

NSW Threatened Species Scientific Committee

Conservation Assessment *Syzygium paniculatum* Gaertn. (Myrtaceae)

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Syzygium paniculatum Gaertn. (Myrtaceae)

Distribution: Endemic to NSW

Current EPBC Act Status: Vulnerable

Current NSW BC Act Status: Endangered

Proposed listing on NSW BC Act: Vulnerable

Summary of Conservation Assessment

Syzygium paniculatum was found to be eligible for listing as Vulnerable under Criterion C2a (i).

The reasons for this species being eligible for listing are: i) The species has a small number of mature individuals (2,087) and there is an inferred future decline in the number of mature individuals because of low recruitment, natural thinning and attrition within an ageing demographic, future clearing, and ongoing habitat degradation. ii) there is a small number of mature individuals across the five subpopulations.

Description and Taxonomy

Syzygium paniculatum, commonly called the magenta lilly pilly, is described by Wilson (2002) as: 'Shrub or small tree with flaky bark. Leaves lanceolate to obovate, 4.5-10 cm long, 1.5-3 cm wide, apex acuminate, base cuneate, glabrous, upper surface green and glossy, lower surface paler; lateral veins numerous, intramarginal vein usually discernible; oil glands small, rather scattered, distinct; petiole 2-10 mm long. Inflorescences cymose or paniculate, terminal and in the upper axils. Petals 4–5 mm long, free and spreading. Stamens 6–15 mm long. Petals 4-5mm long, free and spreading. Stamens 6-15 mm long. Fruit globose to ovoid, 15-25 mm diam., magenta; seed solitary, polyembryonic, cotyledons smooth. Flowers Dec.-Mar.'

Contrary to the description by Wilson (2002) as a 'shrub or small tree', mature individuals in the Shoalhaven typically are between 20-30 m tall and up to 1.5 m diameter at breast height (DBH) (L. Foster pers. obs. March 2023). Large mature individuals are also found in other subpopulations including Ourimbah, Royal National Park, and Swansea.

Prior to a major revision of the Australian members of *Syzygium* and other related genera (Hyland 1983), the species now known as *Syzygium paniculatum* was previously referred to as *Syzygium coolminianum* or *Syzygium australe*. *Syzygium coolminianum* is now taxonomically known as *Syzygium oleosum*. Most published records of *Syzygium paniculatum* that predate Hyland's (1983) revision have been described as *Syzygium australe* (OEH 2012).

The current taxonomic description as described by Hyland (1983) and Wilson (2002) captures a snapshot of present-day variation without reflecting the evolutionary history underlying recent genomic research (Lu-Irving and Rossetto 2021, Lu-Irving *et al.*

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2023). The species and its nearest relatives comprise sub-lineages with complicated, intergrading patterns of morphological and genetic variation. In the species' southern region (approximately from Lake Macquarie to Jervis Bay) trees are typically genetically homogeneous, whereas north of Lake Macquarie, there are several distinct groups co-occurring within sites and phylogenetically intermingled with *S. oleosum*. This suggests that at some point, historic introgression occurred between *S. paniculatum* and *S. oleosum* to form this species complex. These findings correlate with the morphological differences noted by Foster and Mulcahy (2020) in the same populations. The precise nature and origin of the multiple lineages identified (Lu-Irving and Rossetto 2021) have yet to be characterised, but each one represents unique evolutionary events and processes that merit conservation.

Lilly pillies have many names across the traditional language areas where the species is distributed. Language names for lilly pillies include Ngawan in the Yugambeh-Bundjalung language of southeast QLD (Murrumbidgee Aboriginal Language and Culture Cooperative 2022); Burangirrbang in Gathang language from north of Newcastle to around Port Macquarie (Lissarrague 2010); Galungara in Dhurga language from the Nowra/Jervis Bay area and south to Narooma (Donovan and Boyenga 2022); Midjuburi in Dharug and Gadigal languages from around Sydney (Troy J 1992); Dudagur – Dundagoor in Darkinjung language from the Central Coast (Jones 2008; Duncan April 2023); Guntu – Goontoo in Awaba language around Lake Macquarie (Duncan April 2023).

Distribution and Abundance

Syzygium paniculatum is known from the lands of the Yuin, Tharawal, Eora, Dharug, Kuring-gai, Awabakal, Darinung, Worimi, Darkinjung, Biripi, Dainggatti, Wonnarua and Geawegal Aboriginal people (AIATSIS 2022). Aboriginal Peoples have cared for these lands for tens of thousands of years (Bowler *et al.* 2003; Clarkson *et al.* 2017).

Syzygium paniculatum is endemic to New South Wales (NSW) and found along a 400 km stretch of coastal NSW from Upper Lansdowne on the mid North Coast to Conjola National Park on the South Coast (Gecko 2018). All naturally occurring mature individuals are known from five subpopulations within the Jervis Bay, Illawarra, Metropolitan Sydney, the Central Coast, and Karuah Manning regions. There are an estimated 73 sites within these five subpopulations (Focus Flora 2018). In this assessment, the word subpopulation is used to refer to the concept of 'subpopulation' defined by the IUCN (2022).

