

NSW Threatened Species Scientific Committee

Conservation Assessment of *Grevillea raybrownii* Olde & Marriott (Proteaceae)

J Scott May 2019

NSW Threatened Species Scientific Committee

***Grevillea raybrownii* Olde & Marriott (Proteaceae)**

Distribution: Endemic to NSW

Current EPBC Act Status: Not listed

Current NSW BC Act Status: Not listed

Summary of Conservation Assessment

Grevillea raybrownii is found to be eligible for listing as a Vulnerable species under IUCN Criteria B1ab(iii, v) +2ab(iii, v) and Criterion C via C2a(i).

The main reasons for the species being eligible for listing in the Vulnerable category are that: i) the species has a highly restricted geographic range; ii) there is estimated to be a moderately low number of mature individuals; (iii) there are a number of threats affecting both the habitat and some mature individuals at many of the populations; (iv) the lower bound for the estimate of the number of locations is <10; and (v) there are estimated to be <1000 mature individuals in each population.

Description and Taxonomy

Grevillea raybrownii Olde & Marriott (Proteaceae) is described in PlantNET (2019) as a “bushy shrub to 1.5 m high. Leaves bipinnatisect, 2.5–5 cm long, primary lobes 3–5, narrow-linear, secondary lobes divaricate; ultimate lobes linear, subulate, 0.5–2.4 cm long, 0.6–1.2 mm wide, pungent; upper surface glabrous, lower surface double grooved. Conflorescences ovoid, dense, brown in bud. Perianth white with rusty limb, sericeous outside, glabrous inside. Gynoecium 6–7 mm long, glabrous; ovary white-silky, developing lilac hairs after anthesis, subsessile; style white in the lower half, lilac in the upper half, glabrous; pollen presenter erect, conical. Follicle sericeous, red striped and blotched on dorsal side.” Olde & Marriott (1994) provide a detailed description of the species.

Taxonomically, *Grevillea raybrownii* was previously placed within *G. triternata* and it is very similar to that species. However, *G. triternata* “differs in its shorter pedicels and pistil, looser, subcylindrical conflorescence with a white-silky indumentum and pollen presenter greater in length than its width at the base” (Olde & Marriott 1994).

Distribution and Abundance

Grevillea raybrownii is endemic to New South Wales, where it is known from the Central Tablelands in the Wingecarribee and Wollongong local government areas. It currently occurs within an area roughly bounded by Belanglo State Forest near Berrima in the south and west, Nattai National Park to the north and the upper Nepean catchment of the Woronora Plateau to the east. An old record from ‘west of Dapto’, is now considered to refer to the upper Nepean catchment area, consistent with other occurrences of the species on Triassic sandstone and laterite at higher elevations (S. Douglas *in litt.* Sept 2016). A record from Bungonia that was possibly *G. raybrownii* is now thought to be *G. triternata* (BioNet Atlas 2018).

Grevillea raybrownii is present in Nattai National Park and Upper Nepean State Conservation Area (S. Douglas *in litt.* Sept 2016). There may be further potential habitat for *G. raybrownii* in these two reserves, and adjacent areas of Water Catchment land. Olde (*in litt.* November 2016) reports that in 2015, he visited populations of *G. raybrownii* on the sandstone ridgetops in the Water Catchment areas north of Robertson, though a comprehensive survey of the area has not been undertaken. He saw the species “reasonably frequently around sandstone outcrops” (P. Olde *in litt.* October 2017). Even if further populations are located within this area, the extent of occurrence and area of occupancy will not increase beyond the Vulnerable threshold (see IUCN Rule B below).

Grevillea raybrownii has a highly restricted geographic distribution. The extent of occurrence (EOO) was estimated to be 885 km² based on a minimum convex polygon enclosing all mapped occurrences of the species, the method of assessment recommended by IUCN (2017). The area of occupancy (AOO) was

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estimated to be 96 km². This calculation was based on the species occupying 24 (2 km x 2 km) grid cells, the spatial scale of assessment recommended by IUCN (2017).

