Conservation Assessment of *Gaultheria viridicarpa* J.B.Williams (family Ericaceae)

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NSW Threatened Species Scientific Committee

Gaultheria viridicarpa J.B.Williams (Ericaceae)
Current EPBC Act Status: *Gaultheria viridicarpa* J.B. Williams subsp. *viridicarpa* ms is listed as Vulnerable. *Gaultheria* viridicarpa subsp. *merinoensis* J.B. Williams ms is not listed.
Current NSW BC Act Status: *Gaultheria viridicarpa* J.B. Williams ms subsp. *viridicarpa* and *Gaultheria* viridicarpa subsp. *merinoensis* J.B. Williams ms are both listed as Vulnerable.
Current Queensland Nature Conservation (Wildlife) Regulation (2006) Status: *Gaultheria viridicarpa* is listed as Vulnerable.

Conservation Advice: *Gaultheria viridicarpa* J.B.Williams

Summary of Conservation Assessment

Gaultheria viridicarpa J.B.Williams was found to be eligible for listing as Endangered under IUCN Criterion B1ab(iii; v) + B2ab(iii, v).
The main reasons for this species being eligible are i) the species has a highly restricted geographical range; ii) there are a number of threats affecting both the habitat and some mature individuals at some of the populations inferring continuing decline; and (iii) the estimate of the number of locations is <5.

Description and Taxonomy

Gaultheria viridicarpa (family Ericaceae) was described in PlantNET (2018) as a "spreading low shrub 0.2–0.7 m high, spreading to c. 1.6 m dia., or sometimes slender; stems glabrous or almost so, with a few scattered bristles. Leaves narrow-elliptic to broad-ovate, 1.5–6 cm long, 6–20 mm wide, apex acute to rounded, apiculate, margins finely toothed, lamina glabrous, usually thick, leathery, the veins often impressed on upper surface; petiole 1–3 mm long. Inflorescence 1-flowered, in upper axils or in a terminal cluster or short panicle, each peduncle with a terminal flower and 4–9 bracteoles. Sepals ovate, enlarging and becoming firm-fleshy in fruit, remaining green. Corolla 4–5.5 mm long, white. Nectary a 10-lobed ring. Fruit, including the green calyx, 5–6 mm diam. when fresh."

Gaultheria viridicarpa has a complicated taxonomic history because of the widespread use of informal names and unpublished manuscript names. The taxon was originally formally described as *G. appressa* var. *glabra* but has also been called *G.* sp. A (Williams and Chapman 1992), *G.* sp. Point Lookout (J.B.Williams NE37757), *G. viridicarpa* J.B. Williams ms subsp. *viridicarpa, G. viridicarpa* J.B. Williams subsp. *viridicarpa* ms, and *G. viridicarpa* subsp. *merinoensis* J.B. Williams ms. The two subspecies of *G. viridicarpa*, though listed in the *Biodiversity Conservation Act 2016* (BC Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), were never formally described and refer to the two disjunct populations of the species; the type form in the New England/Ebor area in the Northern Tablelands of New South Wales (NSW), and the other from the Mount Merino area on the border of NSW and Queensland (Qld). Telford and Williams (2012) raised *G. appressa* var. *glabra* to species rank and created the new name *G. viridicarpa* and they did not recognise any subspecies.

Distribution and Abundance

Gaultheria viridicarpa is known from two areas separated by approximately 260 kilometres. The northernmost population occurs in the Mount Merino area, McPherson Range, on the Qld–NSW border, c. 20 km north-west of Murwillumbah. Southern populations are found from near Ebor south to Point Lookout along the Great Escarpment, c. 70 km east of Armidale (NSW). *Gaultheria viridicarpa* occurs in skeletal soils on basalt along the cliff-lines of erosional calderas of Pleistocene shield volcanoes, the former on the Tweed Volcano, the latter on the Ebor Volcano (Telford and Williams 2012).

