



Conservation Advice for *Microtis angusii* (Angus's Onion Orchid)

In effect under the *Environment Protection and Biodiversity Conservation Act 1999* from 29 September 2021.

This document provides a foundation for conservation action and further planning.



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Conservation status

Microtis angusii (Angus's Onion Orchid) is listed in the Endangered category of the threatened species list under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) (EPBC Act) effective from 16 July 2000. The species is eligible for listing because prior to the EPBC Act, it was listed as Endangered under the *Endangered Species Protection Act 1992* (Cwlth).

The main factors that make the species eligible for listing in the Endangered category are small population size, very restricted distribution and population declines due to habitat loss, disturbance or modification, invasive species and climate change.

Species can also be listed as threatened under state and territory legislation. For information on the current listing status of this species under relevant state or territory legislation, see the Species Profile and Threat Database.

Species information

Taxonomy

Conventionally accepted as *Microtis angusii* Jones (1996), however, 220 specimens collected from Ingleside, New South Wales (NSW), which appeared to be morphologically similar to *Microtis unifolia* (Common Onion Orchid), were confirmed by genetic analysis to be *Microtis angusii* (Angus's Onion Orchid; SMEC 2017). Additionally, samples thought to be the Common Onion Orchid from other areas of NSW are genetically similar to Angus's Onion Orchid (ELA 2016). Further genetic studies are required to resolve this taxonomic uncertainty (RBG 2015; DPIE 2021).

Description

Angus's Onion Orchid is a terrestrial orchid, which grows to 25–60 cm tall. Leaves are 40–140 cm long and 4–8 mm wide, green, linear, hollow cylindrical and tapering in shape. Leaves are usually much longer than flowering stems, which emerge from an aperture in the leaves, approximately 12–20 cm above the soil. Flowering stems are 8–80 cm long and host 20–60 small green flowers. Flowers are 2.5 mm in diameter, hood-shaped with a short point on the dorsal sepal and a large labellum and lateral sepals. Petals are much smaller. The labellum has a gland-like callus on the apex, a single basal callus gland and a crisped edge to the labellum which is tapered and lacks an apical notch. Fruits are 5–6 mm long and 3.5–4 mm wide, small, ellipsoid-shaped and contain many small seeds. This description is drawn from Jones (1996) and OEH (2019a).

Angus's Onion Orchid can be distinguished from *Microtis parviflora* (Slender Onion Orchid), and *Microtis rara* (Scented Onion Orchid), by more robust habit, larger size and floral characteristics (DECCW 2010). However, distinguishing Angus's Onion Orchid from *Microtis unifolia* (Common Onion Orchid) is more challenging, as the Common Onion Orchid varies in flower morphology and often appears morphologically similar to Angus's Onion Orchid (NSW Flora Online 2020).

Distribution

Known subpopulations

Angus's Onion Orchid is known to occur in the Pittwater sub-region of the Sydney Basin Interim Biogeographic Regionalisation of Australia (IBRA7; OEH 2019b). In this sub-region, Angus's Onion Orchid is known to be associated with Sydney coastal dry sclerophyll forests, Sydney coastal heaths and highly disturbed areas with no or limited native vegetation (OEH 2019b).

In 1987, the type subpopulation (opposite Kimbriki Resource Recovery Centre) was identified within a road reserve beside Mona Vale Road at Ingleside, NSW (Jones 1996). The plants occur along a narrow band, approximately 10 m wide and 50 m long, in 16 discreet clusters of five to 80 individuals (DECCW 2010). In 2014, three peripheral subpopulations were identified along the northern side of Mona Vale Road, at the western end (Terrey Hills) and eastern sections (Tumburra Road to the Baha'i Temple; RBG 2015). The peripheral subpopulations vary in size, from one to 300 observed individuals, and are genetically more similar to each other than to the type subpopulation (RBG 2015). All subpopulations occur in exotic grassland roadside verge habitat, with the type subpopulation occurring on imported fill material (Jones 1996; RBG 2015). The type subpopulation has been surveyed regularly since 1998, while other subpopulations have been surveyed with variable effort since 2014 (Table 1). Population size is considered to fluctuate among years. However, in 2014, population size was estimated as 1300 to 1500 individuals, with ninety percent of individuals in the type subpopulation (Table 1; RBG 2015).

