Conservation Assessment of *Caladenia callitrophila* D.L.Jones (Orchidaceae)

C. Bray 17/10/2024
NSW Threatened Species Scientific Committee

Caladenia callitrophila D.L.Jones (Orchidaceae)

Distribution: Endemic to NSW
Current EPBC Act Status: Not listed
Current NSW BC Act Status: Not listed

Proposed listing on NSW BC Act: Critically Endangered

Summary of Conservation Assessment

Caladenia callitrophila was found to be eligible for listing as Critically Endangered under IUCN Criteria C2a(ii)

The main reasons for this species being eligible are (i) it has a very low population size (<250); (ii) most mature individuals occur within one population; (iii) there is a continuing decline in the number of mature individuals due to threats from herbivory (grazing and browsing), forestry activities, habitat loss and destruction and climate change.

Description and Taxonomy

Caladenia callitrophila was described by D.L. Jones (2021) as “Leaf linear-lanceolate, 70–130 x 4–12mm. Flower stem 200–350mm tall, 1–2-flowered. Flowers 50–60mm across, pale greenish-yellow with reddish markings; sepals with blackish to reddish clubs 6–13mm long; petals lacking clubs. Dorsal sepal erect, 25–40 x 1.5–2mm. Lateral sepals stiffly but obliquely decurved, 24–40 x 3.5–4 mm, divergent. Petals similarly arranged, 20–30 x 2–2.5mm. Labellum stiffly hinged, 12–15 x 7–9mm, yellowish base with red lines and maroon apex; margins with 6–9 pairs of red teeth to 1.3mm long; tip recurved. Calli to 1mm long, maroon, in 4 or 6 rows onto base of midlobe. Column 9.5–11.5 x 4–4.5mm, translucent reddish; basal glands c.1.3mm long, yellow with red basal stalk. Flowers: September to October.”

Synonym: *Arachnorchis callitrophila* (D.L.Jones) D.L.Jones & M.A.Clem. and *Caladenia sp. aff. australis* (Berrigan)

This species is known to occasionally hybridise with *Callitrophila arenaria* (Copeland and Backhouse 2022) and possibly *C. verrucosa* (G. Phillips *in litt*. June 2024).

Distribution and Abundance

The orchid species *Caladenia callitrophila* is endemic to the southern Riverina region of New South Wales (NSW). It is currently known to exist in only three subpopulations located within state forests between the towns of Berrigan and Balldale at altitude range of 120-170 ASL (Copeland and Backhouse 2022). The species has only ever been found in these three sites which are small and isolated patches of habitat (16-50 km apart), separated from one another by cultivated farmland.

This species grows in woodland of *Callitris glaucophylla* (white cypress pine), *Eucalyptus melliodora* (yellow box) and *Eucalyptus microcarpa* (western grey box), with a grassy and sparsely shrubby understorey, on red-brown sandy or sandy-loam soils. Most of the plants have been found in 3-4 m tall white cypress pine regrowth (G. Robertson *in litt*. Feb 2021).

The habitat of this species may occur within 'White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland' a Critically Endangered Ecological Community (CEEC) under the NSW BC Act and the EPBC Act (NSW SC 2011a; DCCEEW 2023), as well 'Sandhill Pine Woodland in the Riverina, Murray-Darling Depression and NSW South Western Slopes bioregions' an Endangered Ecological Community (EEC) under the NSW BC Act (NSW SC 2011b). These EECs most likely correspond with 'Yellow Box - White Cypress Pine grassy woodland on deep sandy-loam alluvial soils of the eastern Riverina Bioregion and western NSW South Western Slopes Bioregion' Plant Community Type (PCT 75), but may not be restricted to this PCT (NSW DPE 2023).

Several surveys have been conducted for this species. During 1999 and 2000, most of the southern Riverina's state forests were surveyed for the closely related and co-occurring species *Caladenia arenaria*, totaling four weeks of survey. However, no further populations of *C. callitrophila* were found (Ecology Australia 2001; NSW DEC 2004; G. Robertson *in litt*. Feb 2021). Additionally, no new populations have been discovered in the last 20 years of surveys conducted for forestry activities or during grazing assessments throughout the region's forests. If the species was common elsewhere or at other sites, it is likely it would have been recorded in these surveys (G. Robertson *in litt.* Feb 2021).

