

NSW Threatened Species Scientific Committee

Conservation Assessment of *Brachyscome mittagongensis*

Dr Steven Douglas March 2024

Ecological Surveys & Planning (consultancy)

***Brachyscome mittagongensis* P.S. Short (Asteraceae)**

Distribution: Endemic to NSW

Current EPBC Act Status: Not listed

Current NSW BC Act Status: Not listed

Proposed listing on NSW BC Act: Endangered

Summary of Conservation Assessment

Brachyscome mittagongensis was found to be eligible for listing as Endangered under Criterion B1a,b (i, ii, iii, iv, v), B2a,b (i, ii, iii, iv, v) and C2a (i). The main reasons for this species being eligible for listing in the Endangered category are: i) it has a highly restricted geographic range; ii) there are a low number of mature individuals; iii) there is a continuing decline due to a number of threats including habitat loss, disturbance, competition from weeds and inappropriate fire regimes; and iv) the number of mature individuals in each population is very low.

In this assessment, the word population is used to refer to the concept of 'subpopulation' in IUCN (2022), in keeping with the terminology used in the NSW Biodiversity Conservation Act and the EPBC Act and general ecological usage.

Description and Taxonomy

Brachyscome mittagongensis was described by Short (2009) as a "Perennial, rhizomatous herb with prostrate to ascending branches to c. 50 cm long, glabrous except for very occasional multicellular, conical glandular hairs c. 0.1–0.15 mm long. Leaves basal and cauline, alternate, lowermost leaves sometimes tapering to a petiole-like base but most leaves manifestly sessile and often subamplexicaul, somewhat narrowly oblong or narrowly elliptic or sometimes ovate-lanceolate to lanceolate or rarely a few oblanceolate, 11–38 mm long, 3.5–11 mm wide, leaf apices usually truncate and 3-dentate, the teeth of about equal length and width, rarely the apex tapering to a single point, leaf margins otherwise entire or sometimes with 1 or 2 additional short, narrow lateral lobes on each margin and these often about 1/2 way along the length of the lamina, all leaves glabrous or margins with very occasional stalked glandular hairs less than c. 0.1 mm long. Capitula c. 6 mm diam., on scapes manifestly exceeding the upper leaves. Bracts in 1 row, overlapping, ovate to lanceolate or elliptic to narrowly lanceolate, 2.2–2.5 mm long, 0.7–0.8 mm wide, subobtusate, mainly thinly herbaceous but with very narrow hyaline margins, glabrous or almost so except for scattered, mostly glandular hairs on the margins; stereome divided. Receptacle subconical, areolate, glabrous. Ray florets c. 40 in largest capitula; corolla c. 8.5 mm long, 1.2–1.3 mm wide, white, with 4 veins converging at the apex; apex unlobed or with 2 or 3 barely discernible lobes; style c. 1.45 mm long. Disc florets perhaps c. 80 or more in largest capitula; corolla with tube 2.1–2.45 mm long, externally with scattered, long, glandular hairs, 5-lobed, yellow, lobes lacking apical hairs, veins extending into and joining at the apex of the lobes. Stamens 5; filament collar almost straight or dilating towards the base; anthers 1.25–1.36 mm long, microsporangia 1.04–1.09 mm long, apical appendages 0.2–0.27 mm

NSW Threatened Species Scientific Committee

long, endothelial tissue radial. Style c. 2 mm long; arms c. 0.7 mm long, the triangular appendage slightly exceeding the length of the stigmatic part. Cypselas flat, obovate, 1.3–1.5 mm long, 0.8–0.9 mm broad, lateral surfaces with two, non-swollen ridges on each lateral surface, uniformly brown; lateral surfaces of cypselas body conspicuously tuberculate, the tubercles with short, straight to apically curved to slightly incurled, biseriate eglandular hairs, multicellular glandular hairs uncommon and only noted on immature fruit; ribs smooth, wings absent; carpodium seemingly present and annular but inconspicuous. Pappus a whitish crown of c. 20 basally united bristles c. 0.2 mm long. Chromosome number: $n = 9$.”

Short (2009) noted that *Brachyscome mittagongensis* can be distinguished from other closely related *Brachyscome* species “in having the largest lower and mid-cauline leaves not tapering towards a petiole-like base but being manifestly sessile and often subamplexicaul while their apices are usually truncate and 3-dentate, with the teeth small and of about equal size.”

Brachyscome mittagongensis P.S. Short (*Asteraceae*) was previously considered to be within *B. angustifolia*, primarily *B. angustifolia* var. *heterophylla*. That broad taxon was accepted to occur over a large area of NSW and into other southern States. A small number of specimens of what is now *B. mittagongensis* were also historically allocated to *B. sieberi* and *B. aculeata*. *B. angustifolia* is now an invalid taxon (Short 2009).

Cultural and community significance

The cultural, customary and spiritual significance of species and the ecological communities they form are diverse and varied for Indigenous Australians and their stewardship of Country. Such knowledge may be held by Indigenous Australians who are the custodians of this knowledge and have the rights to decide how this knowledge is shared and used.

Brachyscome mittagongensis mainly occurs on Gundungarra, Dharug and Tharawal land (AIATSIS 1996).

