reconnect isolated stands and areas of habitat.
- Continue feral goat culling on national parks estate.

Ex situ conservation

- Collect seed and germplasm from multiple subpopulations for long-term storage.

Survey and monitoring

- Continue annual surveys in the NSW subpopulations including monitoring of tagged individuals and census counts of known stands.
- Monitor the abundance, health and condition of existing subpopulations.
- Monitor for evidence of disturbance due to roadworks and other infrastructure maintenance activities where they occur within subpopulations.
- Monitor for evidence of overgrazing and/or disturbance such as trampling in subpopulations where stock grazing occurs.
- Undertake quantitative assessment of pest animal abundance/density/activity at management sites.
- Monitor recruitment, browsing and adult condition immediately post-fire and subsequently every 6 months for up to 3 years in subpopulations affected by fire.
- Continue to survey and add sites and potential habitat to inform infrastructure maintenance planning.

Information and stakeholder liaison

- Support local Landcare and other conservation and land management organisations which may be working on or within the habitat of *Acacia pubifolia.*
- Liaise with private landholders to advocate for suitable fire management and additional goat control.
- Liaise with local government to minimize adverse effects from infrastructure maintenance activities.

References

3D Environmental (2007). Terrestrial Flora Baseline Study, Emu Swamp Dam Project, Severn River, Queensland. A Report to SKM Pty. Ltd. For Stanthorpe Shire Council. 176 pp.

AdaptNSW (2023). Interactive climate change projections map. URL: https://www.climatechange.environment.nsw.gov.au/projections-map (Accessed 10 January 2023).

Allen CD, Breshears DD, McDowell NG (2015). On underestimation of global vulnerability to tree mortality and forest die-off from hotter drought in the Anthropocene. *Ecosphere* **6(8)**: 129.

Atlas of Living Australia (ALA) (2023). [Occurrence download for *Acacia pubifolia*] [dataset]. URL: https://doi.org/10.26197/ala.b8bf0d08-eaad-4764-b3d1-00241fedf8cb (Accessed 24 January 2023).

Auld (1986). Population dynamics of the shrub *Acacia suaveolens* (Sm.) Willd.: Dispersal and the dynamics of the soil seedbank. *Aust. J. of Ecol.* 11: 235-254.

Auld TD (1993). The impact of grazing on regeneration of the shrub *Acacia carnei* in arid Australia. *Biological Conservation* **65**: 165–176.

Auld TD (1997). Ecology of the Fabaceae in the Sydney region: fire, ants and the soil seedbank. *Cunninghamia* **4(4)**: 531-551.

Auld TD, Denham AJ (2006). How much seed remains in the soil after a fire? *Plant Ecology* **187**: 15–24.

Beaumont KP, Mackay DA, Whalen MA (2018). The role of *Rhytidoponera metallica* (Hymenoptera, Formicidae) in facilitating post-fire seed germination of three ant-dispersed legume species. *Austral Ecology* **43(2)**: 128–138.

Bernhardt P (1987). A comparison of the diversity, density, and foraging behavior of bees and wasps on Australian *Acacia*. *Annals of the Missouri Botanic Garden* **74(1)**: 42-50.

Blythe C, Christmas MJ, Bickerton DC, Faast R, Packer JG, Lowe AJ, Breed MF (2020). Increased genetic diversity via gene flow provides hope for *Acacia whibleyana*, an endangered wattle facing extinction. *Diversity* **12**: 299.

Bureau of Meteorology (2023a). Previous droughts. URL: http://www.bom.gov.au/climate/drought/knowledge-centre/previous-droughts.shtml#pageContents (Accessed 27 February 2023).

Bureau of Meteorology (2023b). Monthly rainfall: Girraween Nat Park. URL: http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=139&p_display_type=dataFile&p_stn_num=041454 (Accessed 24 April 2023).

Clarke PJ, Copeland LM, Hunter JT, Nano CE, Williams JB, Wills KE (1997). The Vegetation and Plant Species of Torrington State Recreation Area. A report published by the Division of Botany, The University of New England, for the NSW National Parks and Wildlife Service and The University of New England, Armidale, Australia. 149 pp.

Cook BI, Mankin JS, Anchukaitis KJ (2018). Climate change and drought: From past to future. *Current Climate Change Reports* **4**: 164–179.

Copeland LM (1997). [*Acacia pubifolia* specimen NSW426565] [specimen collection data] Royal Botanic Gardens and Domain Trust, Sydney, Australia.

Copeland LM, Hunter JT (1999). Range extensions and conservation status of 18 restricted plant species in north-eastern New South Wales. *Cunninghamia* **6(2)**: 395-400.