Syzygium paniculatum is predominantly restricted to littoral and subtropical rainforest communities occurring on sand in a narrow coastal strip across its 400 km range. Naturally occurring mature individuals have been found around Palm Grove/Wyong Creek on the Central Coast within approximately 25 km from the coast, where remnant rainforest occurs along sandy creeks (DPE BioNET 2023). There are contemporary and historical *S. paniculatum* records from localities further west than Palm Grove/Wyong Creek (DPE BioNet 2022) including 'Buladelah' (1923), 'Stroud' (1917), 'Blaxland', (1943), 'Kurrajong Heights' (1953), and the Gloucester district (1992 – 2011). However, many of these have never been recorded again, despite attempts to relocate them. This is likely due to a range of factors including records made before Hyland's (1983) revision of *Syzygium* which saw many records of *S. paniculatum*

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changed to *S. australe*; vague descriptions and accuracy of records (some are well before the use of GPS); records of cultivated plants; and misidentification. The lack of verified voucher specimens lodged with herbaria has made determining reliable records outside of the current known range of *S. paniculatum* difficult.

A further complexity with determining the 'natural' range of *S. paniculatum* is that the species has been widely cultivated, sold commercially, planted as popular ornamentals (Thurlby *et al.* 2010) and planted as part of bush regeneration projects. The Sydney Metropolitan subpopulation contains many trees that are not remnant and have been planted in gardens and as street trees over time. The Wyrabalong National Park subpopulation on the Central Coast is noted as having one of the largest populations for the species (Thurlby *et al.* 2012, OEH 2012); however, a chance discussion with a landowner in the nearby Ourimbah Creek Valley (L. Foster pers comm. March 2023), found that substantial seed had been collected from Ourimbah and planted at Wyrabalong National Park some 25 years prior, now representing most of the population at this site. At Seal Rocks on the Mid-North coast, which is within the 'natural' range of the species, another chance discussion with a resident identified that almost every fishing shack had at one point, a lilly pilly planted in the front yard (L. Foster pers comm. May 2023).

The uncertainty around the natural populations of *S. paniculatum* opens a broader debate about what is a 'planted' individual and when is it considered a naturally occurring population. This is a species that is a known food resource (Low 1991, Nash 2004, Renwick 2000, Benson and Eldershaw 2007) and likely would have been moved around by First Nations people for millennia (Silcock 2018), and by people who have arrived over the last 250 years. Without further exploration of what defines 'planted' or a re-analysis of 'natural' distribution for this species, the precautionary approach is to use only confirmed records of occurrence, including available voucher specimens (where vetted), field-verified records, and records sampled during the distribution-wide genomic study (Lu-Irving and Rossetto 2021, Lu-Irving *et al.* 2023) from areas where typical habitat attributes are present, being littoral and subtropical rainforest communities occurring on sand.

EOO and AOO

Syzygium paniculatum has an Extent of Occurrence (EOO) of 17,718 km² calculated as a minimum convex polygon containing all known occurrences, being the method of assessment recommended by IUCN (2022). The Area of Occupancy (AOO) is estimated to be 568 km² based on 2 x 2 km grid cells, the scale recommended by IUCN (2022). Both EOO and AOO were calculated using GeoCAT software (Bachman *et al.* 2011). The data has been cleaned and includes those that are confirmed records of occurrence, including available voucher specimens (where vetted), field-verified records, and records sampled during the distribution-wide genomic study (Lu-Irving and Rossetto, 2021).

Abundance

The estimated abundance of *Syzygium paniculatum* in NSW is 2,087 mature individuals occurring across 73 sites from five subpopulations (Gecko Environmental Management 2018; Focus Flora 2018; DPE BioNet 2023, Lu-Irving and Rossetto,

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2021, DPE 2023). The majority of all counts are mature individuals, as minimal seedling recruitment has been observed.

The Jervis Bay subpopulation consists of 14 known naturally occurring sites. Baseline surveys from two areas across the Jervis Bay subpopulation at Bundarwa (Beecroft Weapons Range) and Booderee National Park identified 575 mature individuals (NSW Government 2021a).

The Illawarra subpopulation contains two sites, at Sublime Point and Coalcliff (DPE BioNet 2023). Both sites have low numbers of trees (total of six). The size of these trees would suggest that they are remnant, but their locations suggest that they are more than likely historically planted.

The Sydney Metropolitan subpopulation contains 19 sites with an estimated 313 records that contain large, isolated remnant trees and small clusters of mature individuals that have persisted in pockets of remnant vegetation, despite surrounding development. These records all occur in areas that have remaining- or would have likely to have contained prior to modification - preferred habitat of littoral, subtropical rainforest and moist vegetation types on sandy soils. These occur in areas such as Balmoral, Pittwater and Lane Cove (Benson and Howell 1990, DPE BioNet 2023, DPE Map Data 2022). While it is considered likely that these occurrences are naturally occurring (Benson and Howell 1990), many populations, particularly those in Woollahra, have a high likelihood of being planted or at least intensely supplemented over time due to long histories of bush regeneration. The NSW Government's Saving our Species (SoS) conservation project for the species identifies a priority management site at Towra Point Nature Reserve, which is the largest remnant population within the Sydney region with 130 mature individuals. This number has remained stable since monitoring began in 2018 (NSW Government 2021b).