Distribution and Abundance

Brachyscome mittagongensis is endemic to New South Wales where it is known from the Sydney Basin and South East Highlands Bioregions. It is currently known primarily from Wingecarribee Shire in the Central Tablelands (Moss Vale and Burragorang Subregions), with two collection records in Upper Lachlan Shire in the Southern Tablelands (Bungonia Subregion). Historically, it has been collected from western and south-western Sydney (Cumberland Subregion: 3 records from mid-late 1800s) and from a single, spatially unclear 1884 record at ‘Shoalhaven’ (inferred to be in the Illawarra Subregion). Populations at those historic collection sites are presumed extinct based on a combination of their age, the land use type and intensity at the named collection localities, and the lack of subsequent records. Most of the Cumberland Subregion has been subject to significant flora survey effort associated with vegetation mapping and many environmental impact assessments over several decades, including in recent times. Most of the area of potential habitat near the lower Shoalhaven River has long ago been cleared for agriculture, including intensive pastoralism for dairying.

It occurs in and near moist areas but can extend well away from watercourses where soils are suitably heavy (good moisture retention) and/or where groundwater seepage may be a factor e.g. at basalt/shale and other geological boundaries. Sites range from riverflat and creekflat forest, riparian wetland / floodplain complex, edges of heathy montane swamps,

NSW Threatened Species Scientific Committee

through to grassy woodland and grassy tall forest. Most occurrences are known from relatively fertile and arable landscapes. *Brachyscome mittagongensis* appears to require relatively open patches of habitat with little or no shrub cover and can occur in very fine-scale patches amongst *Lomandra longifolia*.

Historic and modern records indicate the species has or had an altitude range of ~5 – 750 m. Modern records are known from ~560-750 m altitude. Rainfall for modern and historic sites ranges from ~700 mm at Tarlo River National Park / Greenwich Park to 1200 mm p.a. at Avoca / Wingecarribee Swamp. Whilst the Tarlo River National Park occurrences have far lower annual average rainfall than records from Wingecarribee Shire, they are in riparian swamps that likely receive seepage from upstream erosion-control dams, and potentially from groundwater seepage associated with the Permian/Ordovician disconformity and/or within the associated strata. These occurrences may be at least partially groundwater-dependent.

B. mittagongensis records are strongly associated with Wianamatta Group shales (primarily Bringelly and Ashfield Shales) but include clayey components of the Mittagong Formation. A small percentage of sites are influenced by Tertiary basalt, and one site is associated with a basalt/shale transition and may receive groundwater seepage. The species also occurs on Quaternary alluvium in river/creekflat forest and in the vicinity of upland swamps. Most such sites occur on or downstream of Wianamatta Group shale-dominated landscapes, however those from Tarlo River National Park are in catchments dominated by Ordovician sedimentary rock of the Abercrombie Formation, and Permian sedimentary rock in the form of Tallong Conglomerate. It is also considered likely to occur on or downslope of Jurassic microsyenite and allied intrusive substrates associated with the Mount Gibraltar complex of the Southern Highlands.

Modern records and field observations indicate that the species is associated with vegetation characterised in the canopy by *Eucalyptus macarthurii* (Endangered), *E. ovata*, *E. radiata*, *E. cypellocarpa*, *E. globoidea*, and less often with *E. viminalis*, *E. smithii*, *E. pauciflora* and *E. stellulata*. Habitat modelling (S. Douglas unpubl.) suggests it may also be associated with *E. aggregata* (Vulnerable; Endangered Population in Wingecarribee Shire), *E. amplifolia* and *E. tereticornis*. Short (2009) note associated species on records as *Solenogyne bellioides*, *Plantago varia*, *Dichondra repens*, *Hypochaeris radicata* and various grasses.

There are multiple records of the species from vegetation types that represent Threatened Ecological Communities (TECs) that have been extensively cleared and fragmented, initially for agriculture and later for urbanisation. These TECs include Southern Highlands Shale Woodland; Werriwa Tablelands Cool Temperate Grassy Woodlands; Montane Peatland & Swamps; and Tablelands Basalt Forest.

Historic, spatially uncertain records from the Cumberland Subregion suggest a potential association with Cumberland Plain Woodland (and Shale-Gravel Transition Forest), Sydney Turpentine-Ironbark Forest and Riverflat Eucalypt Forest of Coastal Floodplains. If the species is extant in the 'Shoalhaven' area, it is most likely to be associated with Illawarra (and South Coast) Lowland Grassy (Forest and) Woodland. A very small minority of modern records are associated with habitats that are not currently recognised as TECs or were previously classified as TECs. However, these are close to areas that support one or other of the TECs listed here. They are also associated with the Endangered and significantly range-restricted species, *Eucalyptus macarthurii*.

NSW Threatened Species Scientific Committee

Twenty-four sites or spatial groups of records of *B. mittagongensis* are known, of which 20 are known or considered likely to be extant (see Table 1).

The currently known western extent of the species' distribution is Tarlo River National Park; the northern extent is the locality of Soapy Flat, and Aylmerton near Mittagong; the eastern extent is Avoca / Lower Mittagong / Kangaloon; and the southern extent is Bundanoon. There are no collections or observations of the species between its western extent in Wingecarribee Shire (Canyonleigh east) and Tarlo River NP, though flora survey effort in potential habitat in that area is relatively low, and almost all of the land in that area is freehold. It is considered highly likely that the species occurs between those sightings, most likely in swampy sites, potentially associated with Paddy's River, the Wollondilly River and their confluence.

Table 1. Known sites of *Brachyscome mittagongensis*.