Copeland LM, Sheringham P, Melrose R, Stehn C (2018). [*Acacia pubifolia* survey records for "The Springs"] [unpublished raw data]. Department of Planning and Environment.

Council of Heads of Australian Herbaria (CHAH) (2018). Australian Plant Census. URL: https://biodiversity.org.au/nsl/services/rest/reference/apni/9787312 (Accessed 24 January 2023).

Croft P, Hunter JT, Reid N (2007). Depletion of regenerative bud resources during cyclic drought: What are the implications for fire management? *Ecological Management and Restoration* **8(3)**: 187–192.

Croft P, Hunter JT, Reid N (2010). Threat of fire and drought for the rare wattle *Acacia williamsiana* J.T.Hunter: an experimental burn highlights implications for fire management. *Ecological Management and Restoration* **11(3)**: 217–220.

De Kauwe MG, Medlyn BE, Ukkola AM, Mu M, Sabot MEB, Pitman AJ, Meir P, Cernusak LA, Rifai SW, Choat B, Tissue DT, Blackman CJ, Li X, Roderick M, Briggs PR (2020). Identifying areas at risk of drought-induced tree mortality across South-Eastern Australia. *Global Change Biology* **26(10)**: 5716–5733.

Department of Agriculture, Water and Environment (DAWE) (2012). Interim Biogeographic Regionalisation for Australia, Version 7. URL: http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/maps.html. (Accessed 25 January 2023).

Department of Climate Change, Energy, the Environment and Water (DCCEEW) (2023). *Acacia pubifolia* in Species Profile and Threats Database, DCCEEW,

Canberra, Australia. URL: https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=19799 (Accessed 24 January 2023).

Department of Environment and Science (2019). *QPWS Fire History* [dataset]. Accessed using ArcGIS 10.4 for desktop, Redlands, California, USA. Esri Inc. 1999-2005.

Department of Environment and Science (2023a). [*Acacia pubifolia* survey data] [dataset]. State of Queensland. URL: https://apps.des.qld.gov.au/species/?op=getsurveysbyspecies&taxonid=14081&f=csv (Accessed 22 February 2023).

Department of Environment and Science (2023b). *Biodiversity status of 2019 remnant regional ecosystems – Queensland version 12.2.* URL: https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={8FDF54D2-654C-4822-8295-1D8E8E772373}, exported 28 February 2023.

Department of Environment, Water, Heritage and the Arts (2008). Approved conservation advice for *Acacia pubifolia*. Department of Environment, Water, Heritage and the Arts, Canberra.

Department of Planning and Environment (DPE) (2021). Feral Goats. URL: https://www.environment.nsw.gov.au/topics/animals-and-plants/pest-animals-and-weeds/pest-animals/feral-goats (Accessed 18 August 2022).

Department of Planning and Environment (DPE) (2022a). *NSW State Vegetation Type Map C1.1M1.* Source: NSW Department of Planning and Environment GIS layer, exported 28 February 2023.

Department of Planning and Environment (DPE) (2022b). *NSW PCT master list C1.1.* Source: BioNet Vegetation Classification application, exported 28 February 2023.

Department of Planning and Environment (2023). Project: *Acacia pubifolia*, Saving Our Species database 4.9.0. NSW Department of Planning and Environment (Accessed 28 February 2023).

Donatiu P (2009). 'The Vanishing Wild, Rare Flora Surveys of Current and Proposed Nature Refuge Properties on the Stanthorpe Plateau' (National Parks Association of Queensland, Brisbane, Australia).

Eco Logical Australia (2019). Annual monitoring of Velvet Wattle (*Acacia pubifolia*) in "Romani", "Bai Yai", Warrabah National Park and Torrington State Conservation Area – 2019. An unpublished report for the NSW Office of Environment and Heritage. 16pp.

Eco Logical Australia (2020). Annual monitoring of Velvet Wattle (*Acacia pubifolia*) in "Romani", Warrabah National Park and Torrington State Conservation Area –

2019/2020. An unpublished report for the NSW Department of Planning, Industry and Environment. 17pp.

Eco Logical Australia (2021a). *Acacia pubifolia* monitoring – Torrington 2021. An unpublished report for the NSW Department of Planning, Industry and Environment. 14pp.

Eco Logical Australia (2021b). *Acacia pubifolia* monitoring – "Romani", "Bai Yai" and Warrabah NP, 2021. An unpublished report for the NSW Department of Planning, Industry and Environment. 18pp.

Eco Logical Australia (2023). *Acacia pubifolia* monitoring – Torrington SCA, 2023. An unpublished report for the NSW Department of Planning and Environment. 16pp.

Environmental Systems Research Institute (ESRI) (2015). ArcGIS 10.4 for desktop. Redlands, California, USA. Esri Inc. 1999-2005.