Surveying for juvenile plants is challenging because their long and narrow leaves are visually difficult to distinguish from grass. As a result, surveys can only be conducted during the flowering period and when sufficient rainfall promotes above ground plant growth (Reiter *et al.* 2020; G. Robertson *in litt*. Feb 2021).

EOO and AOO

The geographic distribution of *Caladenia callitrophila* is highly restricted. The area of occupancy (AOO) is estimated to be 12 km^2, based on three 2 x 2 km grid cells, the scale recommended for assessing area of occupancy by IUCN (2024). The extent of occurrence (EOO) is estimated to be 310 km^2. The EOO is based on a minimum convex polygon enclosing all mapped occurrences of the species, the method of assessment recommended by IUCN (2024).

Abundance

There is a very low number of mature individuals of *Caladenia callitrophila*. The total number of *C. callitrophila* flowering plants recorded during the 2020 season, after good winter rain, was around 183 flowering plants, with the majority of those (>90%) occurring at one site (G. Robertson *in litt.* Feb 2021; DCCEEW unpubl. data). During the much drier winter of 2023 only 14 flowering plants were recorded (DCCEEW unpubl. data; L. Carrigan unpubl. data; G. French unpubl. data).

The number of individuals detectable above ground in terrestrial orchid populations commonly varies over time depending on environmental conditions and grazing pressure. Based on comparisons between two years (2000 and 2020) that both had above average autumn/winter/spring rainfall, the total population of this species appears to have declined. In 2000, there were extensive populations of around 200 flowering plants, recorded at two of the sites (G. Robertson *in litt*. Feb 2021). In 2020, only 180 plants were recorded within a few small patches (the largest of which was about 90 plants) at one site, and only two plants were recorded at the other site. These two sites were also sampled in 2023, (a much drier winter than 2000 or 2020) and had a total combined above-ground population of 14. The third site has always contained very low numbers of plants (<10) and in 2023 no plants were recorded.

It is difficult to estimate the current total population size of *Caladenia callitrophila* as plants observed flowering in one season that did not reemerge in the following season are not necessarily dead. Some may remain dormant underground, a common ecological strategy observed in orchids with a similar life history (Dixon and Tremblay 2009), although variability in emergence between years appears to differ among orchid taxa. Emergent numbers fluctuate primarily due to rain and soil moisture, and the underground population is probably capable of persisting for some years without emergence (Dixon and Tremblay 2009). However, given the season in 2020 was considered a year with good conditions for flowering, the population size is likely no more than 250.

Ecology

Little is known of the specific details of the biology of *Caladenia callitrophila* however it is believed to be very similar to other spider orchids. *Caladenia* species are deciduous and die back to a dormant, fleshy tuber over summer (NSW DEC 2004; Dixon and Tremblay 2009). In *Caladenia*, tubers are generally replaced annually by a single daughter tuber on a vertical dropper, but few species appear to reproduce vegetatively by this means (Jones 2021). After a soaking from late autumn/winter rains, the tuber sprouts, with a single leaf developing above ground. Once the leaf is fully extended, a single flower may be produced. *C. callitrophila* flowers in September to October if conditions are suitable and flowers persist for about a month depending on the seasonal conditions (NSW DEC 2004; Copeland and Backhouse 2022).

The prominent calli on the labellum of *C. callitrophila* suggest that is likely pollinated by nectar-foraging thynnid wasps (*Zaspilothynnus* sp.), which are attracted to the flowers, possibly mistaking them for potential mates (NSW DEC 2004; Dixon and Tremblay 2009). Studies indicate that most sexually deceptive species of *Caladenia* have a relationship with a single species of wasp (Phillips *et al*. 2009), though pollinator sharing can occur between species of wasp-pollinated *Caladenia* (Reiter *et al.* 2019).

Once pollination has occurred flower senescence takes place within 48 hours (Swarts 2007). Around four weeks later, the plants produce up to 30 000 tiny dust-like seeds that disperse on wind currents, and the plant enters dormancy again (Dixon and Tremblay 2009). Like most species of *Caladenia*, it is believed that *C. callitrophila* can only reproduce by seed and is unable to reproduce vegetatively (Jones 2021).