There are currently estimated to be 12 populations of *Grevillea raybrownii*. The total number of individuals occurring in the populations is unknown, as there have been no comprehensive surveys to estimate the abundance of the species over its distribution. For the few collections/records that have details, descriptions of abundance range from 'locally uncommon' to 'locally frequent', to 'abundant'. Only four populations had records that included estimates of plant numbers, and three of these recorded fewer than 100 individuals. The population in Belanglo State Forest was estimated to have >250 individuals (S. Douglas *in litt.* October 2017).

Douglas (*in litt.* Sept 2016) estimates that a total of <2,500 plants "is credible based on habitat specificity and plant density or counts at known sites". However, considering the advice of Olde (*in litt.* November 2016) for undocumented populations in the water catchment land, the number of *Grevillea raybrownii* individuals may exceed 2,500, but a precautionary estimate would be that the number of mature individuals does not exceed 10,000.

Ecology

Grevillea raybrownii occurs in *Eucalyptus* open forest and woodland with a shrubby understorey on sandy, gravelly loam soils derived from sandstone (Olde and Marriott (1994); PlantNET 2019) and low in nutrients (S. Douglas *in litt.* Sept 2016). *G. raybrownii* generally occurs on ridgetops and, less often, slopes and benches of Hawkesbury Sandstone and Mittagong Formation (S. Douglas *in litt.* Sept 2016). The annual rainfall varies from 825 mm in the western part of the distribution to 1400 mm for the eastern part.

Grevillea raybrownii is killed by fire and regeneration is from seed that is stored in the soil (OEH 2014). Recruitment appears to be driven by fire or other disturbances.

Grevillea raybrownii flowers in spring (Olde and Marriott 1994; PlantNET 2019). It is not thought to be bird pollinated as it produces insignificant amounts of nectar (P. Olde *in litt.* November 2016).

Threats

Past threats: Historical broad acre land clearing for the towns of Bowral, Berrima, Welby and Moss Vale, and for pastoral activities in the Mandemar, Medway and Joadja districts would have led to some areas of habitat loss (S. Douglas *in litt.* Sept 2016). Areas of habitat in the Belanglo State Forest have been cleared for plantation forestry (S. Douglas *in litt.* Sept 2016).

Current threats:

Disturbance: Recreational pressures have damaged plants and habitat, with tracks and rubbish dumping observed near the Nattai River at Welby (population 1) (S. Douglas *in litt.* Sept 2016; NSW Bionet sighting). Many populations are near roads and on ridgetop fire trails that may be subject to road maintenance activities or clearing for infrastructure. Sites in parts of Belanglo State Forest are threatened by slashing and herbicide use in bushfire hazard Asset Protection Zones (NSW BioNet sighting). The crushing of a significant number of *G. raybrownii* plants resulting from a pine harvester driving within an Asset Protection Zone was recently observed (S. Douglas *in litt.* Oct 2017).

Fire: A single fire event is not a threat to *Grevillea raybrownii*. However, a series of fires in quick succession, such as a hazard reduction burn followed by a wildfire, may exhaust the soil seedbank and consequently eliminate or reduce recovery post-fire. The areas particularly prone to this are the Water Catchment land in the eastern part of the distribution, where hazard reduction burning is carried out to protect the drinking water catchment and mining infrastructure, and Belanglo State Forest, where hazard reduction burning occurs to protect pine plantations.

Fire history records show that large fires occurred over extensive areas of bushland in the Water Catchment land and Upper Nepean State Conservation Area in 1968-69, 1977-78, and 2001-02, including four of the *Grevillea raybrownii* populations (7,8,11,12). In addition, there have been a number of prescribed burns on

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the ridgetops throughout this period. In some of these ridgetop areas there has been a minimum fire frequency of 8 to 9 years from 1968 to 2002 (OEH GIS Fire History 2018). While the time for recovery following a fire for *G. raybrownii* is unknown, data for other fire-sensitive *Grevillea* species (e.g. *G. caleyi*, Auld and Scott 2004) suggests that fire free intervals longer than 8-9 years may be required (Bush Fire Environmental Assessment Code for NSW 2006) and recent fire frequencies in the area may be leading to a slow decline. This trend is likely to be exacerbated by a warming climate under which an increase in the frequency of severe fire weather and hence the frequency of wildfires is predicted (Cary *et al.* 2012).

