Conservation Assessment of *Eucalyptus oresbia* J.T.Hunter & J.J.Bruhl (Myrtaceae)

Gavin P. Phillips 21/11/2024
Conservation Policy and Programs Division
NSW Department of Climate Change, Energy, the Environment and Water

***Eucalyptus oresbia* J.T.Hunter & J.J.Bruhl (Myrtaceae)**
Distribution: Endemic to NSW
Current EPBC Act Status: Not listed
Current NSW BC Act Status: Vulnerable

Proposed listing on NSW BC Act: Endangered

Reason for change: Non-genuine change based on improved knowledge of the species' distribution and threats.

Summary of Conservation Assessment

Eucalyptus oresbia was found to be eligible for listing as Endangered under IUCN Criteria A2c; B1ab(iii,v)+2ab(iii,v).

The main reasons for this species being eligible are: 1) the species is suspected to have undergone a large population reduction of >50% over a three-generation period of 306 years due to historical clearing for agriculture and pine plantations; 2) the species has a highly restricted area of occupancy (44 km^2) and extent of occurrence (420 km^2); 3) the species is known from 3–4 threat defined locations; and 4) continuing decline is inferred in the area, extent and quality of habitat and the number of mature individuals due to conflicting land uses such as plantation forestry and agriculture in prime *E. oresbia* habitat, adverse fire regimes, the maintenance of tracks and trails, and the invasion of weeds such as blackberry and radiata pine.

Eucalyptus oresbia at Hanging Rock, near the type locality. Image: Gavin Phillips

Description and Taxonomy

Eucalyptus oresbia (small-fruited mountain gum) is a species accepted in NSW (PlantNET 2024) in family Myrtaceae that lies phylogenetically within the blue gum group of eucalypts (*Eucalyptus* subgenus *Symphyomyrtus*, section *Maidenaria*, series *Globulares*; Nicolle 2024). It is described by Hunter and Bruhl (1999) as a "Tree to 30 m tall. Bark smooth white, yellow or cream, rarely grey, sock absent or rarely present on younger trees to 1 m. Juvenile stems and branchlets usually strongly quadrangular. Leaves: seedling leaves ovate to elliptic, 3–10 cm long, 1–3.5 cm wide, plane, opposite, apex acute to obtuse, base rounded or ± caudate, petiolate at first and then a few pairs sessile, concolorous; intermediate leaves ovate to lanceolate, 12–18 cm long, 3–6.5 cm wide, sub-opposite to alternate, apex acute to acuminate, ± hooked, base rounded to ± oblique; adult leaves lanceolate, falcate or ± plane, 9.5–18 cm long, 1.2–2.2 cm wide, alternate, conspicuously glossy and dark green, margins entire, apex acuminate and often hooked, base attenuate, acute or oblique, petiole terete to flattened, barely channelled above, 1–2 cm long; venation 30–45° to midrib, intramarginal vein 0.5–2 mm from the margin, midrib channelled above. Inflorescence of axillary umbellasters. Flowers 6–7 per axil; peduncle 8–17 mm long, 2–5 mm wide; pedicel distinct in bud and fruit, 3–5 mm long in buds, 2–4.5 mm long in fruit; buds obloid to clavate, bulbous above and below the suture, ± 1-ribbed, 6–9.5 mm long; calyptra peaked hemispherical, acutely obconical or ± rostrate, 2.5–5 mm long, 2–3.5 mm wide; hypanthium 2.5–5 mm long, 2–3.5 mm wide; style terete, 3–4 mm long; stamens with filaments 3.5–5 mm long, anthers dorsifixed, parallel, dehiscence longitudinal, 0.4–0.6 mm long, white, oil gland orbicular and abaxial. Fruit cupular, ± 1-ribbed, 4.5–8 mm long, 5–8 mm wide, often splitting on one side; disc level to descending, c. 1 mm wide; valves 3, ± level. Seeds red-brown to black. Cotyledons bilobed."

Eucalyptus oresbia is closest morphologically to *E. cypellocarpa* and *E. quinniorum* (Hunter and Bruhl 1999), of which the former occurs elsewhere on the Liverpool Range nearby to, and potentially overlapping with, the distribution of *E. oresbia. Eucalyptus oresbia* is distinguished from both species by the combination of non-ribbed buds and fruit, relatively small fruits to 8 mm diameter (*c.f.* to 11 mm dia. in *E. cypellocarpa*), and the quadrangular juvenile stems and mature branchlets (Hunter and Bruhl 1999).

Eucalyptus oresbia has previously been known by the synonym *E. goniocalyx* var. *parviflora*, which itself was formerly considered a synonym of *E. cypellocarpa* (Hunter and Bruhl 1999; Slee *et al.* 2020; CHAH 2024). Given the slight differences between *E. oresbia* and *E. cypellocarpa*, some authorities still consider these two taxa to be synonymous (*e.g.*, Slee *et al.* 2020; CHAH 2024; Nicolle 2024), however this assessment follows the current treatment of the National Herbarium of New South Wales in recognising *E. oresbia* as a distinct taxon (PlantNET 2024). Recent field and herbarium studies also support the taxonomic distinction of *E. oresbia* (G. Phillips unpublished data).

Distribution and Abundance

Eucalyptus oresbia is a range-restricted species endemic to several small, disjunct sites near the town of Nundle on the New South Wales (NSW) Northern Tablelands (Hunter and Bruhl 1999; OEH 2021). Known sites for the species lie within the Peel subregion of the Nandewar Bioregion, and the Tomalla subregion of the NSW North

Coast Bioregion (DAWE 2012). Sites also lie on the traditional lands of the Kamilaroi and Geawegal people (Horton 1996).

When *Eucalyptus oresbia* was first described in 1999, it was considered to be restricted to a small area between the town of Nundle and the locality of Hanging Rock (Hunter and Bruhl 1999). In 2001, further specimens attributable to *E. oresbia* were found along the Liverpool Range southeast from Hanging Rock, though these were initially thought by the species' author to be another undescribed taxon (Hunter and Copeland 2007). However, following further surveys, these more disjunct stands are now all considered to be within a broader concept of *E. oresbia* (J. Hunter *in litt.* April 2024), expanding the known range across a linear distance of approximately 54 km of the Liverpool and Great Dividing Ranges. It is possible that the species is distributed across other sites along the length of the Liverpool Range (Hunter and Copeland 2007; OEH 2021), however further survey effort would be required to resolve this.

Eucalyptus oresbia is currently known from four disjunct sites (Table 1). The core area is around the type locality at Hanging Rock, due east of Nundle, with smaller outlying stands known from the Scotts Creek area near Murrurundi to the south, in the Dungowan Dam catchment area northeast of Nundle, and in Ben Halls Gap National Park southeast of Nundle. Given the minimum distance between these sites is approximately 11 km, each is considered a separate subpopulation per the IUCN (2024) definition. This is due to the relatively short pollen dispersal distances reported in eucalypts (Peters *et al.* 1990; Butcher *et al.* 2005; Byrne *et al.* 2008; Jones *et al.* 2008; Breed *et al.* 2015) and highly localised seed dispersal (Booth 2017).