Site	Abundance and comments
1. Aylmerton [>50 plants]	Recent vegetation survey plot record of 50 plants (NSW OEH 2017). May represent the same collection site as a spatially indeterminate historic record from nearby Mittagong. Adjoins Hume Motorway on land owned by Transport for NSW. In degraded Southern Highlands Shale Woodland Threatened Ecological Community (TEC).
2. Soapy Flat [>50 plants]	Recent vegetation survey plot record of 50 plants (NSW OEH 2017). Locally common but only in very specific habitat that is a very small percentage of the overall vegetated area. In rare montane swamp woodland. Crown leasehold. Lithology is reported to be deeply weathered Hawkesbury Sandstone altered by subterranean igneous intrusions.
3. Berrima [>100 plants]	Three records: an historic collection that is spatially indeterminate but regarded as likely to be extant (no population data); and two modern records collected for this assessment (S. Douglas <i>in litt.</i>). The latter is in a Council reserve, and the population was estimated at >100. Lithology appears to be Mittagong Formation over Hawkesbury Sandstone. Some plants are present in alluvium associated with the watercourse.
4. Bowral [number of plants not recorded]	Three recent records from the Oxley Hill area west of Bowral. Population data is partial and primarily relates to plants seen in vegetation survey plots (abundance scores of 1 and 2, which translate to an estimated cover of <5% of a 0.04 ha plot) (NSW OEH 2017). All refer to a pastoral environment where grazing is said to have been intensive but was reduced at the time of collection, with regeneration evident. Habitat is Tablelands Basalt Forest and/or Mt Gibraltar Forest TEC.
5. Burradoo [3 plants]	Recent record from a pony club. Three plants estimated by the R. Moule, Wingecarribee Council. In degraded Southern Highlands Shale Woodland TEC.

NSW Threatened Species Scientific Committee

6. Diamond Fields Rd, UNSCA [>20 plants]	Recent vegetation plot record of 20 plants (NSW OEH 2017). Adjoins Upper Nepean State Conservation Area and population is likely to extend into the reserve. In rare <i>E. amplifolia</i> -dominated variant of Southern Highlands Shale Woodland TEC.
7. Henderson Park (Moss Vale) [1 plant]	Recent record, 1 plant. Council-owned land (R. Moule, Wingecarribee Council). Apparently degraded Southern Highlands Shale Woodland TEC or Tablelands Basalt Forest TEC.
8. Berrima Road (Moss Vale Cemetery) [100 plants]	Recent record, 100 plants estimated within Council-owned road verge and cemetery (R. Moule, Wingecarribee Council). Formerly Southern Highlands Shale Woodland TEC. Canopy now absent or <i>Pinus radiata</i> .
9. Belanglo Road [10 plants]	Recent record, 10 plants estimated within Council-owned road reserve. In degraded former Southern Highlands Shale Woodland TEC above ephemeral watercourse.
10. Carters Lane (Sutton Forest) [10 plants]	Recent vegetation survey plot record of 10 plants in degraded but regenerating Southern Highlands Shale Woodland TEC (NSW OEH 2017).
11. Sutton Forest (Hume Hwy) [number of plants unknown]	Two apparently related 1969 collections with spatially broad information ('Between Marulan and Berrima'; '15 miles S of Mittagong') were assigned to this location based on available data and consultation with the Curator of the Sydney University herbarium. Habitat in the vicinity is primarily former or degraded Southern Highlands Shale Woodland TEC. The NSW Herbarium record notes the collection is from 'roadside drain and partly cleared grazing land'.
12. Sutton Forest (village) [>240 plants]	Recent records, including one plot-based, with estimates totalling >120 plants in the Council-owned Cunningham Park (NSW OEH 2017), and at least another 120 estimated from nearby (S. Douglas <i>in litt.</i>). In remnant or former Southern Highlands Shale Woodland, sometimes with influence from upslope Tablelands Basalt Forest TEC.
13. Exeter [30 plants]	Three recent records (2 at same site but different times). The Ellsmore Road verge site is in a vegetation survey plot (NSW OEH 2017) and was estimated at 100 plants, but many were juvenile and at unsustainably high density in a very small patch of habitat in degraded Southern Highlands Shale Woodland TEC. Number of mature individuals <20. The Sallys Corner / Westgrove Road site estimated at 10 plants on a mown roadside (S. Douglas <i>in litt.</i>).

NSW Threatened Species Scientific Committee

14. Meryla State Forest (west) [150 plants]	Two recent plot-based records with estimates of 50 and 100 plants each (NSW OEH 2017). The vegetation at both sites is regenerating Southern Highlands Shale Forest TEC.
15. Bundanoon [250 + >40 + 30 + 100 + 50 + <10 plants]	Comprises several recent plot-based (NSW OEH 2017) and other observations (S. Douglas <i>in litt.</i>), including the largest estimated subpopulation of 250 plants (Ferndale Reserve and adjoining roadside). The Bundanoon Oval/reserve site has an estimate of >40 plants. A small population was found on the verge of Ellsmore Road (30 estimated), and many more plants (~100) were noted in patches along Blue Gum Road. The species was also seen on a dam headwall (50 estimated). A few plants (<10) were recorded in Leaver Park in creekflat forest. All but the dam wall site are on Council-owned road verges or parks. Habitat is primarily degraded or regenerating Southern Highlands Shale Woodland TEC. However, the Ferndale Reserve site is associated with Mittagong Formation lithology between upslope shale forest and downslope sandstone-based forest. The largest number of plants at that site are in a grazed grassy/herbaceous <i>Eucalyptus ovata</i> swamp woodland.
16. Penrose State Forest [>100 plants]	A 1984 record that was verified and correctly located for this assessment (S. Douglas <i>in litt.</i>). Population estimated to be >100 from a brief and incomplete survey. Riverflat forest on recent sediments and colluvium downstream of extant or former Southern Highlands Shale Woodland.
17. Canyonleigh Road (east) [80 + >50 plants]	Recent roadside and rural property sightings estimated at 80 plants, with another recent sighting made but not documented (estimated >50 plants) (S. Douglas <i>in litt.</i>). Cleared pastoral land that was previously Tablelands Basalt Forest and/or Southern Highlands Shale Woodland TECs.
18. Tarlo River National Park [200 plants]	Two relatively recent collections, each estimating 100 plants (total 200). Riparian / wet meadow / sedgeland on recent sediments (as NSW Office of Environment & Heritage. 2014). The only confirmed population in NPWS estate.
19. Wilson Lane [2 plants]	A 2017 plot-based record of 2 plants in roadside Southern Highlands Shale Woodland TEC (NSW OEH 2017). Not seen when checked in 2019 – dense leaf litter and bark covered the site. Nearby habitat mown and ‘tidied’ by residents.
20. Wingecarribee Swamp’ [unknown no.]	A 1969 collection ‘On slopes above swamp’. Said to be ‘fairly common’. Unable to ascertain actual collection location. Presumed extant.
21X. ‘Shoalhaven’	A single historic collection with no additional information. It had been assigned co-ordinates that placed it in dune scrub at Seven Mile Beach, but this is unsuitable habitat, so co-ordinates were selected for