Fire mitigation activities around the rural and urban areas of Mittagong, Welby and Berrima are less well documented, however some of these areas are suspected to have not been burnt for a long time due to their isolation from other remnant bushland. In these areas, *Grevillea raybrownii* is at risk from long interfire intervals because in the absence of fire, mature plants senesce but seedling establishment is unlikely without germination cues associated with fire. However, the potential for regeneration following some future fire progressively declines with the decay of the soil seed bank.

Potential Future threats:

Feral animals such as Deer (*Cervus* spp.) and Goats (*Capra hircus*), are increasingly a problem across the region regardless of tenure (S. Douglas *in litt.* Sept 2016). Whilst no evidence of herbivory has been observed in mature *Grevillea raybrownii* plants (mature plants are very prickly), herbivores may browse the more palatable seedlings and juveniles and damage the habitat via trampling. This may result in reduced recruitment and inadequate regeneration after a fire.

Underground coal mining: Disturbance to the habitat from clearing for access tracks and surface infrastructure is a potential threat to *Grevillea raybrownii*. Populations of *G. raybrownii* are scattered along the ridgetops throughout the Upper Nepean catchment areas where underground coal mining is occurring. Underground coal mining is also proposed in the western part of the distribution of *G. raybrownii* under part of the Belanglo State Forest population (Humecoal project map 2018), although it is unknown if this will impact upon the species.

Assessment against IUCN Red List criteria

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

Criterion A Population Size reduction

Assessment Outcome: Data Deficient.

Justification: To be listed as threatened under Criterion A the species must have experienced a population reduction of at least $\geq 30\%$ (VU threshold) over three generations or 10 years (whichever is longer). Whilst it is likely some habitat of *Grevillea raybrownii* has been cleared in the past, there are insufficient data to assess *G. raybrownii* against this criterion.

Criterion B Geographic range

Assessment Outcome: Vulnerable under B1ab(iii, v)+2ab(iii, v).

Justification: *Grevillea raybrownii* has a highly restricted geographic range.

Extent of Occurrence: The EOO was estimated to be 885 km² based on a minimum convex polygon enclosing all mapped occurrences of the species, the method of assessment recommended by IUCN (2017). To be listed as Endangered under Criterion B1 a species must have an EOO of <5000 km². *Grevillea raybrownii* meets the EOO threshold for Endangered under Criterion B1.

Area of Occupancy: The AOO was estimated to be 96 km². This calculation was based on the species occupying 24 (2 km x 2 km) grid cells, the spatial scale of assessment recommended by IUCN (2017). To be listed as Endangered under Criterion B2 a species must have an AOO of <500 km². *Grevillea raybrownii* meets the AOO threshold for Endangered under Criterion B2.

Although *Grevillea raybrownii* meets the thresholds for restricted geographic distribution (EOO and AOO) for an Endangered species, the relevant subcriteria (see below) are only met at the Vulnerable threshold.

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

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

Assessment Outcome: Subcriterion met at Vulnerable threshold.

Justification: *Grevillea raybrownii* is likely to be found at 9 to 12 locations. To determine the number of locations (as per definition IUCN 2017) the most plausible threats at the different sites over the entire range of the distribution of *G. raybrownii* were considered. For the populations in which disturbance and recreational pressure are the main threats (i.e. 1,2,3,10), each of these populations were considered to be a single location because the symptoms of disturbance are unique to each population. For sites predominately in reserves or water catchment lands, the most plausible threat is likely to be too frequent fire (population declines via mortality of above ground plants and a failure to replenish the soil seed bank) or for other sites, too infrequent fire (resulting in plant senescence and decline in the soil seed bank). Populations 7, 8, 11 and 12 can be considered to be the one location as they are likely to be burnt in a single wildfire. Wildfires burnt large areas of the Water Catchment land, Nattai NP and the Upper Nepean SCA in 1968-69, 1977-78, and 2001-02 fire seasons, including all four of these *G. raybrownii* populations in the area. Population 5 in Nattai NP and population 6 in Water Catchment land, are both also at risk of frequent fire, but are two separate locations, as they have been burnt separately in wildfires in the past. Population 6 has an equal or greater risk from fire trail and powerline maintenance suggesting this should be a separate location. Conversely, population 4, in Nattai NP has had a period of longer fire free intervals and is also a separate location. Population 9 near Joadja has just the one fire recorded in 2002-03, however, fire records may not be as reliable on crown land as in reserved land, so the history prior to 2002 is uncertain. Using this as a basis for the number of locations at risk from adverse fire impacts or disturbance/recreational pressures, the total number of locations is estimated to be nine.