For successful germination, seeds require sufficient moisture, adequate temperatures (usually 15-20^{o}C) and the presence of a suitable fungal symbiont (Batty *et al*. 2001; Ramsay and Dixon 2003). The primary site of fungal infection for *Caladenia* species is at the soil surface where the stem swells and forms a collar (Dixon and Tremblay 2009). Many related *Caladenia* are known to associate with a single type of *Serendipita* mycorrhizal fungi, including the co-occurring *C. arenaria,* so it is likely that *C. callitrophila* is similar (Reiter *et al.* 2020). Seeds are short-lived in the soil seedbank as per other Orchidaceae, often lasting only one or two seasons (NSW DEC 2004; Dixon and Tremblay 2009). Under natural conditions, *C. arenicola* seed that was exposed to moisture, but not a suitable mycorrhizal fungus led to a loss of seed viability within three to four months (Batty *et al.* 2000). The short-lived soil seedbank highlights the need for *Caladenia* species to invest in annual seed production to ensure successful seedling germination during favourable conditions (Dixon and Tremblay 2009).

Despite the small size of *C. callitrophila* seeds that allows for the potential long- distance wind dispersal, most seeds likely fall near the plants. This is because the plants grow under the dense canopy of white cypress pine woodland, which shelters them from the wind. Research on terrestrial orchids, including those of similar size in pine forests, has found that 95% of seeds fall within just a few metres of the plant. This indicates significant barriers to widespread dispersal, especially in fragmented orchid populations (Machon *et al.*2002; Brzosko *et al.*2017).

While the species' response to fire is unknown, its geophytic (underground storage organ) growth habit suggests that at least some individuals are likely to survive fire, depending on the depth of tuberoid burial and the season in which fire occurs. Fires that occur soon after leaf emergence are likely to deplete starch reserves in the tuberoid, potentially reducing survival (Jasinge *et al.* 2018a,b). Additionally, fire in other seasons may play a role in enhancing this species' flowering with a temporary flush of nutrients in ash and by removing competing vegetation biomass in the seasons following a wildfire, similar to what has been observed in other *Caladenia* species (Bower and Medd 2023).

The generation length of this species is not known but is likely to be similar to other species of *Caladenia*. While the time from seed germination to flowering for *Caladenia* species is largely unknown under natural habitat conditions, ex-situ plants have been observed to flower 2-3 years after germination (Swarts 2007). Based on data for closely related *Caladenia* species, these ex-situ plants likely live for at least 10-20 years (Swarts 2007, NSW DEC 2004). Flowering *Caladenia arenaria* have been recorded in the same location 16 years after the initial survey (G. Robertson *in litt*. Feb 2021).

Threats

The main threats to *Caladenia callitrophila* are from habitat clearing and fragmentation, herbivore pressure, weed incursion and reduced reproductive output due to the effects of changing climate.

Habitat clearing and fragmentation

There has been extensive historical clearing of woodlands dominated by *Callitris glaucophylla* (white cypress pine), *Eucalyptus melliodora* (yellow box) and *E. microcarpa* (grey box), in the southern Riverina region. Prior to clearing and cropping, this vegetation was widespread and abundant, and it is estimated that over 80% of these woodlands in the area have been removed (Moore 1953; NSW DEC 2004; Thompson and Eldridge 2005; NSW DPE 2023). Most of the remaining vegetation has been, and continues to be, heavily modified due to a combination of grazing by domestic livestock, browsing by non-native and native animals, forestry activities, weed incursion and altered fire regimes. Currently in the Riverina, *C. glaucophylla* woodlands occur in highly fragmented remnants, with many managed as formal forestry reserves and such woodlands are very poorly represented in protected areas (Thompson and Eldridge 2005; NSW DPE 2023). The removal and degradation of this vegetation type has very likely had a significant impact on the distribution of *C. callitrophila*. It is possible that this orchid may have occurred elsewhere in the region that has now been cleared.