The Central Coast subpopulation has an estimated total of 565 individuals across 18 sites. The SoS project monitors priority management sites at Ourimbah Creek, Wyrrabalong NP, and Wamberal Lagoon (NSW Government 2021b). High population numbers for both Wyrrabalong and Wamberal Lagoon are potentially due to ongoing planting of *S. paniculatum*, including approximately 165 mature individuals at the Wyrrabalong sites that have not been counted in the population estimate. At Wamberal Lagoon, while no anecdotal information is currently known, the number of juvenile individuals and the long history of bush-regeneration in the reserve suggests that planting has occurred (L. Foster pers. comm. May 2023).

The Karuah-Manning subpopulation contains an estimated 628 mature individuals across 20 naturally occurring sites. The core sites include Dark Point, Seal Rocks, The Ruins and Janie's Beach. The largest trees in this subpopulation occur at Mungo Beach and Saltwater. At Yacaaba Headland, 50 seedlings were recorded during 2021, all less than 5 cm tall and all in proximity (within 2 m) of mature *Syzygium paniculatum* trees (NSW Government 2021b).

Mature individuals in the northern part of the species range may be (and may have been) overlooked as *S. oleosum* during surveys (including development assessments) using current species descriptions and identification keys. Misidentification not only

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influences development outcomes but could also substantially affect population size estimates for *S. paniculatum* (Gecko 2018, Foster and Mulcahy 2020).

Land Tenure

Of the 73 naturally occurring *Syzygium paniculatum* sites currently verified, 26 are partly or wholly within conservation reserves. Twenty-four of these sites are within NSW reserves, with the other two occurring in the Commonwealth Booderee National Park at Jervis Bay. Seven sites occur on Commonwealth Department of Defence land at Beecroft Peninsula. These 33 sites all offer some level of conservation protection for *Syzygium paniculatum* under active plans of management (OEH 2012). Twenty-seven sites are located on other publicly managed land, Crown land or straddling public-private property boundaries. Thirteen sites occur entirely on private property (OEH 2012, DPE Map Data 2022).

Ecology

Cultural Significance

Lilly pillies are known to have been significant to the Aboriginal people of the east coast of Australia and are highly regarded as a food resource (Bodkin 2013, Low 1991, Renwick 2000, Lampert and Sanders 1973), a medicinal resource (Duncan April 2023, Locke May 2023), a natural resource for tools and other items (Duncan April 2023), and as an important component to the broader cultural landscape.

As a food resource, the flesh and possibly the seed (Lakshmi 2018, Singh and Sharma 2020) was eaten seasonally (Bodkin 2013). *Syzygium paniculatum* was also one of the first documented species noted by Banks and Solander in the 1770s (Benson and Eldershaw 2007) for its edible attributes and being observed to be eaten by Aboriginal people at Kurnell/Towra Point.

As a medicinal resource, substantial research exists on the chemical qualities and traditional uses on the wider *Syzygium* genus overseas (Ayyanar and Subash-Babu 2012, El-Saber Batiha *et al.* 2020, Lakshmi 2018, Nigam and Nigam 2012, Panghal *et al.* 2019, Uddin *et al.* 2022). In Australia, research has identified similar medicinal qualities within the *Syzygium* genus, including antiseptic properties in *S. australe* and *S. leuhmanni* (Cock 2012), anti-pancreatic cancer properties in *S. paniculatum* extracts (Vuong *et al.* 2014), and antioxidant and antiglycation activities of *S. paniculatum* relevant to Type 2 Diabetes (Kim *et al.* 2020).

These medicinal qualities were well-known by Aboriginal people. On Darkinjung Country on the Central Coast of NSW, “the magenta lilly pilly was considered to be one of many varieties that were collected during the times leading into winter season as they were a great medicinal source” (Duncan April 2023).

As a natural resource for tools and other items, it is known on Darkinjung Country that “we also used the fruit as a dye for woven baskets and mats as they are strong in colour” (Duncan April 2023).

As a broader part of the cultural landscape, Duncan (April 2023) says that for the Darkinjung people “like all nature in Aboriginal culture they (the Magenta lilly pilly) are

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considered as ancestral beings, the very things we as people are made of. This is why we have a totem-ship with all things of nature itself, which gives us responsibility to all things in life that give us life. The lilly pilly would become someone's personal name, kinship skin name or Country. If you were named after the lilly pilly you would learn the legend of it, story, song, dance and during ceremony the symbol or design of the fruit painted on your body. The totem-ship kinship structure is the very way of conservation in our culture, creating a balance between us and our ancestral beings."

The current distribution of *S. paniculatum* along the coastal strip of NSW coincides with areas of high Aboriginal occupation by Saltwater Peoples (people whose traditional Country included the seaboard) (Fuller 2020, Sharp 2002). Comprehensive surveys of all known subpopulations of *S. paniculatum*, anecdotally observed the occurrence of remnant populations in areas of Aboriginal importance (i.e., documented Aboriginal places and places connected to Dreaming stories) or in areas with evidence of Aboriginal inhabitancy (i.e., presence of shell deposits, modified trees, inhabited rock shelters, and burial sites) (L. Foster pers. obs; A. Mulcahy pers. comm. May 2023). Cultural surveys with the Jerrinja community at Bundarwa in the Jervis Bay subpopulation documented Aboriginal cultural artefacts across all populations of *S. paniculatum* (Feary 2023). Evidence included middens and stone artefacts, scarred/modified *S. paniculatum* individuals, modified 'ring-trees' and proximity of stands of *S. paniculatum* adjacent to culturally significant places (Feary 2023, Locke May 2023).