Fensham RJ, Fairfax RJ, Ward DP (2009). Drought-induced tree death in savanna. *Global Change Biology* **15**: 380-387.

Fung HC, Waples RS (2017). Performance of IUCN proxies for generation length. *Conservation Biology* **31(4)**: 883–893.

Gibson MR, Richardson DM, Marchante E, Marchante H, Rodger JG, Stone GN, Byrne M, Fuentes-Ramirez A, George N, Harris C, Johnson SD, Le Roux JJ, Miller JT, Murphy DJ, Pauw A, Prescott MN, Wandrag EM, Wilson JRU (2011). Reproductive biology of Australian acacias: important mediator of invasiveness? *Diversity and Distributions* **17**: 911–933.

Gross CL, Caddy HAR (2006). Are differences in breeding mechanisms and fertility among populations contributing to rarity in *Grevillea rhizomatosa* (Proteaceae)? *American Journal of Botany* **93(12)**: 1791-1799.

Hagler JR, Mueller S, Teuber LR, Machtley SA, Van Deynze A (2011). Foraging range of honey bees, *Apis mellifera*, in alfalfa seed production fields. *Journal of Insect Science* **11**: 144.

He T, Lamont BB, Downes KS (2011). Banksia born to burn. *New Phytologist* **191**: 184–196.

Holmes PM, Newton RJ (2004). Patterns of seed persistence in South African fynbos. *Plant Ecology* 172: 143-158.

Horton DR (1996). The AIATSIS Map of Indigenous Australia. Australian Institute of Aboriginal and Torres Strait Islander Studies. URL: https://aiatsis.gov.au/explore/map-indigenous-australia (Accessed 24 January 2022).

Hughes L, Westoby M (1992). Fate of seeds adapted for dispersal by ants in Australian sclerophyll vegetation. *Ecology* **73(4)**: 1285–1299.

Hunter JT (1997). *Acacia williamsiana* (Fabaceae: Juliflorae): A new granitic outcrop species from northern New South Wales. *Journal of the Royal Society of Western Australia* **80**: 235-237.

Hunter JT (2005). Floristics and distribution of Wattle Dry Sclerophyll Forests and Scrubs in north-eastern New South Wales. *Cunninghamia* **9(2)**: 317–323.

Hunter JT (2022). [Preventing Extinction for New England Endemic Plants record data] [unpublished raw data]. University of New England, Armidale, Australia.

Hunter JT, Copeland LM (2007). Field survey of Western Granite threatened flora species, identified as priority by the Namoi Catchment Management Authority. A report to the Namoi Catchment Management Authority. 166 pp.

IUCN Standards and Petitions Subcommittee (2022). Guidelines for Using the IUCN Red List Categories and Criteria. Version 15.1 (July 2022). Standards and Petitions Committee of the IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.

Johnson RW, McDonald WJ, Fensham RJ, McAlpine CA, Lawes ML (2016). Changes over 46 years in plant community structure in a cleared brigalow (*Acacia harpophylla*) forest. *Austral Ecology* **41**: 644–656.

Kenrick (2003). Review of pollen-pistil interaction and their relevance to the reproductive biology of *Acacia. Australian Systematic Biology* **16**: 119–130.

Liyanage GS, Ooi MKJ (2015). Intra-population level variation in thresholds for physical dormancy-breaking temperature. *Annals of Botany* **116**: 123–131.

Millar MA, Coates DJ, Byrne M (2013). Genetic connectivity and diversity in inselberg populations of *Acacia woodmaniorum*, a rare endemic of the Yilgarn Craton banded iron formations. *Heredity* **111**: 437–444.

Millar MA, Coates DJ, Byrne M (2014). Extensive long-distance pollen dispersal and highly outcrossed mating in historically small and disjunct populations of *Acacia woodmaniorum* (Fabaceae), a rare banded iron formation endemic. *Annals of Botany* **114**: 961-971.

Mitchell-Williams J (2022). [Population monitoring data of *Acacia pubifolia* in Torrington SCA] [unpublished raw data]. Provided to the Department of Planning and Environment.

Murray-Darling Basin Authority (2022a). Catchments in the Murray-Darling Basin. URL: https://www.mdba.gov.au/water-management/catchments (Accessed 24 April 2023).

Murray-Darling Basin Authority (2022b). Border rivers. URL: https://www.mdba.gov.au/water-management/catchments/border-rivers (Accessed 24 April 2023).

National Parks and Wildlife Service (NPWS) (2003a). Torrington State Conservation Area Plan of Management. URL: https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Parks-reserves-and-protected-areas/Parks-plans-of-management/torrington-state-conservation-area-plan-of-management-030126.pdf (Accessed 25 January 2023).