'Clearing of native vegetation' is listed as a key threatening process (KTP) under the *Biodiversity Conservation Act 2016* (BC Act) and 'Land clearance' is listed as KTP under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Forestry operations

Forestry operations can threaten *Caladenia callitrophila* by destroying its habitat and disrupting its lifecycle, especially if conducted at inappropriate times or disturbing soil in areas where the plants occur. Logging practices, in particular, may pose a direct threat through physical damage from treefall, soil compaction, log dumps, and harvesting machinery. They can also indirectly threaten the species by facilitating the incursion of weeds following soil disturbance or opening of the canopy (NSW DEC 2004).

Most *C. callitrophila* populations in state forests are found growing among regrowth white cypress pine. Thinning of these young stands, to reduce competition and encourage faster growth, is likely to be detrimental to populations of *C. callitrophila*, again, either by direct physical damage or by promoting herbaceous competitors (NSW DEC 2004).

The results of a survey in 2020 in one of the state forest sites are suggestive of this threat. In one section that had been subject to stand thinning, only five *C. callitrophila* flowering plants were recorded, a significant decline from previous numbers of 200 to 300 flowering plants. In contrast, a neighbouring stand with thicker, larger *Callitris* regrowth that had not been recently thinned and contained more natural fallen timber (which may have a role in sustaining refuges from vertebrate herbivores), had 70-80 plants. Herbaceous weeds were also much less prevalent in the unthinned stand (G. Phillips *in litt.* June 2024).

Herbivore pressure

The impacts of herbivores, which includes both the consumption of vegetation, as well as the trampling and habitat destruction by domestic, feral and native herbivores, has the capacity to eliminate mature plants and/or disrupt reproductive processes resulting in a decrease in population numbers (NSW DEC 2004).

The leaves and flower stems of *Caladenia* spp. are palatable and evidence of grazing by native and introduced vertebrate herbivores (including macropods, goats (*Capra hircus*) and sheep (*Ovis aries*)) is frequently observed in areas accessible to these animals. Additionally, the tubers may be preyed upon by animals such as, rabbits (*Oryctolagus cuniculus)*, white-winged choughs (*Corcorax melanorhamphos*) or pigs (*Sus scrofa*) (NSW DEC 2004; G. Robertson *in litt.* June 2024).

Rabbits also have the potential to impact this species habitat as they can readily burrow into the lighter-textured soils of the sandy areas where this species grows. Rabbits are thought to be responsible, in part, for eliminating orchid species from sandhills on the Riverine Plain in the 1950s when the rabbits were in plague (NSW DEC 2004). Domestic livestock, particularly sheep and cattle, can also damage the habitat through pugging in wet conditions. The orchid's vulnerability to soil disturbance is increased by the positioning of the collar, its primary nutrient transfer organ, at the soil surface via the mycorrhizal associations (Dixon and Tremblay 2009). Additionally, grazing may negatively impact the plants that pollinators rely on, or the soils where female wasps build their nests (NSW DEC 2004).

As a result of herbivore pressure *C. callitrophila* is now restricted to areas either within dense white cypress pine regrowth (due to concentration of grazing in more open areas of the forests), or in areas adjacent to, or within clumps of unpalatable species like the tough, spiky-leaved *Lomandra effusa* which provide protection from grazing (NSW DEC 2004; G. Robertson *in litt.* Feb 2021; G. Phillips pers. comm. June 2024; A. Murphy pers. comm. June 2024).

'Competition and grazing by the feral European Rabbit, *Oryctolagus cuniculus'*, 'Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa'* and 'Competition and habitat degradation by Feral Goats, *Capra hircus'* are listed as a KTPs under the BC Act. 'Competition and land degradation by rabbits', 'Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs', and 'Competition and land degradation by unmanaged goats' are listed as KTPs under the EPBC Act.

Weeds

There are a number of introduced weed species that occur near *Caladenia callitrophila* populations and in the surrounding state forest. These weeds can result in overshading and soil moisture depletion, reducing resources available for flower emergence and fruit development in the orchid.