Mount Merino population: *Gaultheria viridicarpa* is currently known to only occur along several hundred meters of clifftop in the vicinity of Mount Merino at c. 1,160 m altitude (Telford and Williams 2012). The single population is within land managed for conservation, on the boundary of Limpinwood Nature Reserve (in NSW) and Lamington National Park (in Qld). It predominantly occurs on a steep inaccessible south-facing cliff face that is frequently shrouded in cloud (Weber and Box 2016). In this habitat it commonly grows in crevices and overhangs and is restricted to three vegetation communities: in microphyll thicket within 1 m of the cliff edge where it is in low abundance; in low mossy shrubland up to 5 m down the cliff in high abundance; and in montane mossy herbfield up to 10 m down the cliff in moderate abundance (Weber and Box 2016). Associated species in the mossy montane herbfield vegetation include daisies (*Coronidium telfordii, Podolepis monticola, Olearia elliptica, Senecio amygdalifolius*), orchids (*Dendrobium kingianum*), ferns (*Polystichum fallax*), Snow Grass (*Poa sieberiana*), and shrubs (*Cuttsia viburnea* and *Prostanthera ovalifolia*).

Scattered individuals (<20) of *Gaultheria viridicarpa* occur in the vicinity of Mount Merino lookout (now closed to the public) amongst *Nothofagus* forest and open patches of habitat on the edge of the escarpment. These montane thickets include *Nothofagus moorei* suckers, *Tasmannia insipida, Leucopogon* sp. Lamington and *Cuttsia viburnea*. These shadier areas may be less optimal for growth of *G. viridicarpa* as the plants appeared to be less vigorous than those in more exposed habitats (Weber and Box 2016).

New England populations: There are three known populations of *Gaultheria viridicarpa* in the New England area. Two are within New England National Park and the third is between Ebor and Dorrigo at Allans Water, likely to be on private land. At Point Lookout and Majors Point, *G. viridicarpa* plants have been observed on rocky sites adjacent to cliff tops, in cracks in rock faces and in rock overhangs beneath cliffs at 1,400–1,560 m altitude (Telford and Williams 2012). The associated vegetation types are *Eucalyptus pauciflora* shrubby open forest with *Banksia integrifolia* subsp. *monticola*, *Ozothamnus whitei*, *Gingidia montana* and on the margin of *Nothofagus moorei* layered closed forest with *Trochocarpa montana*, *Coronidium elatum* subsp. *minus, Xerochrysum* sp. Point Lookout (I.R.Telford 12830) and *Wahlenbergia telfordii* (Telford and Williams 2012).

There is only one record of *Gaultheria viridicarpa* for Allans Water, from a collection made in 1992 (University of New England Herbarium specimen NE57394). The vegetation here was described as cool temperate rainforest dominated by *Nothofagus moorei* on the escarpment edge. Associated species include *Prostathera lasianthos* and *Pimelea* sp. Inspection of this site to determine if *G. viridicarpa* remains extant is required.

An early undated record of the species collected by C. Moore (collector lived from 1820 to 1905) was from "Summits of snowy mountains at the head of Bellenger [Bellinger] River, at an elevation of 4000 feet." (NSW Herbarium specimen, NSW 396163). This locality description would place it in the vicinity of the escarpment around the Point Lookout area.

Gaultheria viridicarpa has a highly restricted geographic distribution. The extent of occurrence (EOO) was estimated to be 635 km^2 and is 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 estimated to be between 32 and 48 km^2. This calculation was based on the species occupying 8 to 12 (2 km x 2 km) grid cells, the spatial scale of assessment recommended by IUCN (2017). The lower bound reflects the mapped database records, the upper bound includes the anecdotal evidence that the species occurs scattered around the rim of the escarpment in New England National Park from Banksia Point to Majors Point, a distance of approximately 10 km (Clarke *et al.* 2000).