Whilst the habitat of *Grevillea raybrownii* has been fragmented by urban development, there are currently insufficient data for the number of mature individuals in each population to assess their likely viability across the geographic range of the species. To be severely fragmented, “most (50%) of the species total area of occupancy is in habitat patches that are (1) smaller than would be required to support a viable population, and (2) separated from other habitat patches by a large distance.” (IUCN 2017). An assessment of severe fragmentation cannot be made with the data currently available.

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

Assessment Outcome: Subcriterion met for (iii and v). Continuing decline is inferred for quality of habitat and the number of mature individuals.

Justification: “Continuing declines at any rate can be used to qualify taxa under Criteria B or C2. This is because taxa under consideration for Criteria B or C are already characterized by restricted ranges or small population size.” (IUCN 2017). There are a number of threats that are likely to be contributing to continuing decline across the distribution of *Grevillea raybrownii*. The populations near to urban areas and Belanglo SF are more prone to recreational and/or forestry pressures and there is evidence of habitat degradation and adverse impacts on plants in these areas. A decline in the number of mature individuals is projected to occur as a consequence of increases in fire frequency associated with hazard reduction burns. Ongoing declines in the number of mature individuals are inferred from the location of populations in close proximity to areas subject to routine fire trail and powerline maintenance.

- c) Extreme fluctuations.

Assessment Outcome: Data deficient.

Justification: Currently there is no available data to assess the likelihood of extreme fluctuations in *Grevillea raybrownii*.

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Criterion C Small population size and decline

Assessment Outcome: Vulnerable under Criterion C via C2a(i).

Justification: There are currently known to be 12 populations of *Grevillea raybrownii*. The total number of individuals occurring in the populations is unknown, as there have been no comprehensive surveys to estimate the abundance of the species over its distribution. For the few collections/records that have details, descriptions of abundance range from locally uncommon to locally frequent, to abundant. Only four populations had records that included estimates of plant numbers, and three of these recorded fewer than 100 individuals. The population in Belanglo State Forest was estimated to have >250 individuals (S. Douglas *in litt.* October 2017).

Douglas (*in litt.* September 2016) estimates that a total of <2,500 plants “is credible based on habitat specificity and plant density or counts at known sites”. However, considering the advice of Olde (*in litt.* November 2016), for undocumented populations in the water catchment land, the number of *G. raybrownii* individuals may exceed 2,500, but a precautionary estimate would be that the number of mature individuals does not exceed 10,000.

To be listed as Endangered under Criterion C, a species must have <2,500 mature individuals. To be listed as Vulnerable under Criterion C, a species must have <10,000 mature individuals.

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

C1. An observed, estimated or projected continuing decline of at least 10% in 10 years or 3 generation (up to a max. of 100 years in future).

Assessment Outcome: Data Deficient.

Justification: There are insufficient data to assess *Grevillea raybrownii* against this criterion.

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

Assessment Outcome: Subcriterion met.

Justification: Continuing decline is inferred from the threats at many of the populations. The populations near to urban areas and Belanglo SF are prone to recreational and/or forestry pressures and there is evidence of adverse impacts on plants in these areas. “Continuing declines at any rate can be used to qualify taxa under Criteria B or C2. This is because taxa under consideration for Criteria B or C are already characterized by restricted ranges or small population size.” (IUCN 2017).

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

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

Assessment Outcome: Subcriterion met at Vulnerable threshold.

Justification: The number of *Grevillea raybrownii* plants in each population is mostly unknown. Douglas (*in litt.* September 2016) states there are likely to be <250 plants in most populations except for Belanglo SF (where there is estimated to be >250 individuals), however Olde’s advice (P. Olde *in litt.* November 2016) indicates there may be larger populations not yet documented. A precautionary approach would be to assume *Grevillea raybrownii* meets the threshold for listing as Vulnerable under Criterion C2a(i), ie. no population has >1,000 mature individuals.

a (ii). percentage of mature individuals in one subpopulation = 90-100%(CR), 95-100%(EN), 100% (VU).