NSW Threatened Species Scientific Committee

	a position further inland between Mt Coolangatta and the Shoalhaven River estuary. Presumed extinct.
22X. Parramatta	A single historic collection with no additional information. Presumed extinct.
23X. Toongabbie	A single historic collection with no additional information. Presumed extinct.
24X. Bents Basin	A single historic collection with no additional information. Presumed extinct.

Extent of Occurrence (EOO): Based on records that are known or likely to be extant, the EOO is estimated to be 1003 km² based on a minimum convex polygon enclosing all mapped occurrences of the species with sufficient spatial accuracy for this purpose as recommended by IUCN (2022). When using the same dataset plus historic records that are now presumed extinct, the historical EOO was estimated as 5555 km². This represents an 82% reduction in EOO since the species was first collected.

Area of Occupancy (AOO): Based on records that are known or likely to be extant, the AOO is estimated to be 96 km² based on the species occupying 24 (2 km x 2 km) grid cells, the spatial scale of assessment recommended by IUCN (2022). When using the same dataset plus historic records that are now presumed extinct, the historical AOO was estimated as 112km². This represents a 15% reduction in AOO since the species was first collected.

Even though a substantial number of records of *B. mittagongensis* have been lodged in recent years because of intensive vegetation survey associated with mapping and with targeted survey for this species, there are still incomplete data on the number of mature individuals of *B. mittagongensis*. For the records that have population details, descriptions of abundance include “fairly common”, “common”, “locally common”. However, recent field observations strongly indicate that sites where the species is recorded as common refer to relatively small patches where this is accurate, yet surveys suggest the species is absent from much of the surrounding environment despite the presence of seemingly similar habitat (Douglas *in litt.*). One site was seen to have an estimated 100 plants and the species could be described as locally common, but the site comprised mainly juveniles and the population was confined to ~1m², with the species absent from adjoining habitat with the same lithology and vegetation community. Similarly, at the largest population visited for this assessment, the estimated >250 plants occurred primarily in one patch of several square metres, with other much smaller and sometimes linear patches nearby. The species was not seen over >90% of the surrounding habitat. It appears to be inherently patchily distributed at various scales. Most records are of <50 plants.

A population census has not been undertaken for the species across its distribution. From the available database records and field observations conducted for this assessment (Douglas *in Litt*), the total number of individuals is estimated to be >1000 and <2500 mature plants. Whilst there is a potentially substantial area of habitat in which the species could be present (based on lithology, known associations with Plant Community Types, and tolerance of some forms of disturbance), the available information suggests that it occupies only a very small percentage of that habitat, for reasons that are not yet understood. Preliminary observations during surveys indicate that the species may be displaced by non-native

NSW Threatened Species Scientific Committee

pasture species and dense shrub cover, and has a relatively narrow preference for, at least, seasonally moist conditions.

The majority of inferred population declines in this species would have occurred more than three generations ago in the past (i.e. more than 30-60 years ago) and were associated with widespread clearing of native vegetation for agriculture and for housing and associated infrastructure. As the species can persist in some agricultural environments, it is considered that housing and industry are the strongest land use indicators of local extinctions.

Population declines within the last 30-60 years have not been documented. This is partly because the species was only described in 2009, and because at that time it was known from less than 10 collection records, between two and four of which are believed to be from populations which are now extinct (per Short, 2009), and all of which are historic (pre-1980). All these records lack sufficient detail to determine exactly where they were recorded. At least four are presumed extinct based on the intensity and nature of land use, and that there have been no subsequent records at those localities. All of the collection records considered likely to be extinct were made in the 1800s and are not considered in the assessment of population size reduction.

Ecology

Brachyscome mittagongensis is a rhizomatous perennial, flowering “from about February to May” (Short, 2009). It occurs in environments with varying exposure to frost, ranging from very high exposure (no tree or shrub layer and in cold air drainage lines/depressions), to high exposure (grassy frost hollow woodland and low open forest e.g. with *Eucalyptus pauciflora*), through to low exposure (undulating to steep, rarely rocky, north and east-facing slopes relatively high in the landscape and with open to tall-open forest canopy).

The species' response to fire is not documented but it is likely to resprout from its rhizome, as well as regenerating from seed. The species is extant in parts of western Meryla State Forest that burnt in the 2019-20 wildfire but is very threatened by weed invasion.