S. paniculatum has low genetic diversity across its distribution, with several distinct sub-lineages of *S. paniculatum* spanning multiple sites (Thurlby *et al.* 2012, Lu-Irving and Rossetto, 2021). It is likely Aboriginal people that knew the medicinal and food values of the *Syzygium* taxon, including *S. paniculatum*, influenced the distribution of species through long-distance dispersal, as is the case with many other species within Australia (Clarke 2014, Silcock 2018, Rossetto *et al.*, 2017, Cock 2011, Lullfitz *et al.*, 2020, Fahey *et al.*, 2022) and globally (Balée 1989, Cowan and Smith 1993, Denevan 1992). The lack of genetic differentiation across the geographic range of the southern lineage (Lake Macquarie to Jervis Bay, approximately 250km of coastline) suggests that the species expanded within the 75-200 years to rapidly occupy its present-day distribution (Lu-Irving, 2023). This aligns with cultural knowledge from various Aboriginal communities (e.g., Darkinjung, Jerrinja, Worimi), and may be attributed to dispersal by Aboriginal people (Fahey 2022).

This assessment is not intended to be comprehensive of the Traditional Ecological Knowledge that exists for *Syzygium paniculatum*, or to speak for Aboriginal people. Aboriginal people have a long history of biocultural knowledge, which comes from observing and being on Country, and evolves as it is tested, validated, and passed through generations (Woodward *et al.* (Eds.) 2020). Aboriginal Peoples have cared for Country for tens of thousands of years (Bowler *et al.* 2003; Clarkson *et al.* 2017). There is traditional ecological knowledge for all plants, animals and fungi connected within the kinship system (Woodward *et al.* (Eds.) 2020). Traditional Ecological Knowledge referenced in this assessment belongs to the relevant Knowledge Custodian and has been referenced in line with the principals of the NSW Indigenous Cultural and Intellectual Property (ICIP) (Janke and Company– Lawyers and Consultants 2023).

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Habitat

Syzygium paniculatum grows on flat to gently sloping sites, stabilised sand dunes, dunal ridges, floodplains, creekbanks, and wetlands on gravels, sands, silts, and clays derived mostly from riverside sandstone (Floyd 2008; Hyland 1983; Thurlby *et al.* 2010). On the NSW south coast *S. paniculatum* occurs on grey soils over sandstone, restricted mainly to remnant stands of littoral rainforest. On the central coast *S. paniculatum* occurs on gravels, sands, silts and clays in riverside gallery rainforests and remnant littoral rainforest communities. The species is generally associated with littoral, subtropical and warm temperate rainforest, notably in remnant patches (Thurlby *et al.* 2012).

On Beecroft Peninsula the vegetation is characterised by dominants such as small-leaved fig (*Ficus obliqua*), red olive plum (*Elaeodendron australe*), plum pine (*Podocarpus elatus*) and lilly pilly (*Acmena smithii*). Some sites on Beecroft Peninsula are dominated by magenta lilly pilly, which occurs with the above mentioned overstorey species. At St Georges Basin, dominants include cheese tree (*Glochidion ferdinandi*) and lilly pilly beneath emergent Blackbutt (*Eucalyptus pilularis*) and bangalay (*E. botryoides*), with an understorey including cabbage palm (*Livistona australis*), muttonwood (*Myrsine variabilis*) and scentless rosewood (*Synoum glandulosum*). The Coalcliff subpopulation occurs in riverine subtropical rainforest, with associated species including lilly pilly (*Acmena smithii*), blue lilly pilly (*Syzygium oleosum*) and water gum (*Tristaniopsis laurina*). A number of the Central Coast sites occur in littoral rainforest remnants, which sometimes grade into swamp sclerophyll forest where drainage is impeded. Vegetation associates in these areas include blue lilly pilly, hard quandong (*Elaeocarpus obovatus*), lilly pilly, cabbage palm, black apple (*Planchonella australis*), cheese tree, tuckeroo (*Cupaniopsis anacardioides*), Port Jackson fig (*Ficus rubiginosa*), broad-leaved paperbark (*Melaleuca quinquenervia*) and flax-leaved paperbark (*M. linariifolia*) (OEH 2012). Other Central Coast subpopulations occur in warm temperate rainforest gullies containing coachwood (*Ceratopetalum apetalum*), crabapple (*Schizomeria ovata*), ribbonwood (*Euroschinus falcatus*), guioa (*Guioa semiglauca*) and sweet pittosporum (*Pittosporum undulatum*) yellow tulipwood (*Drypetes deplanchei*), myrtle ebony (*Diospyros pentamera*) and big yellow wood (*Sarcomelicope simplicifolia*) (DPE PCT Map Data 2022).

The distribution of littoral and subtropical rainforest along the NSW coastline has historically always been discontinuous due to microclimatic conditions and soil types required for these communities to persist. However, this has been amplified by substantial losses of these ecological communities in recent decades due to land modification and clearing for development and agriculture (Bale and Williams 2021).