The invasive perennial exotic grass *Ehrharta calycina* has been identified as a direct threat to one of the populations of this species (NSW DEC 2004). Additionally, pasture weeds like *Brassica* spp. and *Trifolium* spp. have high coverage in some areas where

the orchid is found. Annual grasses such as *Avena* spp., *Lolium* spp., *Bromus* spp., and *Vulpia* spp. are present in all the forests where this species has been recorded and where dense, appear to competitively exclude the terrestrial orchids (G. Robertson *in litt.* Feb 2021).

'Invasion of native plant communities by exotic perennial grasses' is listed as a KTP under the BC Act.

Climate Change

The climate in the Riverina Murray region of NSW is characterised by warm, dry summers and cool, wet winters, with the highest level of rainfall occurring in May to September (Eardley 1999; NSW NPWS 2003; NSW OEH 2014).

The climate in this region of NSW is projected to undergo several significant changes. Average temperatures are expected to rise across all seasons, resulting in more frequent and intense heatwaves. Rainfall is predicted to decrease on average with a substantial decline anticipated during autumn, winter and spring. Additionally, evapotranspiration is likely to increase in all seasons except winter (ADAPT NSW 2024; CSIRO 2020). This reduction in average rainfall is expected to lead to decreased soil moisture and an increase in the occurrence and duration of droughts (NSW OEH 2014).

Terrestrial orchids on the southwestern slopes and plains of NSW rely on late autumn and winter rains to trigger their emergence and flowering. Decreases in this seasonal rainfall are likely to make the habitat less suitable, reducing reproductive output for the species. Hotter temperatures can result in a reduced flowering period for *Caladenia* species (NSW DEC 2004). These plants are known to die back to their underground tubers during periods of high temperature (Jones 2021). Some populations of the closely related and sympatric, *C. arenaria,* have declined nearly 10-fold during severe droughts such as the millennium drought. In 2020, a year with above average rainfall and expected high orchid emergence, there was a noticeable reduction in the number of emergent *C. arenaria* plants relative to 2016, following the 2017-2019 drought period when barely any plants emerged (G. Robertson *in litt.* Feb 2021). Reduced flowering during the projected increase in drought frequency, severity and duration suggests climate change may also disrupt the critical overlap between orchid flowering times and pollinator activity, further compromising reproductive success (Brown *et al*. 2008).

Furthermore, the thynnid wasp pollinators of *Caladenia* species are parasitoids of scarabaeid larvae in soil. Climate change, either increased drought or increased rainfall, may negatively affect the availability of scarab larvae (Frew 2016) and therefore abundance of pollinators.

The highly specialized biotic relationships (with pollinators and mycorrhizal fungi) and limited reproductive resilience of *Caladenia* orchids, as evidenced by their low annual seedling recruitment, severely constrain the species' ability to migrate to new, climatically suitable sites, especially in highly fragmented landscapes. Consequently, climate change poses a significant threat to the long-term survival of the species (Dixon and Tremblay 2009).

"Anthropogenic Climate Change" is listed as a KTP under the BC Act and 'loss of climatic habitat caused by anthropogenic emissions of greenhouse gases' is listed as a KTP under the EPBC Act.

Hybridisation

Hybridisation with co-occurring *Caladenia* species has been observed in one population, where *C. callitrophila* has been recorded hybridising with *C. verrucosa* (G. Phillips *in litt.* June 2024). At another site, hybridisation between *C. callitrophila* and *C. arenaria* is possible due to the very low number of *C. callitrophila* plants within a larger *C. arenaria* population, increasing the likelihood of genetic swamping and loss of *C. callitrophila*'s genetic integrity if cross-fertlisation occurs (G. Robertson *in litt.* Feb 2021). The hybridisation could also reduce successful pollinations of *C. callitrophila* potentially decreasing the reproductive success of this species over time (NSW DEC 2004).

Inbreeding and stochasticity associated with small population sizes

The small population sizes of this species make it vulnerable to inbreeding depression due to limited gene flow, pollinator failure, poor recruitment, and stochastic environmental events (G. Robertson *in litt.* Feb 2021).

Number of Locations

Based on the most serious plausible threat of habitat clearing and modification (due to herbivore pressure and forestry activities), the three subpopulations of *C. callitrophilla* can be considered to be three threat-defined 'locations' as per the IUCN (2024) definition. Each of these three locations have different types and levels of impact to the habitat and are unlikely to be affected by the same habitat clearing or modification event now and into the future.