Abundance

The northern area has been more thoroughly surveyed. A recent targeted survey of the Mount Merino area for *Gaultheria viridicarpa* was undertaken as part of a study of the high altitude flora in Limpinwood Nature Reserve and Lamington National Park (Weber and Box 2016). This survey recorded 998 individuals by direct counts (Weber and Box 2016). However, due to the difficulties in accessing the plants (the site was accessed by abseiling down a cliff) and in counting individual plants, the authors suggested the number of plants was best estimated to be between 500 and 1500 individuals (Weber and Box 2016). They describe the difficulties in counting individual plants: "it was difficult to count the individuals as many of the bases of the plants are obscured under moss so what appears to be two separate plants may have connecting stems. This was known in the field and efforts were made not to count closely spaced individuals in the same moss hummock as separate plants but still this may have resulted in an overestimate of the total number of genetic individuals. Other individuals may not have been seen under other vegetation or counted so this may have resulted in an underestimate of the number of plants so overall we feel that the true number of plants is likely to be between 500–1500" (Weber and Box 2016). Beyond this one area of cliff face, no further *G. viridicarpa* plants were found despite searches of nearby areas both above and on the cliff faces of the escarpment (Weber and Box 2016).

There have been no recent surveys of *Gaultheria viridicarpa* in the New England area. Clarke *et al.* (2000) concluded the total population for the New England area was "probably less than 2,000 plants". They reported it as common around the escarpment edge from Banksia Point to Majors Point (Banksia Point is approximately 500m south of Point Lookout), a distance of approximately 10 km. There was an estimate of 450 plants found at Point Lookout from a census by Williams (Clarke *et al.* 2000). Approximately 200 plants were recorded by Bale (Clarke *et al.* 2000) at the Allans Water site.

Telford and Williams (2012) state that the Point Lookout population contains several hundred plants, but the populations at Majors Point and Allans Water require further survey work to ascertain population size.

Lachlan Copeland (*in litt*. July 2018) estimates total numbers of plants to be low (he has seen no more than 100 plants at both Point Lookout and Majors Point though concedes there may be more). He recalls the species to have been quite localised at both sites along just a few hundred meters of escarpment.

Ecology

Gaultheria viridicarpa flowers in spring to early summer (PlantNET). The response of *G. viridicarpa* to fire is unknown. However, *G. appressa,* the only other species of *Gaultheria* in NSW [there are no other species in Queensland], is killed by fire and regenerates from a persistent soil seed bank (OEH Fire Response Database 2014).

The growth habit of *Gaultheria viridicarpa* plants reportedly differs between the two main areas of occurrence. It was observed that *G. viridicarpa* plants at Mount Merino had a sparsely branched erect habit with broader leaves, and often grew in hummocks of moss (Weber and Box 2016). *Gaultheria viridicarpa* plants at Point Lookout New England National Park were bushy, finely branched small rounded shrubs with narrower leaves and pendulous branches (Weber and Box 2016).

Threats

Disturbance

Mount Merino population: *Gaultheria viridicarpa* was previously only known to occur above the cliffs near the lookout and summit at Mount Merino (W. Buch *in litt.* July 2018). Until recently, it was thought the species may be extinct in Queensland as recreational pressures associated with high visitation, trampling of habitat by campers and abseilers, and previous infestations of weeds were thought to have led to the decline of the species from the Mount Merino lookout area (W. Buch pers. comm. July 2018). Even though the sensitive areas around the lookouts and Mount Merino summit have since been closed to the public for a number of years, very few (<20) *G. viridicarpa* individuals currently occur in this area (Weber and Box 2016).

Gaultheria viridicarpa is mostly confined to a steep cliff just below the escarpment rim and is inaccessible without ropes. Abseiling as a recreational activity remains a threat regardless of the restricted access (tracks were closed to limit disturbance from visitation) (W. Buch pers. comm. July 2018). In addition, care needs to be taken when abseiling during survey work to ensure the plants are not trampled or unduly disturbed. The area is also prone to landslide and cliff collapse, an event which could remove a significant portion of the population of *G. viridicarpa* (Weber and Box 2016). The risk of this occurring would be highest following very heavy rainfall events associated with cyclones and east coast lows. *Gaultheria viridicarpa* is likely to have survived and recolonised areas following these events in the past and therefore has the potential to do the same if such events occur in the future (Weber and Box 2016). However, the source of seed for past recolonization may have been from the plants growing above the cliffs, and since these plants are few in number and subject to disturbance, the degree and rate of future recolonisation may have changed and become more uncertain. The disturbed landscape left behind by landslips occurring in this area of the escarpment can become colonised by weeds notably *Lantana camara* (Lantana), *Ageratina riparia* (Mist Flower) and *A. adenophora* (Crofton Weed) (Tarvey *in litt.* August 2018), which may compete with *G. viridicarpa* during recruitment.