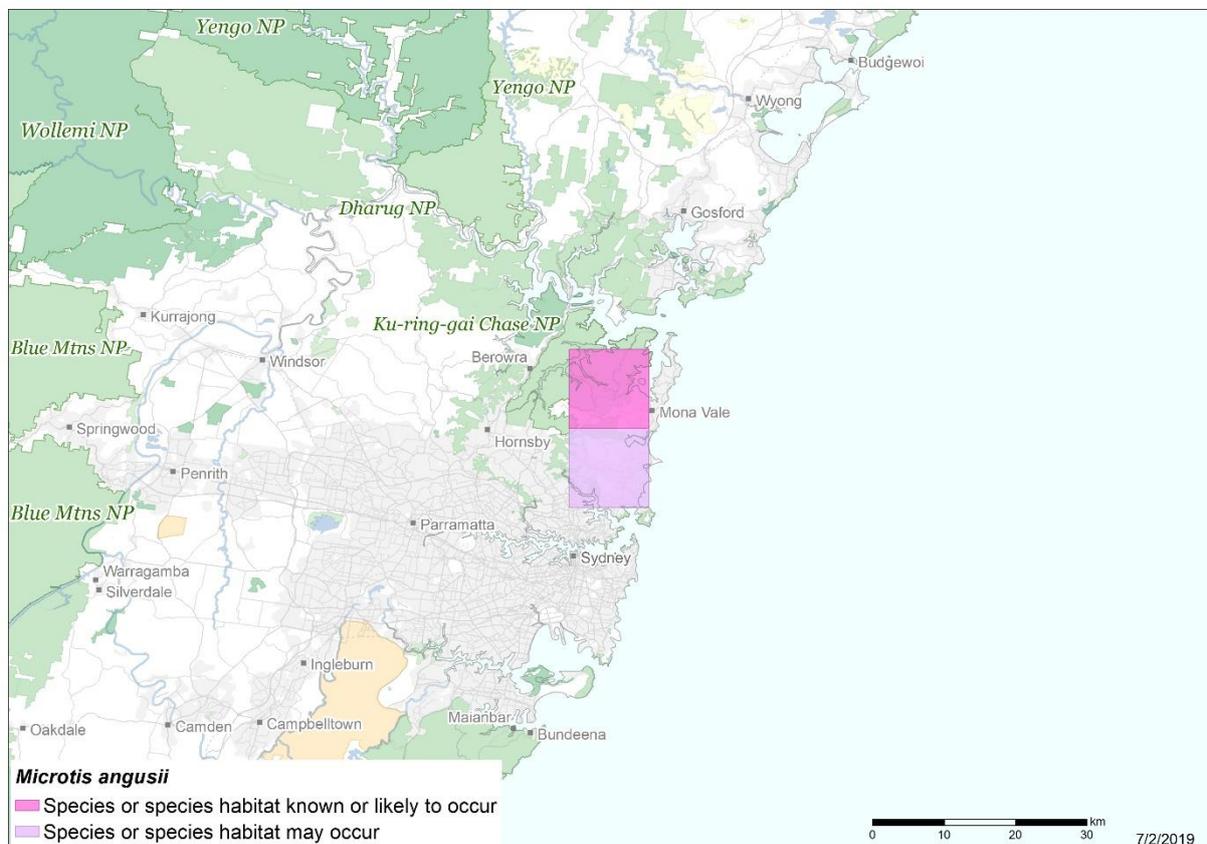
Table 1 Summary of Angus's Onion Orchid population in Warringah Local Government Area, based on DECCW (2010), Smith & Smith (2011), Ecosure (2015) and RBG (2015).