The species is known to have survived livestock grazing and mowing/slashing in some situations, and several occurrences are associated with significant disturbance caused by road drainage works. It appears able to colonise, recolonise or regenerate on disturbed sites from a combination of seed and resprouting.

The generation time for *B. mittagongensis* is estimated to be at least 10 years (L. Murray, pers. comm., 29 March 2019). This is based on the species being a rhizomatous perennial. Because of the uncertainty relating to this parameter, a range of 10-20 years is used in this assessment in accordance with the precautionary principle.

Based on knowledge of other species within the genus, the seed would be primarily wind-dispersed, and as some sites occur in very open landscapes with high exposure and significant elevation, some seed may disperse over considerable distances. On this basis, it is currently difficult to define what parameters might define a population. In sheltered sites such as forested riverflats, seed dispersal by wind is likely to be over relatively much shorter distance, and dispersal by water is feasible, especially given the species is known to grow in quite moist and swampy sites, including some riparian habitats.

Threats

Habitat removal / land clearing

NSW Threatened Species Scientific Committee

Much of the potential habitat for the species in that area has long been cleared for agriculture, and pastoralism is primarily on 'improved' pastures dominated by non-native grass species and associated pasture weeds. The Parramatta, Toongabbie and Bents Basin historic collection records are presumed extinct as inferred by Short (2009), with the likely cause being agricultural and/or urban/industrial/infrastructure uses. The single outlying 'Shoalhaven' record lacks sufficient detail to determine any historic or potentially continuing threats, but these are likely to be like those in greater Sydney and the Southern Highlands. Significant floodplain modifications have taken place in the vicinity. Changed hydrology may have contributed to the apparent extinction of this species in that area.

Most extant records of the species are from the Southern Highlands where urbanisation has increased in extent and intensity, and continues to do so, including in potential or former habitat for this species. Rural-residential land use has also spread and intensified, and manifests as subdivisions of primarily rural land into relatively smaller lots often referred to as 'hobby farms' or 'lifestyle properties'. In some cases, this change from usually at least semi-commercial rural to lifestyle-based rural-residential use may benefit the species where livestock grazing intensity is reduced. However, it may be harmful where there is a conversion from grazing of native or mostly native pastures to intensive horticulture or to more intensive grazing on non-native and fertilised pasture. 'Pasture improvement' (i.e. the replacement of native grasses and forbs with non-native grasses and legumes, often supported by fertilisers) is a significant threat to *B. mitchellii* and is likely a major driver of its apparent widespread loss from affected former habitat. Non-native landscaping is also common in rural-residential land use, including expansive and intensively managed lawns. Such activities are likely to be detrimental to this species.

Associated with habitat loss and degradation are roadworks such as grading, widening, drainage, deposition of spoil, and associated incidental spreading of weeds. Urbanisation and rural-residential land use tend to see an increase in the number of roads, greater use of formalised drainage structures, and ultimately concrete kerb and guttering. These tend to work against the survival of *B. mitchellii*, which has only been seen to survive on roadsides where management is less intense. This includes urban areas but with relatively large lot sizes, no kerb and guttering, grassed verges, patches of remnant vegetation, and relatively infrequent or at least less intensive mowing of verges.

Adverse fire regime

Insufficiently frequent (and possibly low severity) fires may be a threat to *B. mitchellii* in that this species is disadvantaged by increased shrub cover that occurs in long unburnt areas. Such conditions also favour invasion by some woody weed species (e.g. *Pittosporum undulatum* Gleadow and Ashton 1981, Rose and Fairweather 1997), further amplifying the threat.

The species' ecology is such that relatively frequent fire is less likely to be a threat, although the time required for juvenile plants to develop the ability to resprout after fire is currently unknown.

Recreational pressures and adverse mowing, slashing and grazing

Some occurrences of the species were observed to be threatened by recreational uses that entail trampling and soil compaction by people, livestock, and vehicles. Some occurrences were seen to be subject to unsympathetic mowing of parklands, a cemetery, and road verges. Mowing or slashing may be an important vegetation management practice in some habitats and may benefit the species if it occurs outside breeding season or is at least limited

NSW Threatened Species Scientific Committee

to a height below which the plant can persist and reproduce. Some mown sites support the plant in a very low form where it was observed to be flowering and appeared likely to set seed. Mowing, slashing and grazing can suppress competing species such that *B. mittagongensis* is advantaged, but if undertaken without due regard to its ecology, can be damaging and may result in local extinction.

Some public reserves now feature 'no mow zones' where it has been recognised that mowing should cease to allow regeneration of remnant bushland, including TECs. In general, this is likely to benefit *B. mittagongensis*. However, in sites with a high cover of non-native grasses, strategic mowing or slashing may be necessary to prevent those grasses displacing it.

Ideally, non-native grasses and other weeds would be controlled or eliminated by more targeted means such as manual removal and topical application of appropriate herbicide, but resource constraints may mean that only a sympathetic mowing or 'whipper-snipper' control method is feasible at some sites. This may be preferable to a 'do nothing' approach because *B. mittagongensis* can tolerate a suitable mowing or slashing regime, whereas it may be displaced by non-native grasses. The use of seasonally appropriate fire may also be suitable where it is timed to disadvantage the mostly Spring-flowering non-native grasses, and to advantage the mostly Summer-flowering native grasses.

Weeds

Crataegus monogyna (Hawthorn) is sufficiently established at a collection site on Oxley Hill, east of Bowral that the infestation is evident in aerial imagery. It is also patchily distributed and locally common in other areas of potential habitat for *B. mittagongensis* across the urban and pastoral areas of the Southern Highlands, but particularly in Berrima and Sutton Forest.