New England populations: The populations in New England National Park are under threat from disturbance by bushwalkers, walking track maintenance, and erosion (OEH SOS 2018b). Many of the plants are close to popular lookouts and walking tracks and may be prone to illegal collecting/wildflower picking (L. Copeland *in litt.* July 2018). There are many walking tracks through the habitat and erosion is exacerbated by high rainfall and bushwalkers walking off track. The high altitude vegetation grows relatively slowly and any damage can take a significant amount of time to recover (S Horton pers. comm. October 2018).

Weeds

Mount Merino population: The weeds recorded in the recent survey (Weber and Box 2016) were *Ageratina riparia* (Mist Flower), *A. adenophora* (Crofton Weed) and *Hypochaeris radicata* (Flat Weed). All three species are daisies with light wind-blown seeds that can reach cliff ledges and germinate and establish. In the recent survey, all weeds were present in low abundance and the *Ageratina* species appeared to be impacted by fungal biocontrol agents released by CSIRO for the control of these species (Weber and Box 2016). Mistflower is a native of Central America and was introduced to Australia in the 1870's as a garden plant. It is now an invasive weed where it competes with native vegetation and can displace native animals that rely on the habitat for food and shelter (NSW DPI 2018). Weeds were removed a few years ago from above the cliffs by Queensland National Park rangers and volunteers and have so far not returned (W. Buch pers. comm. July 2018). However, there may be a problem in the future as these weeds are seen to be encroaching up the escarpment from below. There are weeds present in the Limpinwood Nature Reserve, on the NSW side of the border, below the cliffs (W. Buch pers. comm. July 2018) and weeds are widespread in the reserve and the Border Ranges area generally making them difficult to control (J. Mallee pers. comm. August 2018). Weed seeds are likely to be blown up the escarpment whereby they may establish on the cliff face. The weeds within the *Gaultheria viridicarpa* population will be monitored, as removing them may in itself cause disturbance to the plants and their habitat (J. Mallee pers. comm. August 2018).

New England populations: *Ageratina riparia* (Mist Flower) occurs at Point Lookout and Majors Point and it is now known to be in the cliff areas. It is difficult to remove from these areas, and once established may disperse into *Gaultheria viridicarpa* habitat providing competition to *G. viridicarpa* (S. Horton *in litt.* July 2018). Weed control is one of the management actions in the 'Saving our Species' program focusing on the Point Lookout area (OEH SOS 2018b).

Climate change

Gaultheria viridicarpa grows at high elevations in mist zones receiving high rainfall (Weber and Box 2016; Horton *in litt.* July 2018) and moisture from cloud cover, making this habitat particularly sensitive to the effects of anthropogenic climate change (Laidlaw *et al*. 2011; Tanner-McAllister *et al*. 2018). With an expected increase in temperature, the elevation with cloud cover is predicted to rise in Lamington National Park (Laidlaw *et al*. 2011) exposing the habitat of *G. viridicarpa* to extended periods of drier conditions. Should predictions for rising cloud base layers under a warming climate be realised (Pounds *et al.* 1999; Richardson *et al.* 2003; Laidlaw *et al*. 2011 Tanner-McAllister *et al*. 2018), then the habitat of this species is likely to diminish over time. Changes in the timing of rainfall are predicted for the North Coast with an increase in spring and autumn rainfall and a decrease in winter rainfall (Adapt NSW 2018). The area at Mount Merino is prone to landslide and cliff collapse and the risk of this occurring would be highest following very heavy rainfall events associated with cyclones and east coast lows. The proportion of east coast lows that are of high intensity is expected to increase (Dowdy *et al.* 2015; Adapt NSW 2018; Tanner-McAllister *et al.* 2018), potentially increasing the risk of land slips. 'Anthropogenic Climate Change' is listed in the Act as a Key Threatening Process.