Assessment Outcome: Criterion not met.

Justification: No one population is known to contain >90% of all mature individuals.

b. Extreme fluctuations in the number of mature individuals

Assessment Outcome: Data Deficient.

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Justification: Currently there are no available data to assess the likelihood of extreme fluctuations in *Grevillea raybrownii*.

Criterion D Very small or restricted population

Assessment Outcome: D not met. D2 not met.

Justification: The total number of mature individuals of *Grevillea raybrownii* is estimated to be >1,000. The species does not have a restricted area of occupancy of < 20 km² or number of locations ≤ 5, such that it would be prone to future threats that could drive it to Critically Endangered or Extinct in a very short time period.

Criterion E Quantitative Analysis

Assessment Outcome: Data Deficient.

Justification: Currently there are not enough data to undertake a quantitative analysis to determine the extinction probability of *Grevillea raybrownii*.

Conservation and Management Actions

There is no NSW Saving Our Species site-managed program for *Grevillea raybrownii*. The following actions are derived from available threat information.

Habitat loss, disturbance and modification

- Assess disturbance and habitat loss at each site. Assess feasibility of restricting recreational vehicle access at sites where damage to the habitat is occurring.
- Belanglo State Forest – advise Forestry Corporation of NSW of the locations of populations of *Grevillea raybrownii* so that damage to the plants and disturbance to the habitat can be avoided.

Invasive species

- Undertake monitoring to assess if there are any weed incursions and control if required.

Ex situ conservation

- Establish and maintain ex-situ seed bank collection and, if necessary, a living collection for sites most at risk.

Stakeholder Management

- Liaise with Forestry Corporation of NSW regarding forestry and recreational activities at Belanglo State Forest and potential impact of these activities on *Grevillea raybrownii*.
- Liaise with landholders and managers regarding fire trail maintenance and minimizing disturbance impacts on known sites of *G. raybrownii*.
- Report new records of *Grevillea raybrownii* to the NSW Office of Environment and Heritage.

Survey and Monitoring priorities

- Survey known sites of *Grevillea raybrownii* and any potential habitat, particularly in the water catchment land north of Robertson, to get an estimate of abundance, size distribution (seedlings, juveniles, adults) and threats.
- Monitoring at known sites should be conducted to determine:
 - If disturbance of the habitat is affecting the *Grevillea raybrownii* plants.
 - The response of *Grevillea raybrownii* to disturbance (e.g., mortality, stem death, resprouting, leaf browning, flowering or fruiting).
 - Post fire monitoring of seedling recruitment and survival and growth.
 - The influence of management actions on threatening processes. Has there been any encroachment of weeds in the habitat? Is there any damage evident from feral animals or forestry activities? Is rubbish dumping an ongoing issue?

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Information and Research priorities

- Understand the ecology of *Grevillea raybrownii*.
 - Response to fire. Time to first flowering, factors promoting germination post-fire (seed biology, including germination and dormancy mechanisms, seed viability and longevity, seed dispersal and predation). Adult longevity and estimates for how long the species can persist without a fire.
 - Recruitment and establishment. Survival rates of seedlings (germination and survival of seedlings post fire), causes of mortality, impacts of any grazers (native and exotic on seedling survival and growth).
 - Pollination ecology – determination of pollination method (e.g. wind, insect), identification of pollinators.
- Understand the habitat of *Grevillea raybrownii* and also provide a baseline against which to monitor future change
 - Define commonly co-occurring species.
 - Define environmental characteristics and associated vegetation (ie biotic and abiotic features).

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Expert Communications

Dr Steve Douglas - Principal Ecologist, Ecological Surveys & Planning; Visiting Fellow, Hawkesbury Institute for the Environment, Western Sydney University.

Peter Olde - Honorary Research Associate (National Herbarium of NSW).

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APPENDIX 1

Assessment against BC Act criteria

Clause 4.2 – Reduction in population size of species

(Equivalent to IUCN criterion A)

Assessment Outcome: Data deficient.