Table 1 - Population breakdown for *Eucalyptus oresbia.*

Subpopulation	Tenure	Estimate of Mature Individuals	Notes	Fire History per NSW NPWS (2022)	References
Hanging Rock	State Forest, Freehold	6,200	*Eucalyptus oresbia* is noted as occurring over 78 ha at an average density of 140 stems (inc. juveniles) per hectare.	November 2019 (Wildfire) - only burnt edge of subpopulation, majority long unburnt	Hunter and Copeland 2007; NSW NPWS 2024
Scotts Creek	Freehold	250-500	Subpopulation originally estimated as a single stand with 50-100 trees over less than 5 ha, with four more similar sized stands since found over ~5 km distance.	Long unburnt	BioNet 2024; NSW NPWS 2024; RBGDT 2024; J. Hunter *in litt.* May 2024
Ben Halls Gap	National Park	6	6 mature trees recorded in 2015	1981-82 (Wildfire) - edge only December 2019 (Wildfire) - edge only	A. Pickersgill *in litt.* May 2024; NSW NPWS 2024; RBGDT 2024

Dungowan Dam	Council reserve - Catchment land	2	Two individuals recorded in 2018	January 2020 (Wildfire)	BioNet 2024; NSW NPWS 2024
ESTIMATED MINIMUM MATURE INDIVIDUALS		**6,458-6,708**			

The type locality at Hanging Rock is the largest and most heavily surveyed subpopulation of *Eucalyptus oresbia*, containing approximately 92-96% of known mature individuals of the species. Here, the majority of trees are within three semi-continuous stands spread over an area of approximately 78 ha (Hunter and Copeland 2007) spanning Hanging Rock State Forest and adjoining crown lands. These stands consist of relatively high densities of trees where *E. oresbia* is dominant, with a mean density of 140 trees (including juveniles) per hectare calculated using four floristic plots (Hunter and Copeland 2007). In 2007, at Hanging Rock there was an estimated total of 6,200 mature individuals among a total of 11,000–15,000 trees including juveniles (Hunter and Copeland 2007). As there have been no further systematic surveys at this site, and trees are long-lived, the estimated 6,200 mature individuals is considered the plausible current minimum given that maturation of the large juvenile cohort is unknown. Scattered trees are also known to be present away from the core stands in this subpopulation, with the species known to recruit within the adjoining radiata pine (*Pinus radiata*) plantations within Hanging Rock State Forest (Hunter and Copeland 2007; G. Phillips pers. obs. August 2023).

The next largest known subpopulation is in the Scotts Creek area, approximately 30 km southwest of Hanging Rock towards the town of Murrurundi. This site consists of several discrete records spread over a linear distance of approximately 5 km, with *E. oresbia* considered to be highly localised and patchy in the area (J. Hunter *in litt.* May 2024). One stand was recorded in 2001 as having 50–100 trees across an area of <5 ha (BioNet 2024; RBGDT 2024). Four other stands around Scotts Creek were recorded in a 2008 survey, and while the size and abundance of these stands was not noted, each was considered to be similar in size to the 2001 record (J. Hunter *in litt.* May 2024). The subpopulation is therefore thought to currently consist of five small, disjunct stands, with an estimated 250–500 trees. All stands in this subpopulation are on freehold land, much of which has been historically cleared in the local area, likely contributing to the species' patchiness in the area.

The Ben Halls Gap subpopulation is approximately 11 km southeast of Hanging Rock, with only six mature trees currently known from Ben Halls Gap National Park (A. Pickersgill *in litt.* May 2024). This subpopulation, first recorded in 2015, is within a section of the national park added in 2019 which was formerly freehold land. It is possible that further stands may be identified in this subpopulation as substantial areas of seemingly unsurveyed habitat exist on other properties adjoining the national park.

The final subpopulation of *Eucalyptus oresbia* is known from the catchment of Dungowan Dam, approximately 18 km northeast of Hanging Rock. This subpopulation

is currently very small, with only two individuals recorded in 2018 (BioNet 2024). This subpopulation is within the reserved lands for the dam managed by Tamworth Regional Council. Again, it is possible that further stands and individuals may be found in this subpopulation given the large areas of suitable yet less accessible habitat in the area.

The minimum estimated population size of *Eucalyptus oresbia* is 6,458-6,708 mature individuals. Approximately 92-96% of the known population occurs within the Hanging Rock subpopulation, and less than 1% of the known individuals occur on lands managed for conservation in the Ben Halls Gap and Dungowan Dam subpopulations.

Area of Occupancy and Extent of Occurrence

The Area of Occupancy (AOO) of *Eucalyptus oresbia* is estimated to be 44 km^2 using 2 x 2 km grid cells, the scale recommended by IUCN (2024). The Extent of Occurrence (EOO) is estimated to be 420 km^2 and is based on a minimum convex polygon enclosing a cleaned dataset of known occurrences of the species, the method of assessment recommended by IUCN (2024). Both EOO and AOO were calculated using ArcGIS (Esri 2021). Based on these estimates, *E. oresbia* has a highly restricted AOO and EOO.

The cleaned spatial dataset used to inform the AOO and EOO estimates contains 69 unique records sourced from BioNet (NSW Wildlife Atlas), the Atlas of Living Australia, and specimen records from the National Herbarium of New South Wales. 19 records were removed from this analysis due to being incorrectly georeferenced, having very low spatial accuracy, or were duplicate records. A single specimen-backed record held at the University of New England Herbarium (NE 75429), tentatively identified as *Eucalyptus oresbia* from east of Walcha, was excluded due to the high likelihood of it being a misidentification of *E. retinens* that occurs in that area.

Cultural Significance

This assessment is not intended to be comprehensive of the Traditional Ecological Knowledge that exists for *Eucalyptus oresbia* 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*. 2020). Aboriginal Peoples have cared for Country for tens of thousands of years (Bowler *et al.* 2003; Clarkson *et al*. 2017). Although no specific information could be collected on *E. oresbia*, it is acknowledged that traditional ecological knowledge exists for all plants, animals and fungi connected within the kinship system (Woodward *et al.* 2020).

Ecology

Habitat

Eucalyptus oresbia is known from steep slopes on soils derived from mudstone and basalt, typically at elevations of 800–1,100 m (Hunter and Bruhl 1999; Hunter and Copeland 2007), though records are known from as low as 600 m at the Scotts Creek subpopulation. It is found in steep-sided valleys and drainage lines with south to southwest aspects that provide a warm yet moist microclimate (Hunter and Copeland 2007). The species appears to be specialised to this habitat and does not appear to

colonise more open valleys (Hunter and Copeland 2007). In these steep valleys it commonly associates with *Eucalyptus laevopinea*, *E. melliodora, Angophora floribunda* and *Casuarina cunninghamiana*, with other co-occurring species including *Eucalyptus malacoxylon*, *E. youmanii*, *E. caliginosa, Allocasuarina torulosa, Cassinia laevis, C. macrocephala, Acacia dealbata, A. implexa, A. obtusifolia, Exocarpos cupressiformis, Poa sieberiana* and *Lomandra longifolia* (Hunter and Copeland 2007). In less rocky areas, *Eucalyptus oresbia* is replaced by *E. elliptica*, *E. melliodora* and *E. pauciflora* (Hunter and Copeland 2007).

The plant community types (PCTs) that *Eucalyptus oresbia* is most commonly associated with are Liverpool Range Apple Gully Forest (PCT 3282) and Liverpool Range Box-Silvertop Stringybark Forest (PCT 3354; Hunter and Copeland 2007; DPE 2022a, 2022b; G. Phillips pers. obs. August 2023). However, *E. oresbia* may not be confined to these PCTs and may be found within other PCTs that occur in the area.