Date surveyed		Total individuals	Comments	Source
1998	September	336	Seedlings and adults, some at pre-flowering stage.	DECCW (2010)
	October	117	Sixty-seven in flower, many withered, spikes chewed.	
	November	0	Assumed to be tubers underground.	
1999	September	336	Seedlings and adults, 34 in flower or fruit.	DECCW (2010)
	October	214	Eighteen in flower or fruit.	
2000	October	358	After site weeded, 150 in flower, several new colonies, plants appeared more robust.	DECCW (2010)
2001	September	503	Dry flowering season.	DECCW (2010)
	October	120	-	
2002	September	656	-	DECCW (2010)
2003-06	-	<12	Low numbers may have been due to dry conditions and a decrease in site maintenance.	DECCW (2010)
2007	-	0	Weeds at site mistakenly sprayed with herbicide.	DECCW (2010)
2008	September	67	Fourteen in flower, seeds collected from 10 plants.	DECCW (2010)
2009	October	79	-	DECCW (2010)
2010	September	294	-	DECCW (2010)
2010	October	281	-	DECCW (2010)
2011	June-August	-	Survey conducted in June-August, before flowering season, but leaves noted in two sites where previously recorded.	Smith & Smith (2011)
2013-14	-	10-562	Plants in 15 sites along Mona Vale Road between McCarrs Road, Terrey Hills and Powder Works Road.	Ecosure (2015)
2014	-	1300-1500	1240 in the type subpopulation between McCarrs Road, Terrey Hills and Powder Works Road.	RBG (2015)

Unconfirmed sightings and misidentifications

In 1983, Angus's Onion Orchid was possibly sighted at Bantry Bay Oval at Seaforth, approximately 10 km from the known location, but no collection was made and the record has never been confirmed (DECCW 2010). In 1998, specimens thought to be Angus's Onion Orchid were collected from Sunny Corner State Forest, near Bathurst, approximately 100 km west of Sydney, however, this collection has since been confirmed as genetically distinct and may be a subspecies (Peakall 2001, 2002; OEH 2019a). In 1999, specimens thought to be Angus's Onion Orchid were collected from Chain Valley Bay, near Wyong, approximately 90 km north of Sydney, however, this collection has since been confirmed as a different *Microtis* species (DECCW 2010). Other collections that share genetic relationships to Angus's Onion Orchid have been found from Helensburgh through the Central Coast, to the upper Blue Mountains, Hunter Valley and as far north as Armidale (DPIE 2021).

Map 1 Indicative distribution of Angus's Onion Orchid



Source: Species distribution data Species of National Environmental Significance_database, Base map Geoscience Australia
Caveat: The information presented in this map has been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything containing herein.

Species distribution mapping: The species distribution mapping categories are indicative only and aim to capture (a) the specific habitat type or geographic feature that represents to recent observed locations of the species (known to occur) or preferred habitat occurring in close proximity to these locations (likely to occur); and (b) the broad environmental envelope or geographic region that encompasses all areas that could provide habitat for the species (may occur). These presence categories are created using an extensive database of species observations records, national and regional-scale environmental data, environmental modelling techniques and documented scientific research.

Cultural and community significance

Angus's Onion Orchid occurs on lands traditionally owned by the Guringai people. Orchids are a culturally significant plants for Indigenous peoples across Australia (Flood 1980; Australian National Botanic Gardens 2007). Orchid Tubers of other orchid species have been documented as bush tucker and can be roasted (Flood 1980; Australian National Botanic Gardens 2007).

Relevant biology and ecology

Habitat ecology

Angus's Onion Orchid is known to be associated with the following vegetation formations: dry sclerophyll forests (shrubby sub-formation), wet sclerophyll forests (grassy sub-formation), heathlands, and highly disturbed areas with no or limited native vegetation (including road verges, table drains, road embankments and ploughed paddocks; OEH 2019b). The type subpopulation occurs in a highly disturbed site with imported soil, which has been cleared of native vegetation, and used as a soil depot and vehicle parking site in the past (DECCW 2010). The dominant species at this site are introduced weeds, Coolatai Grass (*Hyparrhenia hirta*) and *Acacia saligna* (Golden-wreath Wattle; DECCW 2010).

The soil at this site is imported (iron-rich lateritic soil) and is naturally restricted to ridgetops in Duffy's Forest, Terrey Hills, Ingleside and Belrose areas (DECCW 2010). These soils support the Duffy's Forest Ecological Community, which is distinct from the surrounding vegetation on Hawkesbury Sandstone soils and listed as an Endangered Ecological Community under the *Threatened Species Conservation Act 1995* in NSW (OEH 2011). Duffy's Forest Ecological Community is characterised by open forest or woodland, dominated by *Corymbia gummifera* (Red Bloodwood), *Eucalyptus sieberi* (Black Ash), *Angophora costata* (Smooth-barked Apple) and frequently *Eucalyptus capitellata* (Brown Stringybark) or *Eucalyptus oblonga* (White Stringybark; OEH 2017). It is possible that Angus's Onion Orchid may be found at other sites that support this ecological community (Smith & Smith 1997).