Assessment against IUCN Red List criteria

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

Criterion A *Population Size reduction*

Assessment Outcome: Data Deficient

Justification: There are limited data on the above ground abundance of this species over the last 20+ years, with some subpopulations showing large decreases over this time. Based on comparisons between two years (2000 and 2020) that both had above average autumn/winter/spring rainfall, the total population of this species appears to have declined. However, given numbers of standing plants emerging from dormant tuberoids in this species vary from year to year (primarily due to rain and soil moisture), and the population underground is probably capable of persisting for some years without emergence, it is not possible to estimate the magnitude of change in the population size.

Criterion B *Geographic range*

Assessment Outcome: Met for Endangered under Criterion B1ab(iii,v)+2ab(iii,v)

Justification: The area of occupancy (AOO) is estimated to be 12 km^2, based on the species occupying three 2 x 2 km grid cells, the spatial scale of assessment recommended by IUCN (2024). The extent of occurrence (EOO) is estimated to be 310 km^2. The EOO is based on a minimum convex polygon enclosing all mapped occurrences of the species, the method of assessment recommended by IUCN (2024). *Caladenia callitrophila* meets the threshold for Endangered under both EOO (<5 000 km^2) and AOO (<500 km^2).

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

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

   Assessment Outcome: Met for severe fragmentation and number of locations (EN)

   Justification: *Caladenia callitrophila* is only known from three remnant patches of woodland. Prior to European settlement it is likely the species was more widespread. The land in between the surviving subpopulations is mostly cultivated farmland. The distance between the patches ranges from 16 to 50 km. The populations are isolated from one another and any chance of seed dispersal between subpopulations is very low.

   There are three locations. The number of locations is based on the threat of habitat clearing and degradation (due to herbivore pressure and forestry activities).

b) Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals.

   Assessment Outcome: Met for (iii) area, extent and/or quality of habitat; and (v) number of mature individuals.

   Justification: There is continuing decline in the number of plants and this species habitat. Based on comparisons between two years (2000 and 2020), that both had above average rainfall, the total population of this species appears to have declined, although it is not possible to estimate the magnitude of change in the population size. This decline is as a result of the ongoing threats of herbivore pressure, forestry activities, weed incursion and climate change.

c) Extreme fluctuations.

   Assessment Outcome: Data Deficient.

   Justification: Extreme fluctuations are not known for the species. There is variation in the number of plants that appear above ground, but the species does persist below ground between fruiting seasons.

Criterion C Small population size and decline

Assessment Outcome: Met for Critically Endangered under Criterion C2a(ii).

Justification:

It is difficult to estimate the current total population size of *Caladenia callitrophila* as plants seen flowering in one season that did not reemerge in the following season may not have died. Some may remain dormant underground. The proportion of plants emerging above ground from dormant tuberoids vary from year to year, primarily due to rain and soil moisture, and the population underground is probably capable of persisting for some years without emergence (Dixon and Tremblay 2009). However, given the season in 2020 was considered a year with favourable conditions for flowering, and only 183 plants were recorded, it is likely that the population size would be no more than 250, the threshold for Critically Endangered.

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: Based on comparisons between two years (2000 and 2020) that both had above average autumn/winter/spring rainfall, the total population of this species appears to have declined. However, given emergent numbers of this species fluctuates (primarily due to rain and soil moisture), and the population underground is probably capable of persisting for some years without emergence, it is not possible to estimate the magnitude of change in the population size.

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

Assessment Outcome: Met.

Justification: There is continued decline in the number of plants. Based on comparisons between two years (2000 and 2020), that both had above average rainfall, the total population of this species appears to have declined, although it is not possible to estimate the magnitude of change in the population size. This decline is as a result of the ongoing threats of herbivore pressure, forestry activities and weed incursion.

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 Endangered ≤250.

Justification: It is likely that the number of individuals in each subpopulation is small, however based on surveys after favourable conditions (in 2020), it is possible that one of the populations contains more than 50, but less than 250 individuals.