Habit, growth rate and longevity

Previously thought of as a shrub to small tree (Wilson 2002), recent surveys across the range of the species have confirmed the occurrence of trees up to 30m tall and up to 1.5m DBH (DPE BioNET 2023). In the Shoalhaven region, over 500 old remnant individuals were recorded, all between 20–30 meters tall (DPE BioNet 2023). There is also a large mature tree in the Norimbah Valley (Ourimbah Creek) that has a DBH of approximately 2m (DPE BioNET 2023).

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Large specimens are likely to be very old trees with an estimated life expectancy of 75 to 200 years (A. Bofeldt, cited in Benson and McDougall 1998). The age to maturity of *Syzygium paniculatum* is 2-4 years. This has been inferred based on data available from *Acmena smithii* that has a relatively slow growth rate in the first two years, but then reaches flowering age and fruit production at 3-4 years (Permaculture Online 2022).

Syzygium paniculatum has an estimated generation length of 47 years, calculated using a time to maturity of approximately three to four years and a life span estimate of 125 years (the midpoint between life expectancy of 75-200 years).

Reproduction

Syzygium paniculatum is polyembryonic, producing up to nine seedlings per seed (OEH 2012). It is the only known Australian species of *Syzygium* that displays this trait (Thurlby *et al.* 2012). The majority of seedlings are produced asexually at rates between 68% (Thurlby *et al.* 2012) – 100% (Thurlby 2010). The species is also facultative apomictic having the ability to produce fertile seeds (Thurlby *et al.* 2012, Payne 1997). Where the species reproduces asexually, the offspring are clones of the maternal plant (Thurlby *et al.* 2012). Genomic research confirmed low levels of genetic diversity, consistent with predominantly asexual reproduction (Lu-Irving and Rossetto, 2021). Naturally occurring *S. paniculatum* plants generally produce low numbers of fruit, while cultivated individuals and their offspring generally produce high numbers of fruit (L. Foster pers. obs. 2023). Lu-Irving and Rossetto (2021) found that, irrespective of mode of reproduction, 100% of seedlings belonged to the same genetic cluster as their maternal parent. Thus, reproduction via seed in *S. paniculatum* maintains distinct genetic clusters through apomixis, self-fertilization, and/or bi-parental inbreeding (cross-fertilization between co-members of a genetic cluster, which may be clones or close relatives).

Despite these apparent ecological advantages in fruit/seed production and capability to germinate multiple seedlings from the one seed, seed germination appears to be minimal under the canopy of the parent tree, with canopy disturbance being considered a crucial factor for seed germination (Thurlby *et al.* 2012). Many targeted surveys for the species observed minimal seedling recruitment and subpopulations exist predominately as a mature demographic (OEH 2012; Focus Flora 2018, Gecko 2018, NSW Government 2021b).

Pollination has been shown to include both self-pollination and outcrossed pollination (Payne 1997). Important pollinators for the species are flying foxes, possums, honeyeaters, lorikeets, and invertebrates such as introduced and native bees, moths, and butterflies (Focus Flora 2018). These pollinators have a wide range of dispersal capabilities for pollination, for example the native bee species *Tetragonula carbonaria* may forage up to 700 m from the nest (Smith *et al.* 2017), whereas grey-headed flying foxes can travel up to 50km in a single night (Department of Environment, Climate Change and Water 2009).

Seed dispersal is achieved via gravity, water (OEH 2012), and animals that consume the fruits. This includes the Grey-headed Flying-fox (*Pteropus poliocephalus*) (Tidemann 1995, DECCW 2009), White-headed Pigeon (*Columba leucomela*) (Payne

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1991) and potentially Australian Brush Turkeys (*Alectura lathamii*), which have been observed removing the fleshy fruit and eating the seed only (L Foster pers. obs. March 2023). Seed germination has been observed to occur rapidly within 20 days (Floyd 2008), with the life expectancy of seed to be less than three months (A. Bofeldt, cited in Benson and McDougall 1998).

Demarcation of the five subpopulations is based on them being separated by between 45 km and 135 km, as the foraging range of the larger potential dispersal agents may be about 50 km. (Payne 1991; DECCW 2009). The involvement of Aboriginal people in long and short distance dispersal is also likely for *Syzygium paniculatum* given the food and medicinal qualities of the species and broader lilly pilly group, and the presence of cultural artefacts within stands of remnant trees as identified by Feary (2023).

Population Genetics

Thurlby *et al* (2012) found that there is extremely low genetic diversity within 11 sites across the species' range. Additional genomic research of 459 individuals across all 73 sites, confirmed that *S. paniculatum* had very low genetic diversity across its range, and had distinct sub-lineages spanning multiple sites (Lu-Irving and Rossetto 2021). In the southern part of the species range from Lake Macquarie to Jervis Bay, trees are typically genetically homogeneous. North of Lake Macquarie there are several distinct groups co-occurring within sites and phylogenetically intermingled with *S. oleosum*. This suggests that at some point, historic introgression occurred between *S. paniculatum* and *S. oleosum* to form this species complex. These findings correlate with the morphological differences noted by Foster and Mulcahy (2020) in the same populations.