Other threats

The other potential threats to *Gaultheria viridicarpa* include inappropriate fire regimes and stock grazing on private land (OEH Threatened Species Profile 2018). *Gaultheria viridicarpa* should not be burnt in prescribed fires or hazard reduction burns (NSW RFS 2018).

Continuing decline
Until recently, it was not known if the population of *Gaultheria viridicarpa* was extant in the Mount Merino area. The species was known only from an area above the escarpment cliffs near a walking track and lookout. Decline of *G. viridicarpa,* and another co-occurring threatened species *Euphrasia bella,* due to recreational pressures led to the management decision to close the Mount Merino summit lookout and track. In a recent survey (Weber and Box 2016) <20 *G. viridicarpa* plants were found in this area of the summit lookout. The lookout is no longer maintained and regrowth of *Nothofagus moorei* was seen to be overshadowing the *G. viridicarpa* plants (Weber and Box 2016).

In 2016 an estimated 500–1,500 individuals of *Gaultheria viridicarpa* were found growing on the steep cliff face below the escarpment rim (Weber and Box 2016). Further monitoring is required to ascertain if there is continuing decline at this site. This site is less accessible (rope access only) and may be more protected from disturbance due to lower recreational visitation. However, *G. viridicarpa* is only found in a relatively small and restricted area and may be prone to stochastic events such as erosion and cliff collapse following heavy rainfall events. Weed encroachment is a threat as weed species can readily disperse to exposed habitat sites and become established. Abseiling as a recreational sport may also lead to disturbance of the site.

Continuing decline in the New England populations is inferred due to disturbance of the habitat from visitation, track maintenance, erosion/sedimentation, competition from weeds and the potential for illegal picking (OEH SOS 2018b; L. Copeland *in litt.* July 2018; S. Horton *in litt.* July 2018).

The habitat of *Gaultheria viridicarpa* is particularly sensitive to the effects of climate change (Laidlaw *et al*. 2011; Tanner-McAllister *et al*. 2018) and its quality and extent is predicted to decline. Such declines are thought to be due to a decrease in cloud cover (Laidlaw *et al*. 2011) leading to an increased risk of desiccation, and extreme weather events (Dowdy *et al.* 2015) may also lead to increased risk of land slippage.

Assessment against IUCN Red List criteria
For this assessment, it is considered that the survey of *Gaultheria viridicarpa* has been adequate and there is sufficient scientific evidence to support the listing outcome.

Criterion A Population Size reduction

Assessment Outcome: Data Deficient
Justification: Habitat disturbance at Mount Merino lookout and track in recent years may have led to a reduction in the population size. However, there are no data to quantify the extent of any decline in the species.

Criterion B Geographic range

Assessment Outcome: Endangered under Criterion B1ab(iii; v) + B2ab(iii, v).
Justification: *Gaultheria viridicarpa* has a highly restricted geographic range.
Extent of Occurrence: The EOO was estimated to be 635 km^2 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 <5,000 km^2. *Gaultheria viridicarpa* meets the EOO threshold for Endangered under Criterion B1.

Area of Occupancy: The AOO was estimated to be 32 – 48 km^2. This calculation was based on the species occupying 8 to 12 (2 km x 2 km) grid cells, the spatial scale of assessment recommended by IUCN (2017). The lower bound reflects the mapped database records, the upper bound includes the anecdotal evidence that the species occurs scattered around the rim of the escarpment from Banksia Point to Majors Point, a distance of approximately 10 km (OEH SOS 2018b). To be listed as Endangered under Criterion B2 a species must have an AOO of <500 km^2. *Gaultheria viridicarpa* meets the AOO threshold for Endangered under Criterion B2.

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

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

Assessment Outcome: Subcriterion met at Endangered threshold.