Life cycle and reproductive ecology

Angus's Onion Orchid occurs above ground from March to December, producing leaves and flowering stems in late winter and spring, and flowers from May to October (Jones 1996). In *Microtis* species, the flowers at the bottom of the inflorescence mature before those at the top, so seeds may be released at the bottom before flowers have opened at the top (Bates 1986). The above-ground components of the plant wither by early summer, however the plants persist as subterranean tubers throughout the rest of the year (DECCW 2010).

Most *Microtis* species reproduce vegetatively, that is daughter tubers are formed from the main, parent tuber (Peakall & Beattie 1989), and can produce huge clonal colonies (Bates 1986). *Microtis* tubers sprout in autumn, with slow growth in winter and faster growth in spring (Bates 1986). The Slender Onion Orchid produces one to three daughter tuberoids each season, up to 1 cm from the parent tuber (Peakall & Beattie 1991) and in cultivation can have daughter tuberoids on stolons up to 10 cm from the parent (DPIE 2021). Late in the season, tuberoids separate from the parent tuber through breakdown of the stolon, so clones consist of individual unconnected ramets (Peakall & Beattie 1991). Clones rarely exceed 100 cm in diameter and typically consist of 10 to 20 individuals intermingled with other clones (Peakall & Beattie 1991).

Microtis species can also reproduce from seeds, using insects (ants, beetles, small ichneumon wasps) as pollen vectors, self-fertilisation of flowers (autogamy) and seed production without pollination (apomixis; Bates 1986; Peakall & Beattie 1989). The seed is wind-dispersed and not persistent in the soil, so colonisation can only occur from founder events by in-blown seed (DPIE 2021). For this reason, a source population of adults would exist and dispersal into the disturbed site occurs when the seed is released from the fruit (DPIE 2021). Most orchid seeds will not germinate in the absence of the appropriate mycorrhizal fungi. Angus's Onion Orchid may require a specific fungus for seed germination, although most *Microtis* species appear to be generalists with a loose mycorrhizal association (DECCW 2010). For Angus's Onion Orchid, seed viability, factors triggering seedling recruitment and the importance of seedling recruitment as a reproductive strategy are unclear (DECCW 2010).

Fire ecology

Microtis species flower prolifically after fire, suggesting that flowering is promoted by fire-related cues, such as an increase in light or levels of phosphorus and potassium in the soil (Bates 1986) or the presence of soluble chemicals in the ash and smoke (DPIE 2021). The type locality was burnt in 1979, 1989 and 1994, and prolific flowering of Angus's Onion Orchid was observed following the 1994 fire (DECCW 2010). Experiments are required to further understand the fire response of Angus's Onion Orchid, including the effect of fire season (DECCW 2010).

Habitat critical to the survival

Due to the species eligibility for listing (highly restricted range and/or severe fragmentation and/or small population size), all habitat is considered critical to the survival of the species.

No Critical Habitat as defined under section 207A of the EPBC Act has been identified or included in the Register of Critical Habitat.

Important populations

In this section, the word population is used to refer to subpopulation, in keeping with the terminology used in the EPBC Act and state/territory environmental legislation.

There is sufficient evidence through the species eligibility for listing, to declare all populations/the national population of this species under particular pressure of survival and which therefore require protection to support the recovery of the species.

Threats

Angus's Onion Orchid is threatened by habitat loss, disturbance or modification, invasive species, climate change and disease (Table 2). Angus's Onion Orchid is highly susceptible to extinction via stochastic processes, due to its small population size and restricted distribution (OEH 2019a).