Life history

While the fire response of *Eucalyptus oresbia* has not been documented, the primary fire response is expected to be both basal and epicormic resprouting as recorded in all closely related taxa within series *Globulares* (Nicolle 2006). In such combination resprouters, resprouting from epicormic shoots in the stems will occur after most fires, with resprouting from the basal lignotuber only occurring after complete crown destruction (Nicolle 2006). Stem resprouting tends to develop in larger stem sizes in combination resprouters, with resprouting limited to basal coppicing only in plants with smaller stems (Zimmer *et al.* 2021).

Seedling recruitment in eucalypts is typically intermittent and rarely observed without disturbance such as fire (Keeley 1995). This appears true for *Eucalyptus oresbia*, which recruits freely in disturbed areas, while seedlings remain rare in less disturbed sites (Hunter and Copeland 2007). As with other eucalypts, *E. oresbia* develops an aerial seed bank where seeds can be stored for several years in the canopy, with seed being slowly released over time or *en masse* following death of a stem or branch (Tozer and Bradstock 1997; G. Phillips pers. obs. August 2023). Once released, seedling establishment and survival in eucalypts is often dependent on soil moisture availability and levels of competition for resources (Wellington and Noble 1985; Auld *et al.* 1993; Tozer and Bradstock 1997). Reduced competition, increased light levels, and nutrient influxes provided by fire are all thought to bolster recruitment (Etchells *et al.* 2020). Given seedlings are most prevalent in highly disturbed sites such as roadsides (Hunter and Copeland 2007), it is possible that *E. oresbia* requires intermittent natural disturbances such as fire to stimulate stronger germination events.

Lifespan and generation length

Eucalyptus oresbia is a long-lived tree, with many forest species in that genus living for several hundred years (Williams and Woinarski 1997). The largest trees have been recorded as having a diameter at breast height (DBH) of up to 126 cm (Hunter and Copeland 2007), suggesting stem ages of over 300 years are possible assuming growth rates are similar to those seen in other temperate forest eucalypts (Wood *et al.* 2010). However, most *Eucalyptus oresbia* recorded in mature stands are often only up to 70 cm DBH (likely due to previous disturbance cycles; Hunter and Copeland 2007), meaning that the maximum age of the current cohort is more likely to be 150-

250 years. The mean primary juvenile period for resprouting eucalypts under cultivation in South Australia has been calculated as 3.5–8 years with a mean of approximately five years (Nicolle 2006), and the primary juvenile period of *E. oresbia* suspected to be a similar length.

The generation length of *Eucalyptus oresbia*, which relies on resprouting from long-lived lignotubers and epicormic buds for stand maintenance with limited seedling recruitment outside of disturbance cycles, can be estimated using the age of first reproduction + *z* * length of reproductive period (IUCN 2024), where *z* is a constant between 0 and 1 calculated using survivorship and the relationship between fecundity and age. Using a lifespan estimate of 300 years, a primary juvenile period of five years, and a value for *z* of 0.33 as calculated for other long-lived tree species (Fung and Waples 2017), the generation length of *E. oresbia* is estimated at approximately 102 years.

Reproductive and seed ecology

Eucalyptus oresbia has been observed flowering from March to May (Hunter and Copeland 2007). The flowers are protandrous and a mixed mating system that favours outcrossing is likely, as found in many other eucalypts (Breed *et al.* 2015). Other eucalypts with relatively small flowers have been shown to be primarily insect-pollinated (Wilson 2002; Byrne *et al.* 2008; Jones *et al.* 2008). Given the relatively small flowers displayed by *E. oresbia* (Hunter and Bruhl 1999), the species also likely relies on insects for the bulk of pollination services, with birds and small mammals playing a lesser role in pollen dispersal. Therefore, pollen dispersal between stands is likely to be regular at the local scale and infrequent at longer distances, in line with findings in other eucalypts (Jones *et al.* Therefore, pollen dispersal between stands is likely to be regular at the local scale and infrequent at longer distances, in line with findings in other eucalypts (Jones *et al.* 2008; Breed *et al.* 2015).

Seed dispersal in eucalypts is typically highly localised and dependent on plant height, canopy width, seed weight, and prevailing wind conditions (Booth 2017). Given the tree heights and steep hillside habitat typical of *Eucalyptus oresbia*, seed dispersal is likely restricted to the area immediately around and downslope of parent plants. While occasional strong winds may promote further dispersal, this is likely to be minimal. However, rain and gravity may move seed into other pockets of suitable habitat downslope. Predation of seeds by ants is also known to commonly occur in eucalypts (Booth 2017). Furthermore, seeds are short-lived in the soil, with seeds typically germinating or dying within one season of release if not predated (Wellington and Noble 1985; Keeley 1995). Seed supply is therefore maintained in the canopy, potentially for two years or more, with seeds held in capsules and released intermittently over time or once disturbance results in stem or branch death (Tozer and Bradstock 1997).

Released seeds of eucalypts tend to have no dormancy aside from a few montane species (Close and Wilson 2002, Booth 2017). Seeds of *Eucalyptus oresbia* are unlikely to be dormant, as trials on *E. oresbia* seeds newly released from the capsules germinate quickly (G. Errington *in litt.* June 2024).

Threats

The main threats to *Eucalyptus oresbia* are the historical clearing of habitat for softwood pine plantations at Hanging Rock and the ongoing maintenance of these plantations including timber harvesting operations, historical and current clearing for agriculture and grazing, and adverse fire regimes which are projected to worsen under climate change (Hunter and Copeland 2007; OEH 2021). Other identified threats to *E. oresbia* include road maintenance operations, and invasion by weeds such as blackberries (*Rubus anglocandicans*) and radiata pine (*Pinus radiata)* (Hunter and Copeland 2007; OEH 2021).

Pine plantations and timber harvesting activities

Softwood pine plantations are the dominant land use in Hanging Rock State Forest, and the historical clearing for their establishment, and their contemporary maintenance is inferred to have caused decline in the largest subpopulation of *Eucalyptus oresbia*. While most of the known individuals in the Hanging Rock subpopulation exist within remnant bush and adjoining Crown lands, isolated individuals have also been found scattered within the pine plantations (Hunter and Copeland 2007). It is therefore likely that other *E. oresbia* plants will have been historically cleared to establish the current plantations, especially on south-facing slopes within the state forest.

Plantations immediately abut the known stands of *Eucalyptus oresbia* to the north, and extensive areas of seemingly suitable habitat extend upslope into these plantations (G. Phillips pers. obs. August 2023). Mapping shows that there are approximately 455 ha of south-facing slopes above 800 m elevation within and immediately adjoining the extant Hanging Rock subpopulation (Fig. 1), inclusive of the previously recorded 78 ha in Hunter and Copeland (2007). Approximately 198 ha of this area, or 43% has been historically cleared for pine plantations, and this has almost certainly reduced the area of available habitat and the number of mature individuals of *E. oresbia* in this subpopulation.