Justification: The best estimate for the number of locations is 4, based on the known threats at each of the four populations. Disturbance due to recreational pressures and weeds are the most likely threats for each population. Each population would be independently disturbed even though the main threats are the same. Hence each population is considered a separate location. There is insufficient information for the New England populations to ascertain if there are separate locations within each population, so it is assumed each population constitutes a separate location.

A species is considered to be severely fragmented if most of its individuals are found in small and relatively isolated subpopulations, and the subpopulations may go extinct with a reduced probability of recolonization (IUCN 2017). "If >50% of its total area of occupancy is in habitat patches that are (1) smaller than would be required to support a viable population, or (2) separated from other habitat patches by a large distance" (IUCN 2017). At least three out of four populations of *Gaultheria viridicarpa* are currently considered to support a viable population, while only one of the four populations is separated from the others by a large distance. Based on this, *Gaultheria viridicarpa* is not considered to be severely fragmented.

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) area, extent and/or quality of habitat; (v) number of mature individuals.

Justification: Continuing decline is inferred due to disturbance to *Gaultheria viridicarpa* and its habitat from visitation, track maintenance and track erosion. There is encroachment of weeds and the potential for illegal picking (OEH SOS 2018b; L. Copeland *in litt.* July 2018). The habitat of *G. viridicarpa* is particularly sensitive to the effects of climate change (Laidlaw *et al*. 2011; Tanner-McAllister *et al*. 2018) and the quality and extent of the habitat is projected to decline. The habitat is predicted to experience a decrease in cloud cover (Laidlaw *et al.* 2011) leading to an increased risk of desiccation, and extreme weather events (Dowdy *et al*. 2015) may lead to increased risk of erosion and land slippage.

Extreme fluctuations.

Assessment Outcome: Not met, Data Deficient.

Justification: Not much is known about the biology of this species. There is currently no data to assess the likelihood of extreme fluctuations in *Gaultheria viridicarpa*.

Criterion C Small population size and decline

Assessment Outcome: Vulnerable via C2(i).
Justification: The number of mature individuals is most likely to be either <2,500 (E) or <10,000 (V) but there is a level of uncertainty as only the Mount Merino population has been well surveyed. Continuing decline can be inferred (see Criterion B), and if the lower bound for the number of individuals in each population is <1,000, then C2 is met at the Vulnerable threshold via C2(i), even though the threshold for the number of mature individuals may be met at Endangered (< 2,500).

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

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

Assessment Outcome: Data Deficient

Justification: There are insufficient data to assess *Gaultheria viridicarpa* against this criterion.

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

Assessment Outcome: Subcriterion met

Justification: Recent decline is inferred in the number of individuals at the Mount Merino population due to disturbance of the area above the cliffs. This habitat is likely to be disturbed in the future if weed seed is dispersed into the area. Decline is inferred in the New England populations due to disturbance from track use, track maintenance, weeds, and possible picking of plants by visitors.

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 for 'Vulnerable' for the lower bound of abundance estimate and 'not met' at upper bound of abundance estimate.

Justification: There were just under 1,000 (998) mature individuals recorded in the recent survey of the Mount Merino population. However, due to difficulties in counting individual plants in the field, the number of plants was best estimated to be between 500 and 1,500 (Weber and Box 2016). Whilst the populations in the New England Nation Park area have not been recently surveyed, most anecdotal evidence indicates they are small (L. Copeland *in litt.* July 2018; S. Horton *in litt.* July 2018).

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

Assessment Outcome: Subcriterion not met.
Justification: No one population is known to contain >90% of mature individuals.

b. Extreme fluctuations in the number of mature individuals
Assessment Outcome: Data Deficient.
Justification: Currently there are no available data to assess the likelihood of extreme fluctuations in *Gaultheria viridicarpa.*

Criterion D Very small or restricted population

Assessment Outcome: Criterion not met
Justification: D1 and D2 were not met.

To be listed as Vulnerable under D, a species must meet at least one of the two following conditions:

D1. Population size estimated to number fewer than 1,000 mature individuals

Assessment Outcome: Not met

Justification: The total number of mature individuals of *Gaultheria viridicarpa* is estimated to be >1,000.