Table 2 Threats impacting Angus's Onion Orchid

Threat	Status and severity ^a	Evidence
Habitat loss, disturbance or modification		
Road expansion and maintenance	<ul style="list-style-type: none"> • Timing: current • Confidence: known • Consequence: catastrophic • Trend: increasing • Extent: across the entire range 	<p>All known subpopulations occur in road reserves along Mona Vale Road (DECCW 2010; RBG 2015) and as such, mechanical damage to the road reserves through the use, maintenance and/or widening of the road is a significant threat to the species.</p> <p>Approximately 3.4 km of Mona Vale Road, between McCarrs Creek Road, Terrey Hills and Powder Works Road, Ingleside, will be upgraded from two to four lanes (RMS 2020). All known subpopulations occur in road reserves along this segment of Mona Vale Road (DECCW 2010; RBG 2015). Construction commenced in January 2019 and is expected to be completed in 2022 (RMS 2020). Construction is likely to remove Angus's Onion Orchid individuals and their habitat (RBG 2015; SMEC & RMS 2017; OEH 2019a). Road expansion will also intensify the effects of road proximity, such as run-off and road maintenance disturbance (OEH 2019a). A translocation program has been proposed to excavate plants proposed for disturbance and reintroduce them to the type subpopulation (SMEC & RMS 2017), noting that this may result in genetic mixing, which could threaten the species via unknown inbreeding and outbreeding effects.</p> <p>Angus's Onion Orchid may also be damaged during construction of drainage channels, grading and other road maintenance activities (OEH 2019a).</p>
Habitat degradation due to uncontrolled site access	<ul style="list-style-type: none"> • Timing: current • Confidence: known • Consequence: major • Trend: unknown • Extent: across the entire range 	<p>All known subpopulations occur in road reserves along Mona Vale Road (DECCW 2010; RBG 2015). Uncontrolled access to the type locality has led to habitat degradation caused by rubbish and soil dumping, and soil compaction (DECCW 2010). In 1989, during construction of a sewerage pipe, Sydney Water dumped 10 tonnes of sand on top of the type subpopulation (DECCW 2010). When alerted to the presence of the plants, they remediated the site by bulldozing the sand and hosing the site with a high-pressure hose (DECCW 2010). Telecom (now Telstra) then used the site as a portable toilet parking area (DECCW 2010). In 1995, the Australian Gas Light Company (AGL) disturbed the site while putting in a nearby pipeline (DECCW 2010). Upon request, AGL constructed a koppers log fence to keep vehicles and equipment off the site (DECCW 2010). This has mainly stopped vehicles from driving into the site and allowed for the recovery of the type subpopulation (Table 1; DECCW 2010). However, people and vehicles (at high speed) may still enter the site, so the fence is only partly effective (DECCW 2010).</p>

Threat	Status and severity ^a	Evidence
Illegal collection	<ul style="list-style-type: none"> • Timing: current • Confidence: suspected • Consequence: moderate • Trend: unknown • Extent: across the entire range 	<p>As a rare orchid, Angus's Onion Orchid is a possible target for unscrupulous amateur orchid enthusiasts and professional orchid propagators (DECCW 2010). It is an offence under the TSC Act (1995) to collect an endangered plant species without a licence (DECCW 2010). No level of unauthorised collection could be sustained by the population (DECCW 2010; OEH 2019a).</p>
Climate change		
Inappropriate fire regimes	<ul style="list-style-type: none"> • Timing: current • Confidence: known • Consequence: major • Trend: increasing • Extent: across the entire range 	<p>Although flowering in <i>Microtis</i> species may be triggered by fire-related cues (Bates 1986), some terrestrial orchids with shallow tubers may be killed by fires that generate extreme soil heating (Duncan 2012). Furthermore, the growth season for many orchids is in autumn/winter when the starch reserves from tubers are utilised to grow aerial shoots. If fire occurs during this time, it may destroy aerial shoots before tuber reserves are fully replenished, leaving the plant with insufficient resources to recover from fire (Jasinge et al. 2018a, b). Ensure that prescribed fires occur only within the habitat during the dormant phase of the threatened species life cycle.</p> <p>Additionally, intense rainfall events after fires may lead to extensive localised erosion or sedimentation, which may exhume or bury tubers (Tulau 2015).</p> <p>The response of Angus's Onion Orchid to fire is not well understood. However, there is high potential for the species to be adversely affected by bushfires (DECCW 2010). The small population size and restricted distribution of Angus's Onion Orchid may also increase population extinction, following stochastic events (OEH 2019a).</p> <p>Catastrophic bushfires are increasingly likely to reoccur due to climate change. Initial estimates suggest the 2019-20 bushfires overlapped with less than one percent of Angus's Onion Orchid distribution, so the species has not been identified as a high priority species for recovery actions (Gallagher 2020).</p>
Increased temperature and change to precipitation patterns	<ul style="list-style-type: none"> • Status: current • Confidence: known • Consequence: moderate • Trend: increasing • Extent: across the entire range 	<p>The CSIRO & Bureau of Meteorology (2015) predict eastern Australia will experience decreased rainfall, increased average temperatures and frequency of droughts. Ongoing droughts in south-eastern Australia have contributed to reduced flowering rates of terrestrial orchids, including Angus's Onion Orchid (Table 1; Duncan et al. 2009; DECCW 2010), which may reduce reproductive success (Faast & Facelli 2007). Disruptions to flowering processes may also lead to decoupling of orchid-pollinator interactions and increased hybridisation among orchid species, which may also reduce reproductive success (Hoffmann et al. 2019). The small population size and restricted distribution of Angus's Onion Orchid may increase the likelihood of extinction, following stochastic events, such as drought (OEH 2019a).</p> <p>Additionally, increased temperature and changes to precipitation patterns may facilitate weed invasion, as weeds are expected to respond faster to climate change than native plants (Scott et al. 2014).</p>