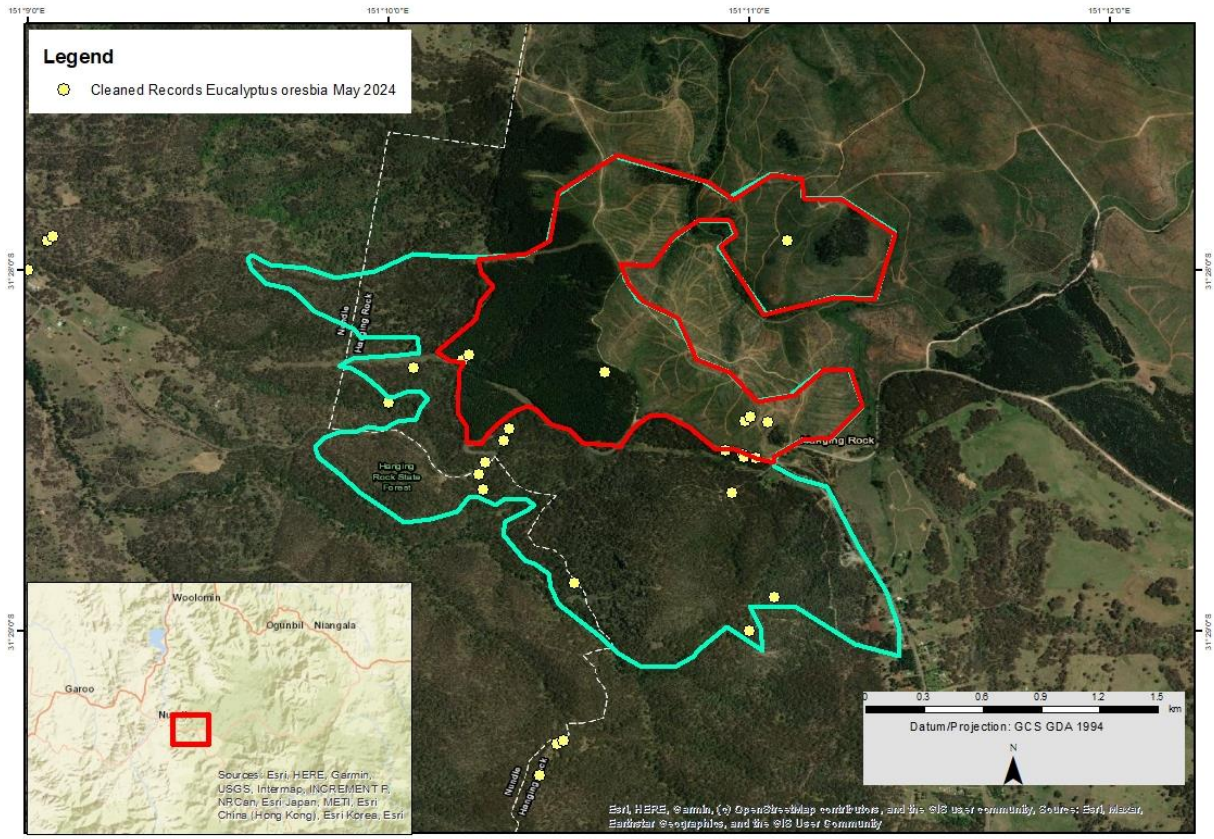

Figure 1 - There are approximately 455 ha of south-facing slopes above 800 m elevation in the Hanging Rock subpopulation (light blue polygon), with approximately 198 ha of this area having been historically cleared for pine plantations (red polygon).

Seedlings of *Eucalyptus oresbia* have also been recorded establishing within the pine plantations at Hanging Rock (Hunter and Copeland 2007), and it is likely that these individuals are at risk when the plantation is harvested, and during maintenance of the plantation. Pine plantations immediately north of known stands contain several records of *E. oresbia,* and these areas were harvested prior to August 2023 with no standing vegetation remaining within the coupes (G. Phillips pers. obs. August 2023; Fig. 1). It is therefore likely that previously recorded seedlings have been destroyed during these operations, and such harvesting also limits any future opportunities for long-term seedling survival in these areas.

Clearing and habitat degradation due to agriculture

Historical clearing of habitat for agriculture has been widespread in the region in which *Eucalyptus oresbia* grows and is likely to have caused past declines at both the Scotts Creek and Ben Halls Gap subpopulations. At the Scotts Creek site, approximately 79% of south-facing hillslopes above 600 m elevation within the immediate area of the known subpopulation has been cleared for agricultural land uses (*c.* 1,512 ha of 1,925 ha of potential habitat; Fig. 2). It is therefore probable that previously unrecorded stands have been historically cleared in this area. The Ben Halls Gap subpopulation similarly exists in an area that was until recently freehold land which has undergone historical clearing. Here, approximately 60% of south-facing slopes immediately

around the known record (*c.* 119 ha of 199 ha of potential habitat; Fig. 3) has been cleared.

Stock grazing is the primary land use in the Scotts Creek area (DFSI 2017) and is known to be a threat to *Eucalyptus oresbia* (Hunter and Copeland 2007; OEH 2021). Stock can trample seedlings, and intensive grazing can reduce regeneration in eucalypt woodlands to the point where stands are not replaced over time as they mature (Dorrough and Moxham 2005; Fensham *et al.* 2020). While stock grazing is likely to have an ongoing adverse effect on the Scotts Creek subpopulation, the formerly freehold property at Ben Halls Gap is now reserved on NSW National Parks and Wildlife Service estate, so some declines caused through clearing at the latter site may be reversible if regeneration is allowed to take place through the ongoing exclusion of stock.

'Clearing of Native Vegetation' is listed as a Key Threatening Process under the *Biodiversity Conservation Act 2016.* 'Land Clearance' is listed as a Key Threatening Process under the *Environment Protection and Biodiversity Conservation Act 1999*.

Adverse fire regimes

Adverse fire regimes may cause decline in the population of *Eucalyptus oresbia* if severe fires were to occur more frequently into the future. Currently, most stands of *E. oresbia* experience a regime of very infrequent fire, with most known trees currently being long unburnt (Table 1). The preferred habitat of steep, sheltered south-facing slopes also typically acts as a form of fire refugia, limiting occurrences of wildfire (Wood *et al.* 2011). It is therefore likely that *E. oresbia* has not historically been placed under pressure from frequent fires of any severity. However, large-scale fires did affect the Dungowan Dam subpopulation, and the edges of the Hanging Rock and Ben Halls Gap subpopulations in 2019-20 (NPWS 2024). Such fires make eucalypt dominated forests more susceptible to repeat severe fires in the near future (Taylor *et al.* 2014) and potentially also expose the long-unburnt portions of the subpopulations to increased risk from severe wildfires.

Higher severity wildfire can alter stand structure and understorey species competition, as well as increase mortality of dominant eucalypts (Etchells *et al.* 2020). Such increases in severe wildfire in a combination resprouter species like *Eucalyptus oresbia* can also push the species to rely more on basal coppicing alone to regenerate, as larger stems capable of epicormic regrowth are eliminated in hotter fires (Zimmer *et al.* 2021). This pattern is enhanced if higher severity fires become more frequent, further limiting the species' ability to coppice, and reducing the chance of escape from subsequent fires, as has been observed in the closely related *E. canobolensis* (Zimmer *et al.* 2021). The majority of *E. oresbia* at Hanging Rock are under 40 cm DBH (Hunter and Copeland 2007), and trees below this size in *E. canobolensis* rapidly lose the ability to resprout from the stem in high severity fire (Zimmer *et al.* 2021). This means that the majority of known *E. oresbia* are currently susceptible to higher mortality rates and a loss of vigour and fecundity through a reduced resprouting response in the case that a severe fire was to affect the subpopulation in the near future.

The Northern Tablelands region in which *Eucalyptus oresbia* occurs, is projected to become hotter, have fewer colder nights under 2°C annually, more hot days over 35°C

annually, and an increase in severe fire weather in spring and summer by 2079 (CSIRO and BOM 2022; AdaptNSW 2024). Additionally, fire weather is predicted to become harsher, and the time spent in drought is projected to increase on the East Coast through the 21st century (CSIRO 2023). Therefore, it is plausible that more frequent and/or severe fires driven by these changes in climate will adversely affect the *E. oresbia* population in the future, causing declines in the number of mature individuals as smaller stems are eliminated, and future reproductive opportunity is diminished.