National Parks and Wildlife Service (NPWS) (2003b). Warrabah National Park Plan of Management. URL: https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Parks-reserves-and-protected-areas/Parks-plans-of-management/warrabah-national-park-plan-of-management-030128.pdf (Accessed 25 January 2023).

National Parks and Wildlife Service (NPWS) (2022). *NSW Fire History.* Scale 1:150,000. Using ArcGIS 10.4 for desktop, Redlands, California, USA. Esri Inc. 1999-2005.

New South Wales Flora Online (2012). *Acacia pubifolia* Pedley in PlantNET, The NSW Plant Information Network System. URL: https://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&lvl=sp&name=Acacia~pubifolia (Accessed 24 January 2022).

Nicholls N (2004). The changing nature of Australian droughts. *Climatic Change* **63**: 323–336.

Office of Environment and Heritage (OEH) (2020). Velvet wattle – profile. URL: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10024 (Accessed 3 March 2023).

Pedley L (1978). A revision of *Acacia* Mill. in Queensland. *Austrobaileya* **1(2)**: 75-234.

Pedley L (1986). Derivation and dispersal of *Acacia* (Leguminosae), with particular reference to Australia, and the recognition of *Senegalia* and *Racosperma. Botanical Journal of the Linnean Society* **92**: 219-254.

Queensland Government (2022). Species profile – *Acacia pubifolia* (Wyberba wattle). URL: https://apps.des.qld.gov.au/species-search/details/?id=14081 (Accessed 24 January 2022).

Queensland Parks and Wildlife Service (QPWS) (2010). Girraween National Park Management Plan. URL: https://parks.des.qld.gov.au/__data/assets/pdf_file/0020/168050/mp004-girraween-management-plan-2010.pdf (Accessed 25 January 2023).

Reichstein M, Bahn M, Ciais P, Frank D, Mahecha MD, Seneviratne SI, Zscheischler J, Beer C, Buchmann N, Frank DC, Papale D, Rammig A, Smith P, Thonicke K, van der Velde M, Vicca S, Walz A, Wattenbach M (2013). Climate extremes and the carbon cycle. *Nature* **500**: 287–295.

Rossetto M, Gross CL, Jones R, Hunter J (2004). The impact of clonality on an endangered tree (*Elaeocarpus williamsianus*) in a fragmented rainforest. *Biological Conservation* **117**: 33–39.

Royal Botanic Gardens and Domain Trust (RBGDT) (2023a). *Acacia pubifolia* specimen records [dataset]. NSW Herbarium specimen catalogue (Accessed 28 February 2023).

Royal Botanic Gardens and Domain Trust (RBGDT) (2023b). [*Acacia pubifolia* germination data] [unpublished raw data]. Source: IrisBG Botanical Garden Collection Management program, exported 1 March 2023.

State of Queensland (2014). Emu Swamp Dam project: Coordinator-General's evaluation report on the environmental impact statement. Department of State Development, Infrastructure and Planning, Brisbane, Australia.

State of Queensland (2023). The Long Paddock – Queensland Future Climate Dashboard. URL: https://www.longpaddock.qld.gov.au/qld-future-climate/dashboard/#responseTab1 (Accessed 15 March 2023).

Stone GN, Raine NE, Prescott M, Willmer PG (2003). Pollination ecology of acacias (Fabaceae, Mimosoideae). *Australian Systematic Botany* **16**: 103-118.

Tame T (1992). 'Acacias of southeast Australia' (Kangaroo Press, Kenthurst, Australia).

Tindale MD, Kodela PG (2018). *Acacia pubifolia* Pedley. In Maslin BR (coordinator) WATTLE, Interactive Identification of Australian Acacia. Version 3. (Australian Biological Resources Study, Canberra; Department of Biodiversity, Conservation and Attractions, Perth; and Identic Pty. Ltd., Brisbane).

Trenberth KE, Dai A, van der Schrier G, Jones PD, Barichivich J, Briffa KR, Sheffield J (2013). Global warming and changes in drought. *Nature Climate Change* **4**: 17–22.

Tsakalos JL, Ottaviani G, Chelli S, Rea A, Elder S, Dobrowolski MP, Mucina L (2022). Plant clonality in a soil-impoverished open ecosystem: insights from southwest Australian shrublands. *Annals of Botany* **130**: 981–990.

Vanstone VA, Paton DC (1998). Extrafloral nectaries and pollination of *Acacia pycnantha* by birds. *Australian Journal of Botany* **36**: 519–531.

Williams KAW (1987). 'Native Plants of Queensland, Volume 3' (Keith Williams, Ipswich, Australia).

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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:
Acacia pubifolia was found to be Endangered under Clause 4.3 (b) (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: Endangered under Clause 4.3 (b) (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,	
		(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)
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.