Threat	Status and severity ^a	Evidence
Invasive species		
Grazing by introduced species	<ul style="list-style-type: none"> • Status: current • Confidence: known • Consequence: moderate • Trend: decreasing • Extent: across the entire range 	<p>Herbivores can remove or trample orchids, which may prevent flowering and photosynthesis, ultimately exhausting the energy reserves of tubers (Croft et al. 1999). The type subpopulation of Angus's Onion Orchid was grazed almost to ground level by Rabbits (<i>Oryctolagus cuniculus</i>) and unmanaged Goats (<i>Capra hircus</i>) in the 1999 flowering season (DECCW 2010). The unmanaged Goats are believed to have escaped from a nearby goat farm and have since been captured (DECCW 2010), although future incursions could occur.</p> <p>Rabbits and unmanaged Goats are found in all states and territories of Australia and have been listed as Key Threatening Processes (KTPs) under the EPBC Act (DEWHA 2008; DOEE 2016). Unmanaged Goats are no longer considered a threat to Angus's Onion Orchid, but they are likely to re-emerge as a threat, if reintroduced to the area. Grazing by Rabbits remains a threat to many subpopulations of Angus's Onion Orchid (DECCW 2010). If grazing continues, Angus's Onion Orchid may fail to flower and set seed for the season, which may affect long-term reproductive success (DECCW 2010).</p>
Weed invasion	<ul style="list-style-type: none"> • Timing: current • Confidence: known • Consequence: moderate • Trend: unknown • Extent: across the entire range 	<p>Weeds can invade, establish in and outcompete native vegetation, particularly following disturbance events, such as bushfires (Hobbs 1991; Hobbs 2002; Brown et al. 2016). In particular, grassy weeds can increase fuel load and alter fire regimes (Milberg & Lamont 1995; Setterfield et al. 2013). These altered fire regimes can create conditions that are detrimental to the maintenance of native species and favourable to the establishment and spread of weeds (D'Antonio & Vitousek 1992; Grigulis et al. 2005).</p> <p>The invasion of native plant communities by exotic perennial grasses was listed as a KTP under the Threatened Species Conservation Act in NSW (NSW Scientific Committee 2003). Introduced weeds, including Coolatai Grass and Golden-wreath Wattle, dominate the type locality of Angus's Onion Orchid (DECCW 2010). Other subpopulations of Angus's Onion Orchid also occur in road reserves (RBG 2015). Accordingly, weed invasion is considered a current threat to all Angus's Onion Orchid subpopulations.</p> <p>Although weed management practices are in place to reduce the threat of weeds (DECCW 2010), some practices may also threaten Angus's Onion Orchid. In 2007, weeds at the type locality were mistakenly sprayed with herbicide (DECCW 2010). Although no plants were recorded following the incident in 2007, 67 individuals were recorded in 2008, suggesting that some individuals survived (DECCW 2010). As a result of this spraying event, stricter reporting guidelines and protection procedures have been implemented (DECCW 2010).</p>