Adverse fire regimes may also negatively affect the population of *Eucalyptus oresbia* if fire is kept out of the landscape for too long by reducing recruitment events that it may replenish senescent stands. Like other eucalypts, *E. oresbia* seeds are held within the canopy until release upon death of the supporting branch, typically after fire. Many eucalypts, including resprouting species, have increased germination rates following fire (Wellington and Noble 1985; Keeley 1995), with release from competition, increased light levels, and nutrient influxes provided by fire all thought to contribute to this enhancement (Etchells *et al.* 2020). This also appears true for *E. oresbia*, with seedlings having been observed to be much more abundant in highly disturbed areas such as roadsides when compared to less disturbed areas (Hunter and Copeland 2007).

'High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition' and 'Anthropogenic climate change' are listed as Key Threatening Processes under the *NSW Biodiversity Conservation Act 2016,* and 'Fire regimes that cause declines in biodiversity' and 'Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases' are listed as Key Threatening Processes under the *Environment Protection and Biodiversity Conservation Act 1999*.

Road and trail maintenance

Eucalyptus oresbia is subject to adverse effects of road and trail maintenance activities, especially in the Hanging Rock subpopulation where substantial portions of the known stands occur in the immediate vicinity of a regional road. Roadworks and vegetation maintenance along the main road into Hanging Rock may cause the death of mature trees as well as reduce recruitment opportunities, with the latter especially problematic given seedlings are most prevalent in disturbed roadside sites (Hunter and Copeland 2007). Death of seedlings of *E. oresbia* has been observed in the road corridor following herbicide application (G. Phillips pers. obs. August 2023), likely undertaken to maintain the vegetation within the road corridor and the adjoining pine plantations. This is limiting recruitment, which reduces the probability of replacement of lost mature individuals into these disturbed sites, and is therefore contributing to continuing decline in the number of mature individuals in the largest subpopulation.

Habitat degradation due to weed invasion

Introduced blackberry (*Rubus anglocandicans*) is a widespread weed, and is recognised as a regional priority weed for containment in the NSW North West region (North West LLS 2022). Blackberry is able to rapidly spread and form extensive, dense thickets and adds to the fuel load available for fire when abundant (NSW DPI 2024). Blackberry has been found to be common in the habitat of *Eucalyptus oresbia,*

particularly in the Hanging Rock subpopulation where thickets can be found among dense stands of the trees (Hunter and Copeland 2007), and at Ben Halls Gap, where extensive thickets have been noted on adjoining properties to the National Park (NSW NPWS 2002).

Blackberry thickets suppress eucalypt recruitment from seed in the absence of fire and interact with fire to reduce seedling recruitment in post-fire landscapes where blackberry is abundant. Zimmer *et al.* (2021) found seedling density in the related *Eucalyptus canobolensis* decreased with increasing cover of ground layer plants including blackberry. Burning does not kill blackberry (NSW DPI 2024) and thickets can resprout rapidly from buried crowns and root suckering (Ainsworth and Mahr 2006). Fire severity has no effect on the regenerative capacity of blackberry, with infestations affected by high severity fires still retaining enough live belowground material to re-establish pre-fire numbers by the end of the summer following fire, thus rapidly reforming thickets to compete with seedlings of native species (Ainsworth and Mahr 2006). The suppressive effect of dense blackberry infestations in both the pre- and post-fire landscape therefore poses a significant threat to recruitment and population maintenance of *E. oresbia* and contributes to continuing decline in the habitat quality of areas where blackberry is found.

Radiata pine (*Pinus radiata*) can be found encroaching in many stands of *Eucalyptus oresbia* adjoining the plantations at Hanging Rock State Forest (Hunter and Copeland 2007). Radiata pines can form dense stands in native bushland, crowding out native species through overshading and the thick layer of leaf mulch they rapidly accumulate underneath (Parfitt and Ross 2011; BMCC 2024). Soil nitrogen has been found to be lower under radiata pine compared to eucalypt forest (Turner and Lambert 1987), and soil nitrogen is often a limiting factor in the growth of montane eucalypts (*e.g., E. nitens*; Smethurst *et al.* 2004). The competition for these essential nutrients due to the presence of radiata pine therefore results in decline in habitat quality and mortality of seedlings in stands of *E. oresbia* where pine wildlings are found in abundance.

Number of Locations

When the threat of adverse fire regimes, especially increased frequency and severity of wildfires, is considered, the four subpopulations of *Eucalyptus oresbia* can be considered to be 3-4 threat-defined locations, as per the IUCN (2024) definition. This is due to the increased frequency and severity of wildfires being the most serious plausible threat that results in the lowest number of locations for the taxon. While the Ben Halls Gap and Scotts Creek subpopulations are sufficiently disjunct that they are unlikely to ever be affected by a single fire event, the Dungowan and Hanging Rock subpopulations can and have been affected by a single fire event in the past and may be defined as one or two locations.

Assessment against IUCN Red List criteria

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

Overall assessment outcome

Eucalyptus oresbia was found to be eligible for listing as Endangered under IUCN Criteria A2c; B1ab(iii,v)+2ab(iii,v).

Criterion A *Population size reduction*

A. Population size reduction. Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4

	Critically Endangered	Endangered	Vulnerable
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3 & A4	≥ 80%	≥ 50%	≥ 30%

A1 Population reduction observed, estimated, inferred, or suspected in the past where the causes of the reduction are clearly reversible AND understood AND have ceased.

A2 Population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

A3 Population reduction projected, inferred or suspected to be met in the future (up to a maximum of 100 years) *[(a) cannot be used for A3]*.

A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

based on any of the following:

(a) direct observation *[except A3]*

(b) an index of abundance appropriate to the taxon

(c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality

(d) actual or potential levels of exploitation

(e) effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

Outcome

Eucalyptus oresbia is Endangered under Criterion A2c.

Population reductions

The estimated three-generation timespan in *E. oresbia* is 306 years. This timespan encompasses the extensive clearing of habitat that has occurred since European colonisation of the NSW Northern Tablelands. Across all known subpopulations, there is approximately 2,676 ha of south-facing slope habitat in and around confirmed records of *E. oresbia*, and analysis of satellite imagery and land use mapping shows that approximately 1,829 ha of this area has been cleared (Figs. 1, 2 and 3). This represents an estimated reduction in the area of available habitat for *E. oresbia* of 68%, with a population reduction equivalent to that amount being inferred to have occurred within the three-generation timeframe. Given *E. oresbia* has been recorded recruiting into previously cleared habitat within plantation areas (Hunter and Copeland 2007), it is suspected that *E. oresbia* would have dominated the canopy in a larger area of habitat than at present. As <1% of the population is in conservation reserves, large areas of potential habitat are still maintained as softwood pine plantations preventing regeneration in the Hanging Rock subpopulation, and small-scale clearing may still be a threat in the Scotts Creek subpopulation, land clearing is not considered to have ceased, and may not be reversible in more heavily modified areas.

Conclusion

Eucalyptus oresbia is eligible to be listed as Endangered as a large population reduction is suspected to have occurred over the past three generations (306 years) based on historical land clearing for agriculture and softwood forestry plantations removing up to 68% of the available habitat within the species modern range.