(1) - The species has undergone or is likely to undergo within a time frame appropriate to the life cycle and habitat characteristics of the taxon:			
	(a)	for critically endangered species	a very large reduction in population size, or
	(b)	for endangered species	a large reduction in population size, or
	(c)	for vulnerable species	a moderate reduction in population size.
(2) - The determination of that criteria is to be based on any of the following:			
	(a)	direct observation,	
	(b)	an index of abundance appropriate to the taxon,	
	(c)	a decline in the geographic distribution or habitat quality,	
	(d)	the actual or potential levels of exploitation of the species,	
	(e)	the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.	

Clause 4.3 - Restricted geographic distribution of species and other conditions

(Equivalent to IUCN criterion B)

Assessment Outcome: Vulnerable via Clause 4.3 (c*) (d) (e i, iii).

[Equivalent to Criterion B via B1ab(iii, v)+B2ab(iii, v).]

* Although *Grevillea raybrownii* meets the thresholds for highly restricted geographic distribution (EOO and AOO) for an endangered species, only at the vulnerable threshold are two of the three other required conditions met.

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

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

Assessment Outcome: Vulnerable under Clause 4.4 (c) (e i, ii A(III))
[equivalent to IUCN Criterion C via C2a(i).]

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.
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Notice of and reasons for the Determination

The NSW Threatened Species Scientific Committee, established under the *Biodiversity Conservation Act 2016* (the Act), has made a Final Determination to list the shrub *Grevillea raybrownii* Olde & Marriott as a VULNERABLE SPECIES in Part 3 of Schedule 1 of the Act. Listing of Vulnerable species is provided for by Part 4 of the Act.

Summary of Conservation Assessment

Grevillea raybrownii is eligible for listing as Vulnerable, as the highest threat category met by the taxon across all categories, under Clause 4.3 (c) (d) (e i, iii) and Clause 4.4 (c) (e i, ii AIII) because: i) the species has a highly restricted geographic range with an extent of occurrence of 885 km² and an area of occupancy of 96 km²; ii) there is estimated to be a moderately low number of mature individuals; (iii) there are a number of threats affecting both the habitat and some mature individuals at many of the populations; (iv) the lower bound for the estimate of the number of locations is <10; and (v) there are estimated to be <1000 mature individuals in each population.

The NSW Threatened Species Scientific Committee has found that:

1. *Grevillea raybrownii* Olde & Marriott (family Proteaceae) is described in PlantNET 2018 as a “bushy shrub to 1.5 m high. Leaves bipinnatisect, 2.5–5 cm long, primary lobes 3–5, narrow-linear, secondary lobes divaricate; ultimate lobes linear, subulate, 0.5–2.4 cm long, 0.6–1.2 mm wide, pungent; upper surface glabrous, lower surface double grooved. Conflorescences ovoid, dense, brown in bud. Perianth white with rusty limb, sericeous outside, glabrous inside. Gynoecium 6–7 mm long, glabrous; ovary white-silky, developing lilac hairs after anthesis, subsessile; style white in the lower half, lilac in the upper half, glabrous; pollen presenter erect, conical. Follicle sericeous, red striped and blotched on dorsal side.”
2. *Grevillea raybrownii* is endemic to New South Wales, where 12 populations are currently known to occur in the Wingecarribee and Wollongong local government areas. It is present in Nattai National Park and the Upper Nepean State Conservation Area (S. Douglas *in litt.* Sept 2016).
3. *Grevillea raybrownii* generally occurs on ridgetops and, less often, slopes and benches of Hawkesbury Sandstone and Mittagong Formation (S. Douglas *in litt.* Sept 2016). It occurs in *Eucalyptus* open forest and woodland with a shrubby understorey on sandy, gravelly loam soils derived from sandstone (Olde and Marriott 1994; PlantNET 2018) that are low in nutrients (S. Douglas *in litt.* Sept 2016). *Grevillea raybrownii* is killed by fire and regeneration is from seed that is stored in the soil (OEH 2014). Recruitment appears to be promoted by fire or other disturbance.
4. The total population of *Grevillea raybrownii* is unknown, as there have been no formal estimates of plant numbers of the species over its distribution. Based on habitat specificity and plant counts at some of the known sites, there are estimated to be less than 2,500 individuals (S. Douglas *in litt.* Sept 2016). However, as there are areas of potentially suitable habitat in water catchment land nearby to known populations, plant numbers may exceed this estimate of 2,500 but are expected to be less than 10,000.