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

Assessment Outcome: Met for Critically Endangered.

Justification: During surveys after favourable conditions in 2020, one subpopulation contained approximately 94-98% of the total population.

b. Extreme fluctuations in the number of mature individuals.

Assessment Outcome: Data Deficient, but unlikely.

Justification: Extreme fluctuations are not known for the species. There is variation in the number of plants that appear above ground, but the species does persist below ground between fruiting seasons.

Criterion D Very small or restricted population

Assessment Outcome: Met for Endangered under Criterion D.

Justification: It is difficult to estimate the current total population size of *Caladenia callitrophila* as plants seen flowering in one season that did not reemerge in the following season are not necessarily dead. Some may remain dormant underground. Emergent numbers fluctuate primarily due to rain and soil moisture, and the population underground is probably capable of persisting for some years without emergence (Dixon and Tremblay 2009). However, given the season in 2020 was considered a year with good conditions for flowering, and only 183 plants were recorded, it is likely that the population size would be no more than 250.

Even though Criterion D is met for Endangered, Criterion D2 needs to be additionally and independently assessed, as it is relevant to Clause 4.7 of the NSW Biodiversity Conservation Regulation 2017. The highest threat category for Criterion D2 is Vulnerable.

D2. Population with a very restricted area of occupancy (typically less than 20 km^2) or number of locations (typically five or fewer) such that it is prone to the effects of human activities or stochastic events within a very short time period in an uncertain future and is thus capable of becoming CR or even EX in a very short time period.

Assessment Outcome: Met for Vulnerable.

Justification: The species has a very restricted AOO (12 km^2) and only three locations. Given the small area of habitat occupied and low population size, herbivory, forestry activities or other localised disturbances could drive the taxon to CR or EX in a very short time.

Criterion E Quantitative Analysis

Assessment Outcome: Data Deficient.

Justification: There have been no quantitative analyses for *Caladenia callitrophila*.

Conservation and Management Actions

This species is currently not listed on the NSW *Biodiversity Conservation Act 2016.* Following publication of a Final Determination by the NSW Threatened Species

Scientific Committee, a conservation project will be developed by the NSW Department of Planning and Environment under the Saving our Species (SoS) program. The conservation project will identify priority locations, critical threats and required management actions to secure the species in the wild for the next 100 years. The following is derived from the threat information and could be used to develop management actions.

Conservation and management priorities

Habitat loss, disturbance and modification

- Prevent clearing or disturbance of known or potential habitat.
- Ensure infrastructure (e.g., road and track) construction does not damage plants or key habitats.
- Ensure activities such as thinning and harvesting of forest products do not negatively impact on plants and their key habitats.
- Minimise/prevent habitat disturbance that may promote invasion or establishment of weeds or attract browsers.
- Ensure appropriate management of populations in areas of recreational use, including, where appropriate, fencing and/or signage to encourage users to keep to established tracks.

Fire

- Develop and implement a fire management strategy in consultation with relevant authorities and land managers. The strategy should define fire management measures, including fire season, intensity, frequency as well as mitigation of anticipated post-fire herbivory that would promote persistence of the species.

Impacts of grazing

- Where livestock grazing occurs in the area, ensure land owners and managers use an appropriate management regime and density that does not detrimentally affect this species. In particular, try to avoid grazing during flowering and seed maturation periods and after fire.

Browsing

- Limit impacts of native and feral herbivores that may consume plants/rhizomes. This may require exclusion fencing, depending on potential adverse disturbance impacts of installation of fencing into the habitat.

Invasive species

- Identify and remove weeds in the local area that may be a threat to the species, using appropriate methods.

Ex situ conservation

- Develop and implement a targeted seed or other germplasm collection program (e.g., *ex situ* seed banking, following best-practice guidelines (Martyn Yenson *et al.* 2021).
- If appropriate, investigate the feasibility of establishing translocated populations from *in vitro* material that will improve the conservation outlook of the species. Translocations should be conducted in accordance with best practice guidelines and procedures (refer to Commander *et al*. 2018), including monitoring translocated populations through to recruitment to ensure they are viable.

Restoration actions

- Restore degraded habitat using bush regeneration techniques.