It is possible that the southern group represents one part of a large clonal stand of *S. paniculatum* that may have been broken into smaller subpopulations by clearing and modification of habitat for coastal development, agriculture, and sand mining (Floyd 1990). However, due to the wide geographic spread of this homogeneous genetic lineage (>250km), this theory is difficult to support without further evidence. Further research into this area, including long distance dispersal by Aboriginal people and declines in faunal dispersal are warranted (Fahey *et al.*, 2022, Silcock 2018).

Threats

Habitat clearing and fragmentation

The distribution of littoral and subtropical rainforest along the NSW coastline has always been discontinuous due to microclimatic conditions and soil types required for these communities to persist. However, discontinuation has been amplified by substantial losses of these rainforest communities due to land modification and clearing for development and agriculture. Much of the species preferred near-coastal distribution in specific habitat of littoral and sub-tropical rainforests has been cleared and now exists only in small fragments, many of which remain vulnerable to further clearing and modification (Floyd 2008, OEH 2012).

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Habitat that is suitable to support *S. paniculatum* continues to be cleared for urban expansion and infrastructure development (OEH 2012). This is particularly evident in the Central Coast and Jervis Bay regions, where residential and associated developments are expanding rapidly. Clearing can impact *S. paniculatum* directly by removing habitat, destroying individuals and by causing ongoing degradation of habitat through the disruption of ecosystem processes and increasing the impact from edge effects (OEH 2012).

The removal of large remnant trees is a major threat to this species. With the exception of a few larger sites (e.g., Jervis Bay, Wamberal Lagoon), most sites contain small numbers (between 6 – 628) of predominately mature individuals. Clearing of valley floor vegetation for agriculture, including lowland rainforest and riparian gallery forest, has led to a contraction in habitat available to the species, a reduction in recruitment under mature stands, and a reduction in total numbers within localised sites. At some sites where *S. paniculatum* occurs in riparian remnants, under scrubbing of habitat and grazing by livestock has reduced the ability of the species to regenerate through seedling recruitment (Focus Flora 2018).

Weeds

Weed invasion is a site-specific threat to *S. paniculatum*. Sites in Wyrabalong National Park, Bouddi National Park and Wamberal Lagoon Nature Reserve have been notably impacted by lantana (*Lantana camara*) and bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata*). Observations at these sites show small seedlings and smaller trees being smothered by lantana (Focus Flora 2018). Rapid colonisation of canopy gaps by these weeds substantially reduces opportunities for native *S. paniculatum* seedlings to grow and establish, resulting in poor recruitment success. For small or isolated populations, the lack of suitable habitat for recruitment due to weed invasion represents a significant threat (Focus Flora 2018).

Other significant weeds that posed a threat to the species include morning glory (*Ipomoea indica*), small-leaved privet (*Ligustrum sinense*) and Japanese honeysuckle (*Lonicera japonica*). Littoral rainforest remnants on private property and council-managed lands within the Central Coast subpopulation are threatened by these weeds invading remnant vegetation. The small subpopulation at Abrahams Bosom near Jervis Bay is infested with asparagus fern (*Asparagus aethiopicus*), impacting on the species ability to establish seedlings (Focus Flora 2018, OEH 2012).

Weed management is a key management action at priority management sites under the SoS conservation project for the species. Targeted removal of lantana, bitou bush, asparagus fern and other vines and scramblers has been ongoing since the project's inception (NSW Government 2021a).

Road, Track and Powerline Easement Maintenance

Populations that occur on edges of roads/tracks and powerline easements, including Booti Booti NP South, Seal Rocks, Yacaaba Headland and Wyrabalong are affected by routine maintenance involving slashing, grading or other earthworks. These areas are also subjected to frequent human visitation (OEH 2012). Sites in the Jervis Bay subpopulation are adjacent to camping areas at Honeymoon Bay on Beecroft

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Peninsula. The parking, picnic and recreation areas at the St Georges Basin and Abrahams Bosom sites are high use areas, with large numbers of visitors passing through the populations and habitat. The Elizabeth Beach site occurs adjacent to a walking track to the beach, which may impact *S. paniculatum* through damaging the structural root zone of trees from soil disturbance or compaction, trampling of the understorey and increasing edge effects (Flora Focus 2018, OEH 2012). The relatively large population in Wyrribalong National Park is exposed to edge effects associated with an existing road and has been further threatened by highway expansions (NSW Threatened Species Scientific Committee 2009).

Changes in Hydrological Regimes and Dune Movement

Movement of sand dunes over time has the potential to impact *Syzygium paniculatum* sites occurring in dune systems along the coastline (OEH 2012). The subpopulations assessed as being most vulnerable to impacts from dune movement include Yacaaba Peninsula, Mungo Beach South, and Shelly Beach in Booti Booti NP South. Several *S. paniculatum* individuals on the Yacaaba Peninsula are currently impacted by sand deposition (Focus flora 2018). Mills (1996) postulates that *S. paniculatum* was lost from the Northern Illawarra because of large-scale disturbance of local sand dune systems.

High Intensity Fire

Syzygium paniculatum is a fire sensitive species. Fire may trigger regenerative mechanisms in some mature individuals, with Payne (1991) observing coppicing from the bases of burnt-out main trunks of trees at North Entrance. However, it has been generally accepted that fire is likely to kill individuals (particularly medium to high intensity fire) and only fires of low intensity induce coppicing (OEH 2012). Frequent higher intensity fires are likely to kill plants, interfere with reproduction, and alter the surrounding rainforest habitat (OEH 2012). '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 BC Act.