As noted above, non-native grass species are a particularly significant threat to *B. mittagongensis*. Records collected for this assessment noted that these include *Paspalum dilatatum* (Paspalum), *Holcus lanatus* (Yorkshire Fog), *Anthoxanthum odoratum* (Sweet Vernal Grass), *Phalaris aquatica* (Phalaris) and *Dactylis glomerata* (Cocksfoot).

Other weed threats include the vines/scramblers *Lonicera japonica* (Japanese Honeysuckle), *Rubus anglocandicans* (Blackberry), *Vinca major* (Greater Periwinkle); the shrubs *Berberis vulgaris* (Common Barberry), *Ligustrum sinense* (Small-leaved Privet), and the trees *Pinus radiata* (Radiata Pine) and *Pittosporum undulatum* (a highly invasive native mesophyll species that readily colonises comparatively fertile sites where cattle and fire are absent or rare/low intensity).

Fieldwork undertaken for this assessment found that weeds are a significant concern at most sightings of this species, though to varying degrees and involving a significant range of weed species and plant forms. The strong association between *B. mittagongensis* and weeds is unsurprising because of its preference for moist and relatively fertile landscapes, most of which are substantially disturbed by agriculture, roads and settlements.

Fragmentation of habitat and populations

The species occurs in a severely fragmented pattern across a substantially modified environment dominated by threats that have removed or degraded, and/or continue to remove and degrade the species' habitat. When extant occurrence records are overlain with the latest fine-scale Plant Community Type mapping within the species' core distribution in Wingecarribee Shire, a more accurate image of fragmentation is evident because of the extent to which TECs in which the species is known to occur have been cleared and

NSW Threatened Species Scientific Committee

fragmented. For example, Douglas & Grogan (2019) calculated that the Southern Highlands Shale Forest & Woodland (SHSF&W) TEC has been 80.64% cleared, with only 25% of remnants ≥ 2 ha. Most remnants have a high edge to area ratio and are isolated from other remnants of the TEC and from other remnant woody vegetation. Mapping by OEH (2017) indicates a similar pattern for other TECs that are known habitat for *B. mittagongensis*, with those on more fertile substrates e.g. Tablelands Basalt Forest (TBF), being even more likely to have a primarily or exclusively non-native ground stratum because they have either been invaded by non-native grasses and forbs, have been sown to introduced pasture species, or are used for cropping. Within the known range of the species, Werriwa Tablelands Cool Temperate Grassy Woodland TEC is now extremely rare and largely restricted to paddock trees and roadside remnants.

All sites observed during research for this assessment, and where observations were available from others, indicate that the species is very patchy at the site scale, and that it is often unclear why it is limited to small patches amongst what would otherwise appear to be more extensive suitable habitat. This is a significant factor when considered in combination with the level of fragmentation experienced by the species, even allowing for it being likely to be primarily wind dispersed.

Furthermore, the nature and extent of threatening processes is such that many extant occurrences may be of low viability or unviable in the longer-term due to very small subpopulation size, and the substantial areas of non-viable habitat between them. Most occurrences are in relatively insecure settings such as road verges in urban or rural settings; on rural pastoral properties; Council reserves that are managed primarily for recreation and/or where threats are substantial and may not be under control or readily controlled; and in or near riparian zones or floodplains where a range of threats occur, many of which are effectively beyond control due to catchment-scale land use changes. Very few occurrences are known from conservation estate, and some of these also face significant and on-going threats.

Based on the above considerations, the species' distribution is considered to be severely fragmented as it is likely that $>50\%$ of the remnant area occupied by the species (AOO) is unlikely to be viable, while at the same time, patches are separated by distance over which dispersal and successful recolonisation is not likely. Because of its apparently highly specific habitat requirements and the extent to which it is outcompeted by non-native plants, especially grasses, the species has very limited likelihood of recolonisation of what would otherwise be deemed to be potential habitat. All occurrences appear to be remnant or relictual, with no evidence yet observed to indicate that it can recolonise former habitat where threats are significant.

Assessment against IUCN Red List criteria

It is considered that recent surveys of *Brachyscome mittagongensis* are adequate for the purpose of this assessment, and there is sufficient scientific evidence to support the listing outcome.

Criterion A Population Size reduction

Assessment Outcome: Data deficient.

Justification:

The magnitude of reduction in *Brachyscome mittagongensis* is currently uncertain. The generation time for *B. mittagongensis* is estimated to be at least 10 years (L. Murray, pers. comm., 29 March 2019). This is based on the species being a rhizomatous perennial. Because of the uncertainty relating to this parameter, a range of 10-20 years is used in this assessment in accordance with the precautionary principle.

The majority of inferred population declines in this species would have occurred more than three generations ago in the past (i.e. more than 30-60 years ago) and were associated with widespread clearing of native vegetation for agriculture and for housing and associated infrastructure. As the species can persist in some agricultural environments, it is considered that housing and industry are the strongest land use indicators of local extinctions.

Population declines within the last 30-60 years have not been documented. This is partly because the species was only described in 2009, and because at that time it was known from less than 10 collection records, between two and four of which are believed to be from populations which are now extinct (per Short, 2009), and all of which are historic (pre-1980). All these records lack sufficient detail to determine exactly where they were recorded. At least four are presumed extinct based on the intensity and nature of land use, and that there have been no subsequent records at those localities. All of the collection records considered likely to be extinct were made in the 1800s, so cannot be considered in assessing the species against Criterion A.