Stakeholders

- Inform landowners and managers of sites where there are known populations and consult with these groups regarding options for conservation management and protection of the species.
- Collaborate with the Forestry Corporation of NSW on management actions.
- Ensure land owners and managers are aware of the vulnerability of the species to herbicide or pesticide spray drift and fertiliser runoff.
- Raise awareness of the problems associated with illegal collection of specimens or flowers while maintaining the confidentiality of the locations.

Survey and Monitoring priorities

- Monitor all populations to determine trends in mortality and recruitment and to improve understanding of the species population numbers and detection rates under varying environmental conditions, levels of hybridization and seed set. This requires the establishment of permanent plots and the recording of the location of individuals so that mortality and recruitment can be followed over time.
- Document threats to plants, loss of plants (plant survivorship) and recruitment of any new plants in relation to habitat disturbance or other factors.
- Monitor for habitat degradation or other site disturbances.
- Monitor for any browsing impacts when plants are above ground.
- Undertake survey work in suitable habitat and potential habitat to locate any additional populations and to more precisely assess population size and distribution.

Information and Research priorities

- Conduct research into the life history and ecology of the species. This includes continued monitoring to determine above ground flowering, plant survival and longevity, pollinators, recruitment, and seed dispersal.
- Investigate options for enhancing gene flow through managed cross pollination and the establishment of additional populations.
- Prepare an ex-situ conservation strategy that involves germplasm storage and germination. Re-introduction could be considered in suitable habitat.
- Establish experimental exclosures to examine the influence of vertebrate herbivores on the species.
- Undertake weed removal experiments to examine the influence of weeds on the populations.
- Investigate seed viability, germination, dormancy and longevity (in the wild and in storage).
- Conduct management trials of thinning and fire to assess impacts to the species.

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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:

Caladenia callitrophila was found to be Critically Endangered under 4.4(a)(e i,ii B).

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

(1) - The species has undergone or is likely to undergo within a time frame appropriate to the life cycle and habitat characteristics of the taxon:			
	(a)	for critically endangered species	a very large reduction in population size, or
	(b)	for endangered species	a large reduction in population size, or
	(c)	for vulnerable species	a moderate reduction in population size.
(2) - The determination of that criteria is to be based on any of the following:			
	(a)	direct observation,	

	(b)	an index of abundance appropriate to the taxon,
	(c)	a decline in the geographic distribution or habitat quality,
	(d)	the actual or potential levels of exploitation of the species,
	(e)	the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.

Clause 4.3 - Restricted geographic distribution of species and other conditions

(Equivalent to IUCN criterion B)
Assessment Outcome: Endangered under Clause 4.3(b)(d)(e i,iii)

The geographic distribution of the species is:			
	(a)	for critically endangered species	very highly restricted, or
	(b)	for endangered species	highly restricted, or
	(c)	for vulnerable species	moderately restricted,
and at least 2 of the following 3 conditions apply:			
	(d)	the population or habitat of the species is severely fragmented or nearly all the mature individuals of the species occur within a small number of locations,	
	(e)	there is a projected or continuing decline in any of the following:	
		(i)	an index of abundance appropriate to the taxon,
		(ii)	the geographic distribution of the species,
		(iii)	habitat area, extent or quality,
		(iv)	the number of locations in which the species occurs or of populations of the species,
	(f)	extreme fluctuations occur in any of the following:	
		(i)	an index of abundance appropriate to the taxon,
		(ii)	the geographic distribution of the species,
		(iii)	the number of locations in which the species occur or of populations of the species.

Clause 4.4 - Low numbers of mature individuals of species and other conditions
(Equivalent to IUCN criterion C)
Assessment Outcome: Critically Endangered under Clause 4.4(a)(e i,ii B)

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: Endangered

The total number of mature individuals of the species is:			
	(a)	for critically endangered species	extremely low, or
	(b)	for endangered species	very low, or
	(c)	for vulnerable species	low.

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

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

Clause 4.7 - Very highly restricted geographic distribution of species– vulnerable species
(Equivalent to IUCN criterion D2)
Assessment Outcome: Vulnerable

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.

Professor Caroline Gross
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