Sites of *Syzygium. paniculatum* that were assessed as having a higher risk to impacts from fire include Wyrribalong, Yacaaba Peninsula, and Booti Booti NP North. Some individuals within these subpopulations are considered to have a higher fire risk due to the relatively small size of the rainforest patches they occupy, high abundance of fire-prone vegetation within or around habitat patches (e.g., Lantana), high recreational use, and/or close proximity to urban areas (OEH 2012).

Threat Locations

The most serious plausible threat to *Syzygium paniculatum* is ongoing habitat loss through clearing and habitat degradation. Based on these threats there are greater than 10 locations identified for *Syzygium paniculatum*. There are 13 sites located on private property that are at risk of vegetation clearing that can be considered one location when using the definition under the IUCN Guidelines (2022) that state that "Where the most serious plausible threat is habitat loss that occurs gradually and cumulatively via many small-scale events, such as clearance of small areas for developments, or gradual degradation of habitat patches, a location can be defined by

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the area over which the population will be eliminated or severely reduced within a single generation or three years, whichever is longer.” Within the next 47 years (being one generation) a number of small-scale clearing events could severely reduce the number of individuals from these 13 sites. The remaining 60 sites are on tenure that may offer greater protection from clearing, being within managed conservation reserves, Crown lands, and publicly managed lands. These sites are exposed to the threat of ongoing habitat degradation, which is site by site specific, indicating that they are each an individual threat-based location. It is highly unlikely that the most plausible threats of clearing, and habitat degradation would result in the extirpation of an entire subpopulation as the threats are localised and act independently at each of the sites.

Assessment against IUCN Red List criteria

Criterion A *Population Size reduction*

Assessment Outcome: Data deficient

Justification: Standardised monitoring data of *Syzygium paniculatum* is only available from 2018, providing only five years of comparable data for the species. Although a historic population reduction has been inferred in the past due to intensive habitat clearing and modification along the NSW coast, this reduction cannot be quantified with the available data over 3 generations (calculated as approximately 141 years) for this long-lived species.

Criterion B *Geographic range*

Assessment Outcome: Not met

Justification: *Syzygium paniculatum* has a restricted Extent of Occurrence (EOO) of 17,718 km². The Area of Occupancy (AOO) has been calculated 568 km² (based on the IUCN grid cell width of 2km). Both EOO and AOO meet the threshold for Vulnerable. However, the number of threat locations is greater than 10 and the species is not considered to be severely fragmented, therefore *Syzygium paniculatum* does not meet this sub criterion for Criterion B.

In addition to these thresholds, at least two of three other conditions must be met. These conditions are.

- (a) The population or habitat is observed or inferred to be severely fragmented or there is 1 (CR), ≤5 (EN) or ≤10 (VU) locations.

Assessment Outcome: Not met

Justification: The most serious plausible threat to *Syzygium paniculatum* is ongoing habitat loss through clearing and habitat degradation. Based on these threats there are greater than 10 identified locations for *Syzygium paniculatum* - one location for all sites on private tenure still subject to potential clearing and habitat degradation, and 60 sites within managed areas that remain vulnerable to ongoing habitat degradation where the threat remains site by site specific.

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Syzygium paniculatum is not severely fragmented as despite the species being distributed throughout fragmented habitat patches, four of the five subpopulations are large enough and capable of producing seed to support a viable population of *S. paniculatum*: Jervis Bay (575), Metropolitan Sydney (313), Central Coast (565) and Karuah- Manning (628). In addition, dispersal, and pollinating agents such as the Grey Headed Flying Fox (*Pteropus poliocephalus*) (Tidemann and Nelson 2004) and White-headed Pigeon (*Columba leucomela*) (Payne 1991) have an approximate 50 km foraging range from their camp roosts and territories. Subpopulations of *Syzygium paniculatum* are between 45km-135km from each other, and therefore it is considered possible for recolonisation to occur in habitat if one of the subpopulations are to go extinct.

- (b) Continuing decline observed, estimated, inferred or projected in any of: (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 inferred decline in (ii) area of occupancy, and v) number of mature individuals in the future and an observed decline in (iii) area, extent, and quality of habitat.

Justification: Continuing decline has been inferred for *Syzygium paniculatum* because of intense coastal development within the known natural range along the coastal fringe. Past clearing is inferred to have resulted in loss of entire subpopulations, and habitat of *S. paniculatum* continues to be cleared for urban expansion, agriculture, and infrastructure development. Ongoing clearing continues to threaten the species and its habitat, reducing its area of occupancy. Clearing of valley floor vegetation for agriculture, including lowland rainforest and riparian gallery forest, has led to a contraction in habitat available to the species, a reduction in recruitment under mature stands, and a reduction in total numbers within localised sites. At some sites where *S. paniculatum* occurs in riparian remnants, under-scrubbing of habitat and grazing by livestock has reduced the ability of the species to regenerate through seedling recruitment (Focus Flora 2018).