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5. *Grevillea raybrownii* has a highly restricted geographic distribution. The extent of occurrence is estimated to be 885 km², based on a minimum convex polygon enclosing all mapped occurrences of the species, the method of assessment recommended by IUCN (2017). The area of occupancy is estimated to be 96 km², based on the species occupying 24 (2 km x 2 km) grid cells, the spatial scale of assessment recommended by IUCN (2017).
6. There has previously been a loss of *Grevillea raybrownii* habitat as a result of clearing for urban and rural areas. Currently, the main threat to the species is from disturbance to its remaining habitat. Many sites are near roads and along ridgetop fire trails that may be subject to road maintenance activities and clearing for infrastructure and its maintenance. Ongoing recreational pressures have damaged plants and habitat, with tracks through the habitat and rubbish dumping observed at one population near the Nattai River at Welby (S. Douglas *in litt.* Sept 2016; NSW BioNet sighting). The population in Belanglo State Forest is threatened by slashing and herbicide use for the maintenance of Asset Protection Zones (NSW BioNet sighting 2016). 'Clearing of native vegetation' is listed as a Key Threatening Process under the Act.
7. *Grevillea raybrownii* is an obligate seeder (Olde & Marriott 1994; Benson & McDougall 2000) and is threatened by high frequency fire. There is evidence that fire frequencies have been relatively high at some sites containing populations such as the Water Catchment land in the eastern part of the distribution, where hazard reduction burning is carried out regularly to protect the drinking water catchment and mining infrastructure, and at Belanglo State Forest where hazard reduction burning occurs to protect pine plantations (SEED 2018). Any future increase in fire frequency resulting from the combination of hazard reduction burning and wildfires may be detrimental to the species and its ability to regenerate after fire. 'High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition' is listed as a Key Threatening Process under the Act.
8. *Grevillea raybrownii* Olde & Marriott is not eligible to be listed as an Endangered or a Critically endangered species.
9. *Grevillea raybrownii* Olde & Marriott is eligible to be listed as a Vulnerable species as, in the opinion of the NSW Threatened Species Scientific Committee, it is facing a high risk of extinction in Australia in the medium-term future as determined in accordance with the following criteria as prescribed by the *Biodiversity Conservation Regulation 2017*:

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Clause 4.2 – Reduction in population size of species

(Equivalent to IUCN criterion A)

Assessment Outcome: Data deficient.

(1) - The species has undergone or is likely to undergo within a time frame appropriate to the life cycle and habitat characteristics of the taxon:			
	(a)	for critically endangered species	a very large reduction in population size, or
	(b)	for endangered species	a large reduction in population size, or
	(c)	for vulnerable species	a moderate reduction in population size.
(2) - The determination of that criteria is to be based on any of the following:			
	(a)	direct observation,	
	(b)	an index of abundance appropriate to the taxon,	
	(c)	a decline in the geographic distribution or habitat quality,	
	(d)	the actual or potential levels of exploitation of the species,	
	(e)	the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.	

Clause 4.3 - Restricted geographic distribution of species and other conditions

(Equivalent to IUCN criterion B)

Assessment Outcome: Vulnerable via Clause 4.3 (c*) (d) (e i, iii).

[Equivalent to Criterion B via B1ab(iii, v)+B2ab(iii, v).]

* Although *Grevillea raybrownii* meets the thresholds for highly restricted geographic distribution (EOO and AOO) for an endangered species, only at the vulnerable threshold are two of the three other required conditions met.

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

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

Assessment Outcome: Vulnerable under Clause 4.4 (c) (e i, ii A(III))
[equivalent to IUCN Criterion C via C2a(i).]

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

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

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

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Clause 4.6 - Quantitative analysis of extinction probability

(Equivalent to IUCN criterion E)

Assessment Outcome: Data deficient

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

Clause 4.7 - Very highly restricted geographic distribution of species–vulnerable species

(Equivalent to IUCN criterion D2)

Assessment Outcome: Not met.

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

Chairperson

NSW Threatened Species Scientific Committee

Supporting Document:

Scott J (2019) Conservation Assessment of *Grevillea raybrownii* Olde & Marriott (Proteaceae). Version 1.0. NSW Threatened Species Scientific Committee.

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