Criterion B Geographic range

Assessment Outcome: Endangered under Criterion under B1a,b (i, ii, iii, iv, v), B2a,b (i, ii, iii, iv, v)

Justification:

The Extent of Occurrence was estimated to be 1003 km² based on a minimum convex polygon enclosing all reliably mapped occurrences of the species, the method of assessment recommended by IUCN (2022). To be listed as Endangered under Criterion B1 a species must have an EOO of <5000 km². *Brachyscome mittagongensis* meets the EOO threshold for Endangered under Criterion B1.

The Area of Occupancy was estimated to be 96 km². This calculation was based on the species occupying 24 (2 km x 2 km) grid cells, the spatial scale of assessment recommended by IUCN (2022). To be listed as Endangered under Criterion B2 a species must have an AOO of <500 km². *Brachyscome mittagongensis* meets the AOO threshold for Endangered under Criterion B2.

NSW Threatened Species Scientific Committee

In addition to this threshold, 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 at Endangered.

Justification: The species' known or inferred distribution is severely fragmented because of extensive land clearing; the often small and potentially unviable size of many habitat remnants and populations (>50% of extant occurrences and AOO); combined with limited dispersal and recolonisation ability. There are estimated to be >10 extant locations based on major threats of ongoing habitat loss, inappropriate fire, disturbance and weed impacts.

- 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 populations; (v) number of mature individuals

Assessment Outcome: Met

Justification: Continuing decline is estimated, inferred and projected for the geographic distribution of the species; habitat area, extent and quality; the number of locations in which the species occurs or of populations of the species and the number of mature individuals. These are based on the effects of recent and ongoing habitat clearing and degradation and associated threats, and the generally low security of most known occurrences of the species. All but two sightings/collections of the species occur outside NPWS estate, though one other sighting adjoins another NPWS reserve and is considered likely to occur within it. Most sightings are in very vulnerable situations with little or no protection and limited capacity to provide protection. Some are known from Council-managed lands where the species still faces considerable threats and where it cannot yet be regarded as secure due to factors such as very constrained land management resources and competing uses of some public lands.

- c) Extreme fluctuations.

Assessment Outcome: Not met.

Justification: The species is not known to experience extreme fluctuations in its geographic distribution, number of locations or populations or number of mature individuals.

Criterion C Small population size and decline

Assessment Outcome: Endangered under Criterion C2a (i)

Justification: The total number of mature plants is estimated to be >1000 and <2500.

At least one of two additional conditions must be met. These are:

- C1. An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future).

Assessment Outcome: Data Deficient.

Justification: No data on the rate of continuing decline are available.

NSW Threatened Species Scientific Committee

C2. An observed, estimated, projected or inferred continuing decline

Assessment Outcome: Met.

Justification: A continued decline in the number of mature individuals is projected and inferred due to the effects of historic, recent and on-going habitat removal and degradation, and other threats (weeds, localised disturbances and adverse fire).

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

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

Assessment Outcome: Met at Endangered threshold.

Justification: Whilst the parameters defining a population of this species are not well understood, none of the current sightings or collections that provide population data provide counts or estimates exceeding 250 mature plants.

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

Assessment Outcome: Data deficient.

Justification: Available information indicates that the species does not meet this criterion.

- b. Extreme fluctuations in the number of mature individuals

Assessment Outcome: Data deficient.

Justification: Extreme fluctuations in the number of mature individuals is not known in this species.

Criterion D Very small or restricted population

Assessment Outcome: Not met.

Justification: The number of mature individuals is estimated to exceed 1000, though counts and estimates from recently surveyed sites total <650 plants over several sites, and mostly in small patches.

To be listed as Vulnerable, 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 number of mature individuals is estimated to exceed 1000.

- 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: The AOO exceeds 20km² and the number of 'locations' likely exceeds 5.

NSW Threatened Species Scientific Committee

Criterion E Quantitative Analysis

Assessment Outcome: Data Deficient.

Justification: A quantitative analysis of extinction probability is not currently available for this species.

Conservation and Management Actions

There is no National Recovery Plan and no NSW Saving our Species program for this species. The following is derived from the threat information and can be used to formulate management actions.

Habitat loss, disturbance and modification

- Prevent ongoing habitat loss associated with intensification of urban/industrial land use and intensification of rural land use.
- Pasture improvement represents a very significant threat. Where possible, assess impacts on this species prior to conversion of paddocks with remnant ground stratum to non-native pastures or to cropping.
- Avoid 'tidying-up' of roadside and other remnant bushland habitat where this species occurs.
- Ensure surveys associated with proposed habitat removal or detrimental modification address this species, especially given it was only published in 2009 and is a highly range-restricted endemic that most botanists will not be familiar with.
- Assess and mitigate impacts associated with changes to hydrology of even the smallest ephemeral drainage lines because these can influence habitat condition for this species. Changes to larger streams may alter dynamics relating to flooding and the functionality of floodplain habitat and associated wetlands. As the species is known to occur in swampy habitats, changed hydrology affecting upland wetlands or moist grassy areas should be considered in impact assessments.
- When implementing any mowing, slashing and grazing regimes, ensure they do not adversely impact on *B. mittagongensis*.

Invasive species

- Identify and remove/control invasive plant species that include grasses, herbs/forbs, vines, and woody species. Many of these species are already recognised as threats to Threatened Ecological Communities with which *B. mittagongensis* is known or likely to be associated. *Pittosporum undulatum* is a particular threat because it creates dense shade, exhibits allelopathic suppression, and changes vegetation structure, potentially making ecological burning more difficult to achieve and control. That species should be regarded as not native to grassy and shrubby sclerophyll communities (as it has recently spread from rainforest and adjoining wet sclerophyll forest).
- Identify and remove/control feral animals such as rabbit, hare, deer, pig and goat in known habitat.