Threat	Status and severity ^a	Evidence
Disease		
Dieback caused by <i>Phytophthora cinnamomi</i>	<ul style="list-style-type: none"> • Timing: future • Confidence: suspected • Consequence: major • Trend: unknown • Extent: across the entire range 	<p><i>Phytophthora cinnamomi</i> is an introduced soil-borne pathogen, which infects a large range of plant species and may contribute to plant death, when other stresses present, such as waterlogging, drought and bushfire (DOEE 2018). <i>Phytophthora cinnamomi</i> can disperse in water flowing from roots of infected plants to roots of healthy plants and mud clinging to vehicles, animals and walkers (DOEE 2018). Dieback caused by <i>P. cinnamomi</i> is listed as a KTP under the EPBC Act (DOEE 2018). The disease has been detected in Ku-ring-gai Chase National Park and Garigal National Park, which border Mona Vale Road to the north and south (Suddaby 2008; ALA 2020).</p> <p>The susceptibility of Angus's Onion Orchid to <i>P. cinnamomi</i> is unknown. However, 32 percent of threatened South Australian plants, listed by Velzeboer et al. (2005) as potentially vulnerable to infection by <i>P. cinnamomi</i>, were orchids. Additionally, orchids may be indirectly affected by <i>P. cinnamomi</i>. Endangered orchids growing in close proximity to <i>Xanthorrhoea</i> (Grass Trees) were more vulnerable to herbivory following dieback of Grass Trees caused by <i>P. cinnamomi</i> (Petit & Dickson 2005). Angus's Onion Orchid may be severely impacted if <i>P. cinnamomi</i> spreads to known subpopulations. The small population size and restricted distribution of Angus's Onion Orchid may increase the likelihood of extinction, following stochastic events, such as disease (OEH 2019a).</p>

Timing—identify the temporal nature of the threat;

Confidence—identify the extent to which we have confidence about the impact of the threat on the species;

Consequence—identify the severity of the threat;

Trend—identify the extent to which it will continue to operate on the species;

Extent—identify its spatial content in terms of the range of the species.

Each threat has been described in Table 2 in terms of the extent that it is operating on the species. The risk matrix (Table 3) provides a visual depiction of the level of risk being imposed by a threat and supports the prioritisation of subsequent management and conservation actions. In preparing a risk matrix, several factors have been taken into consideration, they are: the life stage they affect; the duration of the impact; and the efficacy of current management regimes, assuming that management will continue to be applied appropriately. The risk matrix and ranking of threats has been developed in consultation with experts using available literature.

Table 3 Angus's Onion Orchid risk matrix

Likelihood	Consequences				
	Not significant	Minor	Moderate	Major	Catastrophic
Almost certain	Low risk	Moderate risk	Very high risk Weed invasion Increased temperature and change to precipitation patterns	Very high risk Inappropriate fire regimes	Very high risk Road expansion and maintenance
Likely	Low risk	Moderate risk	High risk Grazing by introduced species	Very high risk Habitat degradation due to uncontrolled site access	Very high risk
Possible	Low risk	Moderate risk	High risk Illegal collection	Very high risk Dieback caused by <i>P. cinnamomi</i>	Very high risk
Unlikely	Low risk	Low risk	Moderate risk	High risk	Very high risk
Unknown	Low risk	Low risk	Moderate risk	High risk	Very high risk

Priority actions have then been developed to manage the threat particularly where the risk was deemed to be 'very high' or 'high'.

Conservation and recovery actions

Primary conservation objective

By 2030, the population of Angus's Onion Orchid will have increased in abundance and viable populations are sustained in disease-free habitats.

Conservation and management priorities

Habitat loss, disturbance and modifications

- Minimise the loss and fragmentation of habitat due to road development, by promoting impact avoidance, providing advice to planning authorities, and monitoring disturbance impacts.
- Ensure local governments, relevant state agencies and utility service providers have access to adequate distribution information and use best practice methods for roadside and utility corridor maintenance to protect the species and its habitat.
- Prevent access of recreational users to subpopulations, by maintaining the existing fence around the western patch and installing a similar fence around the eastern patch.
- Ensure that information (especially location details) and access is managed securely to minimise the risk of illegal collection.

Invasive species (including threats from grazing, trampling, predation)

- Implement weed management actions in consultation with land managers and community groups, using hand weeding, slashing or localised application of herbicide during the appropriate season to minimise the effect of herbicide on Angus's Onion Orchid.