There has been an observed decline in the area, extent, and quality of habitat for *Syzygium paniculatum* throughout its known range. The distribution of littoral and subtropical rainforest along the NSW coastline has always been discontinuous due to microclimatic conditions and soil types required for these communities to persist. This fragmented distribution has been amplified by substantial losses of these rainforest communities due to land modification and clearing for development and agriculture. While many remaining stands are now reserved within conservation areas (Bale and Williams 2021), degradation of habitat continues to disrupt rainforest ecosystem processes through the exposure of remnants to potentially damaging threats and edge effects (Thurlby *et al.* 2000).

Extreme fluctuations.

Assessment Outcome: Not met

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Justification: Due to the long-lived nature of the species estimated to be between 75 to 200 years (Benson and McDougall 1998 as cited in OEH 2012), *S. paniculatum* it is unlikely to experience extreme fluctuations.

Criterion C Small population size and decline

Assessment Outcome: Met for Vulnerable C2a (i)

Justification: Based on the most recent survey results of population data available from the SoS project and existing BioNet (2022) records, the total population size of *Syzygium paniculatum* has been estimated as 2,087 mature individuals from five subpopulations (Gecko Environmental Management 2018; Focus Flora 2018; DPE BioNet 2023). This number of mature individuals meets the threat category for listing as Endangered, however the sub criterion is only met for Vulnerable for the number of individuals in each subpopulation being $\leq 1,000$.

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

- C1. An observed, estimated, or projected continuing decline of at least: 25% in 3 years or 1 generation (whichever is longer) (CR); 20% in 5 years or 2 generations (whichever is longer) (EN); or 10% in 10 years or 3 generations (whichever is longer) (VU).

Assessment Outcome: Data Deficient

Justification: There is insufficient monitoring data available for the last 47-141 year (1-3 generations) to determine a qualifiable decline at the necessary resolution to apply sub criterion C1.

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

Assessment Outcome: Met for Vulnerable C2a (i)

Justification: *Syzygium paniculatum* exist as a long-lived tree in five subpopulations within an ageing demographic. Subpopulations appear to be predominantly mature individuals. There has been minimal natural seedling recruitment observed across all five subpopulations (NSW Gov 2012b). There has been an observed decline in the extent and quality of habitat for *Syzygium paniculatum* throughout its known range through ongoing clearing. Therefore, *Syzygium paniculatum* is inferred to experience a continuing decline in the number of mature individuals at each of the five subpopulations through natural thinning and attrition within an ageing demographic, ongoing clearing, and ongoing habitat degradation across the entire population.

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 for Vulnerable

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Justification: The number of mature individuals in each subpopulation of *S. paniculatum* is ≤ 1000 for four of the subpopulations: Jervis Bay $n= 575$, Metropolitan Sydney $n= 313$, Central Coast $n= 565$ and Karuah- Manning $n= 628$. Only the Illawarra subpopulation contains a small number of individuals $n=6$.

- a (ii). % of mature individuals in one subpopulation is 95-100%.

Assessment Outcome: Not met

Justification: None of the five subpopulation contains 90-100% of the total number of mature individuals.

- b. Extreme fluctuations in the number of mature individuals

Assessment Outcome: Data Deficient

Justification: This long-lived stable nature of all the subpopulations is unlikely to undergo extreme fluctuations.

Criterion D Very small or restricted population

Assessment Outcome: Not met

Justification: *Syzygium paniculatum* is currently known to have a population of 2087 mature individuals. This does not classify as being a very small or restricted population under the IUCN 2022 Guidelines.

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: *Syzygium paniculatum* is currently known to have a population of 2087 mature individuals. This does not classify as being a very small or restricted population under the IUCN 2022 Guidelines.

- D2. Restricted area of occupancy (typically $<20 \text{ km}^2$) 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: *Syzygium paniculatum* occurs at greater than 10 threat-defined locations, the estimated AOO is 568 km^2 and therefore cannot be assessed under criterion D2.

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Criterion E Quantitative Analysis

Assessment Outcome: Data Deficient

Justification: Currently there is not enough data to undertake a quantitative analysis to determine the extinction probability of *Syzygium paniculatum*.

Conservation and Management Actions

Syzygium paniculatum is currently listed on the NSW *Biodiversity Conservation Act 2016* and requires site-based management to secure it from extinction in NSW for 100 years. 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.

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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:

Syzygium paniculatum was found to be Vulnerable under Clause 4.4(c)((e)(i)(iiAIII))

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: Not met

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,

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		(iii)	the number of locations in which the species occur or of populations of the species.
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**Clause 4.4 - Low numbers of mature individuals of species and other conditions
(Equivalent to IUCN criterion C)**

Assessment Outcome: Vulnerable 4.4(c)((e)(i)(iiAIII))

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.

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**Clause 4.6 - Quantitative analysis of extinction probability
(Equivalent to IUCN criterion E)
Assessment Outcome: Data Deficient**

The probability of extinction of the species is estimated to be:			
	(a)	for critically endangered species	extremely high, or
	(b)	for endangered species	very high, or
	(c)	for vulnerable species	high.

**Clause 4.7 - Very highly restricted geographic distribution of species–vulnerable species
(Equivalent to IUCN criterion D2)
Assessment Outcome: Not met**

For vulnerable species,	the geographic distribution of the species or the number of locations of the species is very highly restricted such that the species is prone to the effects of human activities or stochastic events within a very short time period.
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