Criterion B *Geographic range*

B. Geographic range in the form of either B1 (extent of occurrence) AND/OR B2 (area of occupancy)			
	Critically Endangered	Endangered	Vulnerable
B1. Extent of occurrence (EOO)	< 100 km²	< 5,000 km²	< 20,000 km²
B2. Area of occupancy (AOO)	< 10 km²	< 500 km²	< 2,000 km²
AND at least 2 of the following 3 conditions:			
(a) Severely fragmented OR Number of locations	= 1	≤ 5	≤ 10
(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			
(c) Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals			

Outcome

Eucalyptus oresbia is Endangered under Criterion B1ab(iii,v)+2ab(iii,v).

EOO and AOO

Eucalyptus oresbia is endemic to a small area of the NSW Northern Tablelands and has a highly restricted geographic distribution. The Extent of Occurrence (EOO) of *E. oresbia* has been calculated as 420 km^2. The Area of Occupancy (AOO) has been calculated as 44 km^2.

Number of threat-defined locations

Eucalyptus oresbia is found at 3–4 threat-defined locations when considering the most serious plausible threat resulting in the minimum number of locations, being increased frequency and severity of wildfires.

Severely fragmented

Eucalyptus oresbia is not considered severely fragmented as most known individuals are found in large, non-isolated subpopulations which are considered viable.

Continuing decline

Continuing decline of *Eucalyptus oresbia* is inferred in the area, extent and quality of habitat and the number of mature individuals due to conflicting land uses such as plantation forestry and agriculture in prime *E. oresbia* habitat, the maintenance of tracks and trails, and the invasion of weeds such as blackberry and radiata pine. While much of the clearing in the region in which *E. oresbia* occurs has been historical, the ongoing maintenance and harvesting of pine plantations, and ongoing stock grazing in *E. oresbia* habitat causes the direct mortality of seedlings and suppresses ongoing recruitment through the direct destruction of plants in otherwise suitable habitat. Road and track maintenance also results in the death of substantial numbers of plants on the immediate road edges in the large Hanging Rock subpopulation (G. Phillips pers. obs. August 2024) and reduces recruitment opportunities in disturbed areas that typically contain the highest seedling counts (Hunter and Copeland 2007). The presence of weeds such as blackberry and radiata pine, which can alter the habitat quality of *E. oresbia* by making it more flammable, less conducive to seedling growth, and change soil chemistry, further contribute to habitat degradation. Adverse fire regimes may also contribute to continuing decline by the elimination of stems capable of resprouting and increased mortality of mature individuals if severe fires were to become more frequent in the habitat of *E. oresbia*, as seen in other forest eucalypts

(Etchells *et al.* 2020; Zimmer *et al.* 2021). Conversely, too infrequent fire may limit recruitment episodes required to replenish senescent stands (Keeley 1995). These threats mean that the quality and availability of habitat and number of mature individuals of *E. oresbia* are likely to remain under pressure, with current declines inferred to continue into the future.

Extreme fluctuations

Eucalyptus oresbia is a long-lived eucalypt and is not known to undergo extreme fluctuations.

Conclusion

Eucalyptus oresbia is eligible to be listed as Endangered as the EOO, AOO, and number of threat-defined locations all fall under the endangered thresholds. Additionally, continuing decline in the area, extent and or quality of habitat and the number of mature individuals is inferred due to conflicting land uses such as plantation forestry and agriculture in prime *E. oresbia* habitat, the maintenance of tracks and trails, and the invasion of weeds such as blackberry and radiata pine.

Criterion C Small population size and decline

C. Small population size and decline				
		Critically Endangered	Endangered	Vulnerable
Number of mature individuals		< 250	< 2,500	< 10,000
AND at least one of C1 or C2				
C1. An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future):		25% in 3 years or 1 generation (whichever is longer)	20% in 5 years or 2 generations (whichever is longer)	10% in 10 years or 3 generations (whichever is longer)
C2. An observed, estimated, projected or inferred continuing decline AND at least 1 of the following 3 conditions:				
(a)	(i) Number of mature individuals in each subpopulation	≤ 50	≤ 250	≤ 1,000
	(ii) % of mature individuals in one subpopulation =	90–100%	95–100%	100%
(b) Extreme fluctuations in the number of mature individuals				

Outcome

Eucalyptus oresbia is data deficient under Criterion C1 and is not eligible to be listed under Criterion C2.

Number of mature individuals

The minimum estimated population for *Eucalyptus oresbia* is 6,458-6,708 mature individuals.

Continuing decline

Continuing decline is inferred in the number of mature individuals of *Eucalyptus oresbia* due to conflicting land uses such as plantation forestry and agriculture in prime *E. oresbia* habitat, and the maintenance of tracks and trails.

While a population reduction of >50% is suspected in *Eucalyptus oresbia* over a three-generation period, and continuing decline in the number of mature individuals is inferred, these do not meet the minimum data quality requirements (estimated or projected) for listing under C1.

Mature individuals in each subpopulation

The largest known subpopulation of *Eucalyptus oresbia*, Hanging Rock, contains a minimum of 6,200 mature individuals.

% of mature individuals in a single subpopulation

Current knowledge suggests the vast bulk of mature individuals of *Eucalyptus oresbia* reside within the Hanging Rock subpopulation, which contains an estimated 92-96% of the total population, which however fails to meet the threshold (100%) required for Vulnerable status under criterion C2(a)ii.

Extreme fluctuations

Eucalyptus oresbia is a long-lived eucalypt and is unlikely to undergo extreme fluctuations.

Conclusion

While the overall number of mature individuals of *Eucalyptus oresbia* is below the Vulnerable threshold and there is continuing decline inferred in the number of mature individuals due to conflicting land uses, minimum data quality requirements (estimated or projected) are not met to enable listing under Criterion C1.

Additionally, while there are fewer than 10,000 mature individuals of *Eucalyptus oresbia*, the largest subpopulation at Hanging Rock contains more than 1,000 mature individuals, there is more than one subpopulation, and there is no evidence of extreme fluctuations, meaning the thresholds for listing under Criterion C2 are not met.

Criterion D Very small or restricted population

D. Very small or restricted population			
	Critically Endangered	Endangered	Vulnerable
D. Number of mature individuals	< 50	< 250	D1. < 1,000
D2. *Only applies to the VU category* Restricted area of occupancy or number of locations with a plausible future threat that could drive the taxon to CR or EX in a very short time.	-	-	D2. typically: AOO < 20 km² or number of locations ≤ 5

Outcome

The thresholds for listing under Criterion D1 and D2 are not met for *Eucalyptus oresbia.*

Number of mature individuals

Eucalyptus oresbia is currently estimated to have a minimum population of at least 6,458-6,708 mature individuals.

Risk of future extinction in a very short amount of time

Eucalyptus oresbia occurs at only 3–4 threat-defined locations and has an estimated AOO of 44 km^2. However, no plausible threat is apparent that may rapidly drive the species to Critically Endangered or Extinct in a very short time.

Criterion E Quantitative Analysis

E. Quantitative Analysis	Critically Endangered	Endangered	Vulnerable
Indicating the probability of extinction in the wild to be:	≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)	≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)	≥ 10% in 100 years

Outcome

Eucalyptus oresbia is data deficient under Criterion E.

Probability of extinction

Currently there are not enough data to undertake a quantitative analysis to determine the extinction probability of *Eucalyptus oresbia.*

Conservation and Management Actions

This species is currently listed on the NSW *Biodiversity Conservation Act 2016* and a conservation project has been developed by the NSW Department of Climate Change, Energy, the Environment and Water under the Saving our Species (SoS) 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. *Eucalyptus oresbia* sits within the Site-managed species stream of the SoS program, and the conservation project can be viewed here.