Fire and climate change

- Provide maps of known occurrences to local and state Rural Fire Services and seek inclusion of mitigation measures in bushfire risk management plan/s, risk register and/or operation maps.
- Develop and implement an evidence-based fire management strategy that optimises the survival of Angus's Onion Orchid during planned burns and bushfires.
- Ensure that prescribed fires occur only within the habitat during the dormant phase of the threatened species life cycle.
- Avoid any use of managed fire research and other activities that impact upon the persistence of the population unless there is evidence to show the impact would be a positive and enduring effect on the species' persistence.
- Understand and ameliorate the effects of climate change on the species.

Disease

- Determine the susceptibility of Angus's Onion Orchid to *P. cinnamomi*.
- Implement a *P. cinnamomi* management plan to ensure it is not introduced into known subpopulations of Angus's Onion Orchid (xDOEE 2018). Ensure appropriate hygiene protocols are adhered to when entering or exiting known subpopulations, such as those outlined in Podger et al. (2001).

Breeding, seed collection, propagation and other ex situ recovery action

- Identify a suitable location for translocation and establishment of additional wild populations, i.e. suitable habitat/geology, vegetation, secure tenure and minimal threats. Establish a new population at the site from either existing ex-situ material, e.g. seed, or material collected from other extant populations, according to Commander et al. (2018). Continue maintenance of the population until it is viable and able to persist for long periods without intensive management.
- Avoid mixing genetic material from different subpopulations until the genetic structure and mating systems of the species is understood

Stakeholder engagement/community engagement

- Engage and involve Traditional Owners in conservation actions, including the implementation of Indigenous fire management and other survey, monitoring and management actions.
- Liaise with the local community and government agencies to ensure that up-to-date population data and scientific knowledge inform the implementation of conservation actions for this species.
- Contribute to impact assessment and planning processes on measures to protect Angus's Onion Orchid and its habitat.
- Raise awareness of Angus's Onion Orchid within the local community. The importance of biodiversity conservation and the protection of the Angus's Onion Orchid could be promoted to the public through poster displays and the development of an information sheet.
- Provide signage to encourage the public to keep to established paths and to not collect orchids or damage plants in any way, and to inform workers of the presence of a significant asset that must not be disturbed.

Survey and monitoring priorities

- Undertake annual monitoring of known subpopulations and potential habitat during the flowering season (September to October).
- Undertake annual monitoring of habitat condition/degradation (including impacts from weed invasion, introduced species and diseases), population stability (expansion or decline), pollination activity, seed production, recruitment and longevity.
- Monitor the size, structure and reproductive status of populations at different stages in the fire cycle, taking opportunities to monitor after planned and unplanned fires (where they occur) and improve understanding of the fire response of the species.

Information and research priorities

- Resolve taxonomic uncertainties between Angus's Onion Orchid and the Common Onion Orchid and establish which subpopulations fall within the circumscription of *Microtis angusii*.
- Investigate options for linking, enhancing or establishing additional populations.
- Survey suitable habitat and potential habitat to locate any additional populations/occurrences/remnants to assess population size and distribution more precisely.
- Investigate the ecological requirements of Angus's Onion Orchid, that are relevant to persistence:
 - population genetic structure, levels of genetic diversity and minimum viable population size,
 - seed production, seedling establishment and vegetative recruitment dynamics and the role of fire, competition, rainfall and grazing in germination and recruitment,
 - Effect of climate change on reproductive strategies, phenology and seasonal growth, and
 - habitat association, pollinator biology and requirements.
 - Undertake experiments to improving understanding of how populations of the species respond to variations in fire season in terms of survival, growth and reproduction (flowering, seedling recruitment, vegetative reproduction)

Links to relevant implementation documents

Draft Survey Guidelines for Australia's Threatened Orchids (2013)

NSW Saving our Species Strategy - Angus's Onion Orchid (*Microtis angusii*)

Recovery Plan for *Microtis angusii* (2010)

Threat Abatement Plan for Competition and Land Degradation by Rabbits (2016)

Threat Abatement Plan for Competition and Land Degradation by Unmanaged Goats (2008)

Threat Abatement Plan for Disease in Natural Ecosystems caused by *Phytophthora cinnamomi* (2018)

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