Ex situ conservation

- Develop and implement a targeted seed collection program for ex situ seed banking, with sampling across the full range of the species, following best-practice guidelines

NSW Threatened Species Scientific Committee

(Martyn Yenson *et al.* 2021). The species is likely to be readily propagated from seed and is known to survive careful translocation of whole plants. *Ex situ* plantings in botanic gardens may assist its conservation to a limited extent.

- Implement national translocation protocols (Commander *et al.* 2018) if establishing additional populations or enhancing populations is considered necessary and feasible.

Stakeholder Management

- Inform land owners and managers of sites where there are known populations and consult with these groups regarding options for conservation management and protection of the species.
- Engage with private landholders and public land managers responsible for the land on which populations occur and encourage these key stakeholders to contribute to the implementation of conservation management actions.

Survey and Monitoring priorities

- Conduct surveys to determine if and to what extent the species is present in Upper Nepean SCA, and if present, what threats are operating.
- Conduct survey to assess the extent, abundance and threats to the species in Tarlo River NP.
- Conduct surveys for the species in potential habitat in other NPWS and Council conservation estate within its known range.
- Monitor for increased habitat degradation in NPWS and Council reserves or other conservation estate e.g. Land for Wildlife properties.
- Monitor known sites for impact of fire, including time for new recruits to become resistant to fire or other disturbances.

Information and Research priorities

- Research the ecology of the species and the conditions under which it is most likely to persist, with particular regard to the interaction between disturbance regimes and invasive grasses.
- Provide a species profile to assist ecologists and land managers to correctly identify and assess this species.

NSW Threatened Species Scientific Committee

References

- AIATSIS (1996) The AIATSIS map of indigenous Australia. [accessed 10th March 2022]. Available at: <https://aiatsis.gov.au/explore/map-indigenous-australia>
- Douglas SM, Grogan R (2019) *Conservation assessment and nomination of Southern Highlands Shale Forest & Woodland as a Critically Endangered Ecological Community under the NSW Biodiversity Conservation Act*. Report to Wingecarribee Shire Council and the NSW Threatened Species Scientific Committee. Ecological Survey & Planning.
- Commander LE, Coates D, Broadhurst L, Offord CA, Makinson RO, Matthes M (2018) 'Guidelines for the translocation of threatened plants in Australia'. (Third Edition. Australian Network for Plant Conservation, Canberra).
- Gleadow, RM and Ashton DH (1981) Invasion by *Pittosporum undulatum* of the forests of Central Victoria Australia. I invasion patterns and plant morphology. *Australian Journal of Botany* **29**, 705–720.
- IUCN Standards and Petitions Subcommittee (2022) Guidelines for Using the IUCN Red List Categories and Criteria, Version 15. Available at <https://www.iucnredlist.org/resources/redlistguidelines>
- Martyn J (2019) *Rocks and trees: a photographic journey through the rich and varied geology, scenery and flora of the Sydney region*. STEP Inc., Turramurra NSW.
- Martyn Yenson AJ, Offord CA, Meagher PF, Auld TD, Bush D, Coates DJ, Commander LE, Guja LK, Norton SL, Makinson RO, Stanley R, Walsh N, Wrigley D, Broadhurst L (2021) *Plant Germplasm Conservation in Australia: strategies and guidelines for developing, managing and utilising ex situ collections. Third edition*. Australian Network for Plant Conservation, Canberra.
- NSW OEH, 2017. Wingecarribee fine-scale native vegetation (PCT) map v2.1. NSW OEH, Parramatta.
- NSW Office of Environment & Heritage. 2014. TARLORIVNP Vegetation Survey, Data from the Atlas of NSW database: VIS flora survey module, Version 11 /2013. Persistent URL: http://aekos.org.au/collection/nsw.gov.au/nsw_atlas/vis_flora_module/TARLORIVNP
- Rose S and Fairweather PG (1997) Changes in floristic composition of urban bushland invaded by *Pittosporum undulatum* in northern Sydney, Australia. *Australian Journal of Botany* **45**, 123–149.
- Short PS (2009) A revision of the *Brachyscome linearifolia* group (*Asteraceae*) from south-eastern Australia. *Muelleria* **27**, 3–35.

Expert Communications

Louisa Murray, recently retired Curator of *Asteraceae* at the NSW Herbarium.

NSW Threatened Species Scientific Committee

APPENDIX 1

Assessment against *Biodiversity Conservation Regulation 2017* criteria

The Clauses used for assessment are listed below for reference.

Overall Assessment Outcome: *Brachyscome mittagongensis* was found to be Endangered under Clauses 4.3 (b)(d)(e i,ii,iii,iv) and Clause 4.4 (b) (e i,ii,A(II)).

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,ii,iii,iv).

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,

NSW Threatened Species Scientific Committee

		(iii)	the number of locations in which the species occur or of populations of the species.
--	--	-------	--

Clause 4.4 – Low numbers of mature individuals of species and other conditions (Equivalent to IUCN criterion Clause C)

Assessment Outcome: Endangered under Clause 4.4 (b) (e i,ii,A(II))

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.

NSW Threatened Species Scientific Committee

Clause 4.7 – Very highly restricted geographic distribution of species–vulnerable species (Equivalent to IUCN criterion D2)

Assessment Outcome: Clause 4.7 is data deficient.

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.
-------------------------	--