Activities to assist this species currently recommended by the SoS program (OEH 2021; NSW DCCEEW 2024) include:

Habitat loss, disturbance and modification

- Protect areas of known habitat from frequent fire.
- Practice sustainable grazing in areas of habitat and protect regenerating trees from grazing stock where able.
- Identify roadside stands and ensure protection during roadworks.
- Protect known stands and areas of potential habitat from further clearing and development.
- Protect known stands from damage during timber harvesting activities.
- Expand and reconnect isolated stands in areas of appropriate habitat where recent and historical declines have been suspected.
- Regenerate and protect disturbed areas of habitat.

Survey and monitoring

- Monitor the spread of weed species including radiata pine and control as needed.

Stakeholder Engagement

- Liaise with local councils to inform them of locations of the species and minimize accidental damage during road and track works.
- Support local Landcare groups in restoration activities concerning the species.

References

AdaptNSW (2024) Interactive climate change projections map. URL: https://www.climatechange.environment.nsw.gov.au/projections-map (accessed 17 June 2024).

Ainsworth N, Mahr F (2006) *Regrowth of blackberry two years after the 2003 wildfires in Victoria.* pp 211–214 in 'Fifteenth Australian Weeds Conference Proceedings' (Eds Preston C., Watts J. H. and Crossman N. D.). Weed Management Society of South Australia.

Auld TD, Bradstock RA, Keith DK (1993) *Fire as a threat to populations of rare plants*. Australian National Parks and Wildlife Service Endangered Species Program, Endangered Species Project No. 31, Canberra.

BioNet (2024) Records of Small-fruited Mountain Gum (Species: Eucalyptus oresbia) recorded until 28 May 2024. [dataset]. NSW Department of Climate Change, Energy, the Environment and Water.

BMCC (Blue Mountains City Council) (2024) *Weeds of the Blue Mountains – Radiata Pine.* URL: https://weedsbluemountains.org.au/weeds/radiata-pine/ (accessed 24 June 2024).

Bowler JM, Johnston H, Olley JM, Prescott JR, Roberts RG, Shawcross W, Spooner NA (2003) New ages for human occupation and climatic change at Lake Mungo, Australia. *Nature* **421(6925)**: 837–840.

Booth TH (2017) Going nowhere fast: a review of seed dispersal in eucalypts. *Australian Journal of Botany* **65**: 401–410.

Breed MF, Ottewell KM, Gardner MG, Marklund MHK, Stead MG, Harris JBC, Lowe AJ (2015) Mating system and early viability resistance to habitat fragmentation in a bird-pollinated eucalypt. *Heredity* **115**: 100–107.

Butcher PA, Skinner AK, Gardiner CA (2005) Increased inbreeding and inter-species gene flow in remnant populations of the rare *Eucalyptus benthamii*. *Conservation Genetics* **6**: 213–226.

Byrne M, Elliott CP, Yates CJ, Coates DJ (2008) Maintenance of high pollen dispersal in *Eucalyptus wandoo*, a dominant tree of the fragmented agricultural region in Western Australia. *Conservation Genetics* **9**: 97–105.

CHAH (Council of Heads of Australian Herbaria) (2024) Australian Plant Name Index. URL: https://biodiversity.org.au/nsl/services/rest/name/apni/162316/api/apni-format (accessed 28 May 2024).

Clarkson C, Jacobs Z, Marwick B, Fullagar R, Wallis L, Smith M, Roberts RG, Hayes, E, Lowe K, Carah X, Florin SA (2017) Human occupation of northern Australia by 65,000 years ago. *Nature* **547(7663)**: 306-310.

Close DC, Wilson SJ (2002) Provenance effects on pre-germination treatments for *Eucalyptus regnans* and *E. delegatensis* seed. *Forest Ecology and Management* **170**: 299-305.

CSIRO (2023) Climate Change in Australia: East Coast South projection summaries. URL: https://www.climatechangeinaustralia.gov.au/en/projections-tools/regional-climate-change-explorer/sub-clusters/?current=ECSC&tooltip=true&popup=true (accessed 17 June 2024).

CSIRO and the Bureau of Meteorology (BOM) (2022) State of the Climate 2022. CSIRO and the Bureau of Meteorology, Commonwealth of Australia. URL: http://www.bom.gov.au/state-of-the-climate/2022/documents/2022-state-of-the-climate-web.pdf (accessed 17 June 2024).

DAWE (Department of Agriculture, Water and Environment) (2012) Interim Biogeographic Regionalisation for Australia, Version 7. URL: http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/maps.html. (Accessed 28 May 2024).

DFSI (Department of Finance, Service and Innovation) (2017) *NSW Landuse 2017.* Scale 1:150,000. Using ArcGIS 10.4 for Desktop, Redlands, California, ESRI Inc. 1999–2005.

Dorrough J, Moxham C (2005) Eucalypt establishment in agricultural landscapes and implications for landscape-scale restoration. *Biological Conservation* **123**: 55‑66.

DPE (Department of Planning and Environment) (2022a) *NSW State Vegetation Type Map C1.1M1.* Source: NSW Department of Planning and Environment GIS layer, exported 4 June 2024.

DPE (Department of Planning and Environment) (2022b) *NSW PCT master list C1.1.* Source: BioNet Vegetation Classification application, exported 4 June 2024.

Esri (Environmental Systems Research Institute) (2021) ArcGIS 10.8.2 for desktop. Redlands, California, USA. Esri Inc. 1999–2021.

Etchells H, O'Donnell AJ, McCaw WL, Grierson PF (2020) Fire severity impacts on tree mortality and post-fire recruitment in tall eucalypt forests of southwest Australia. *Forest Ecology and Management* **459**: 117850.

Fensham RJ, Laffineur B, Collingwood TD, Beech E, Bell S, Hopper SD, Phillips G, Rivers MC, Walsh N, White M (2020) Rarity or decline: Key concepts for the Red List of Australian eucalypts. *Biological Conservation* **243**: 108455.

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

Horton DR (1996) The AIATSIS Map of Indigenous Australia. Australian Institute of Aboriginal and Torres Strait Islander Studies. URL: https://aiatsis.gov.au/explore/map-indigenous-australia (Accessed 16 April 2024).

Hunter JT, Bruhl JJ (1999) Two new species of *Eucalyptus* (Myrtaceae) from northern New South Wales (series *Viminales* section *Maidenaria*). *Telopea* **8(2)**: 257–263.

Hunter JT, Copeland LM (2007) Field Survey of Western Granite Threatened Flora Species, Identified as Priority by the Namoi Catchment Management Authority. A report to the Namoi Catchment Management Authority.

IUCN (2024) Guidelines for Using the IUCN Red List Categories and Criteria. Version 16 (March 2024). Standards and Petitions Committee of the IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.

Jones ME, Shepherd M, Henry R, Delves A (2008) Pollen flow in *Eucalyptus grandis* determined by paternity analysis using microsatellite markers. *Tree Genetics and Genomes* **4**: 37–47.

Keeley JE (1995) Seed germination patterns in fire prone Mediterranean climate regions. In 'Ecology and biogeography of Mediterranean ecosystems in Chile, California and Australia. Vol. 108' (Eds Arroyo MDK, Zedler PH, Fox MD) pp. 239–273. (Springer Science and Business Media, New York, USA).

Nicolle D (2006) A classification and census of regenerative strategies in the eucalypts (*Angophora, Corymbia* and *Eucalyptus* – Myrtaceae), with special reference to the obligate seeders. *Australian Journal of Botany* **54**: 391–407.

Nicolle D (2024) Classification of the eucalypts, genus *Eucalyptus* Version 7. URL: https://dn.com.au/Classification-Of-The-Eucalypts.pdf (Accessed 15 April 2024).

North West LLS (Local Land Services) (2022) *North West Regional Strategic Weed Management Plan 2023-2027.* URL: https://www.lls.nsw.gov.au/__data/assets/pdf_file/0010/722917/North-West-Regional-Strategic-Weed-Management-Plan-2023-2027.pdf (accessed 24 June 2024).

NSW DCCEEW (Department of Climate Change, Energy, the Environment and Water) (2024) *Small-viewed Mountain Gum (*Eucalyptus *oresbia): Saving Our Species Strategy.* URL: https://www.environment.nsw.gov.au/savingourspeciesapp/project/351 (accessed 9 July 2024).

NSW DPI (Department of Primary Industry) (2014) NSW Weedwise: Blackberry (*Rubus fruticosus* species aggregate). URL: https://weeds.dpi.nsw.gov.au/Weeds/Details/18. (Accessed 24 June 2024).

NSW NPWS (National Parks and Wildlife Service) (2024) *NSW Fire History* [spatial data set]. Accessed using ArcGIS 10.8.2 for desktop, Redlands, California, USA. Esri Inc. 1999–2021.

NSW NPWS (National Parks and Wildlife Service) (2002) *Ben Halls Gap National Park Plan of Management.* URL: https://www.environment.nsw.gov.au/research-and-publications/publications-search/ben-halls-gap-national-park-plan-of-management (accessed 24 June 2024).

OEH (Office of Environment and Heritage) (2021) Small-fruited Mountain Gum – profile. URL:

https://threatenedspecies.bionet.nsw.gov.au/profile?id=10303(accessed 16 April 2024).

Parfitt RL, Ross DJ (2011) Long-term effects of afforestation with *Pinus radiata* on soil carbon, nitrogen, and pH: a case study. *Soil Research* **49**: 494–503.

Peters GB, Lonie JS, Moran GF (1990) The breeding system, genetic diversity and pollen sterility in *Eucalyptus pulverulenta*, a rare species with small disjunct populations. *Australian Journal of Botany* **38**: 559–570.

PlantNET (2024) *Eucalyptus oresbia* in 'PlantNET (The NSW Plant Information Network System)'. Royal Botanic Gardens and Domain Trust, Sydney. URL: https://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&lvl=sp&name=Eucalyptus~oresbia (accessed 28 May 2024).

RBGDT (Royal Botanic Gardens and Domain Trust) (2024) *Eucalyptus oresbia* specimen records [dataset]. NSW Herbarium specimen catalogue. EMu (RBGNSW) Application (accessed 28 May 2024).

Slee AV, Brooker MIH, Duffy SM, West JG (2020) Euclid: Eucalypts of Australia, Fourth Edition. URL: https://apps.lucidcentral.org/euclid/text/intro/index.html (accessed 15 April 2024).

Smethurst P, Holz G, Moroni M, Baillie C (2004) Nitrogen management in *Eucalyptus nitens* plantations. *Forest Ecology and Management* **193**: 63–80.

Taylor C, McCarthy MA, Lindenmayer DB (2014) Nonlinear effects of stand age on fire severity. *Conservation Letters* **7(4)**: 355–370.

Tozer MG, Bradstock RA (1997) Factors influencing the establishment of seedlings of the mallee, *Eucalyptus leuhmanniana* (Myrtaceae). *Australian Journal of Botany* **45**: 997–1008.

Turner J, Lambert MJ (1987) Soil properties as affected by *Pinus radiata* plantations. *New Zealand Journal of Forestry Science* **18(1)**: 77–91.

Wellington AB, Noble IR (1985) Seed dynamics and factors limiting recruitment of the mallee *Eucalyptus incrassata* in semi-arid, south-eastern Australia. *Journal of Ecology* **73(2)**: 657–666.

Williams JE, Woinarski JCZ (1997) *Eucalypt ecology: Individuals to ecosystems.* (Cambridge University Press, Cambridge, New York).

Wilson J (2002) *Flowering ecology of a box-ironbark Eucalyptus community*. [Doctoral dissertation, Deakin University]. Deakin University Figshare Repository. URL: https://hdl.handle.net/10536/DRO/DU:30023163.

Wood SW, Hua Q, Allen KJ, Bowman DMJS, (2010) Age and growth of a fire prone Tasmanian temperate old-growth forest stand dominated by *Eucalyptus regnans*, the world's tallest angiosperm. *Forest Ecology and Management* **260**: 438‑447.

Wood SW, Murphy BP, Bowman DMJS (2011) Firescape ecology: how topography determines the contrasting distribution of fire and rain forest in the south-west of the Tasmanian Wilderness World Heritage Area. *Journal of Biogeography* **38**, 1807–1820.

Woodward E, Hill R, Harkness P, Archer R (Eds.) (2020) *Our Knowledge Our Way in caring for Country: Indigenous-led approaches to strengthening and sharing our knowledge for land and sea management. Best Practice Guidelines from Australian Experiences*. NAILSMA and CSIRO, Cairns, Australia. URL: https://www.csiro.au/en/research/indigenous-science/indigenous-knowledge/our-knowledge-our-way (accessed 28 May 2024).

Zimmer H, Allen J, Smith R, Gibson R, Auld T (2021) Post-fire recruitment and resprouting of a threatened montane eucalypt. *Australian Journal of Botany* **69**: 21-29.

Expert Communications

Errington, Graeme. Seedbank Curator, Australian Institute of Botanical Science, Botanic Gardens of Sydney, NSW.

Hunter, John T. Consulting Botanist, University of New England, Armidale, NSW.

Soderquist, Todd. Senior Threatened Species Officer, NSW Department of Climate Change, Energy, the Environment and Water, Armidale, NSW.

APPENDIX 1

Assessment against *Biodiversity Conservation Regulation 2017* criteria
The Clauses used for assessment are listed below for reference.

Overall Assessment Outcome:
Eucalyptus oresbia was found to be Endangered under Clause 4.2(1 b)(2 c) and Clause 4.3(b)(d)(e i,iii).

Clause 4.2 – Reduction in population size of species
(Equivalent to IUCN criterion A)
Assessment Outcome: Endangered under Clause 4.2(1 b)(2 c)

(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: Data deficient

The estimated total number of mature individuals of the species is:						
	(a)	for critically endangered species			very low, or	
	(b)	for endangered species			low, or	
	(c)	for vulnerable species			moderately low,	
and either of the following 2 conditions apply:						
	(d)	a continuing decline in the number of mature individuals that is (according to an index of abundance appropriate to the species):				
		(i)	for critically endangered species		very large, or	
		(ii)	for endangered species		large, or	
		(iii)	for vulnerable species		moderate,	
	(e)	both of the following apply:				
		(i)	a continuing decline in the number of mature individuals (according to an index of abundance appropriate to the species), and			
		(ii)	at least one of the following applies:			
			(A)	the number of individuals in each population of the species is:		
				(I)	for critically endangered species	extremely low, or
				(II)	for endangered species	very low, or
				(III)	for vulnerable species	low,
			(B)	all or nearly all mature individuals of the species occur within one population,		
			(C)	extreme fluctuations occur in an index of abundance appropriate to the species.		

Clause 4.5 - Low total numbers of mature individuals of species
(Equivalent to IUCN criterion D)
Assessment Outcome: Not met

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

	(b)	for endangered species	very low, or
	(c)	for vulnerable species	low.

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

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

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

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