D2. Restricted area of occupancy (typically <20 km^2) or number of locations (typically <5) with a plausible future threat that could drive the taxon to CR or EX in a very short time.

Assessment Outcome: Not met.

Justification: There are four locations. The threat of climate change is a plausible future threat that may drive *Gaultheria viridicarpa* to be critically endangered or extinct. Temperature increases may lead to a gradual decline of the species, or a more accelerated decline if desiccation results from periods of reduced cloud cover over the highest peaks. A stochastic event such as erosion or cliff collapse at Mount Merino would be sudden and unpredictable. Landslips occur from time to time (especially after heavy rainfall events) but may increase in frequency under a changing climate. Whilst these factors may lead to the future decline of *G. viridicarpa* it may not be in a 'very short time period' as required for meeting D2.

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 *Gaultheria viridicarpa.*

Conservation and Management Actions

The following sources are available for conservation and management actions for *Gaultheria viridicarpa*:

- NSW Office of Environment and Heritage 'Saving Our Species' program for the Mount Merino population of *Gaultheria viridicarpa* (OEH SOS 2018a).
- NSW Office of Environment and Heritage 'Saving Our Species' program for the New England populations of *Gaultheria viridicarpa* (OEH SOS 2018b) (although it may not cover the full distribution of the species in the New England area).
- Commonwealth Conservation Advice listing actions for the New England populations (Department of the Environment and Energy, 2008). This can be found via the following link: http://www.environment.gov.au/biodiversity/threatened/species/pubs/67411-conservation-advice.pdf
- The survey of the Mount Merino population by Weber and Box (2016).
- The OEH species profile for *Gaultheria viridicarpa* subsp. *viridicarpa* (ie. the New England populations) lists 'activities to assist the species'.

The following actions have been compiled from the above reports:

Habitat loss, disturbance and modification

- Prevent disturbance to *Gaultheria viridicarpa* and its habitat by restricting walkers etc to established walking tracks when visiting the Mount Merino area and New England National Park and other tablelands reserves, and continue to keep the tracks to Mount Merino closed to general use
- Protect areas of potential habitat in rocky mountainous woodland and Antarctic Beech cool temperate rainforest from clearing or disturbance.
- Implement fire regime appropriate for habitat type, do not allow all individuals of *Gaultheria viridicarpa* in any one population to be burnt in a single event.
- Exclude cattle from known habitat.
- To reduce the introduction of pathogens into the area, employ appropriate on-site hygiene protocols for the Mount Merino site based on known effective techniques. This includes washing and disinfecting all equipment (including shoes, bags, climbing equipment) before entering the management site and before moving between sites.

Invasive species

Monitor weeds occurring in and adjoining the known populations. Assess the level of competition caused by weeds on *Gaultheria viridicarpa*.

Undertake fine-scale sensitive weed removal where appropriate. Sensitive hand removal of mistflower, crofton weed, flat weed and other competing weeds in and directly adjacent to the known populations, only when the benefits resulting from the removal of the weeds outweigh any further disturbance to the *Gaultheria viridicarpa* plants.

Ex situ conservation

Develop a targeted seed collection program for *ex situ* seed banking.

Maintain viable *ex situ* live and seedbank collection.

Stakeholder Management

Keep land owners and managers of sites where there are known populations of *Gaultheria viridicarpa* informed of management actions and consult with these groups regarding options for conservation management and protection of the species.

Survey and Monitoring priorities

Undertake regular surveys to determine whether there is a decline in the populations of *Gaultheria viridicarpa*. Count all individuals (or subset of individuals) and assess individual condition, growth and evidence of reproduction at all known sites.

Monitor population dynamics and threats at all known sites.

Monitor for increased habitat degradation. Monitor for erosion and sedimentation and any damage on road or track edges.

Monitor for the presence of grazing and evidence of illegal picking of *Gaultheria viridicarpa* plants.

Monitor for the presence of competing native vegetation and its potential for impacting growth and recruitment of *Gaultheria viridicarpa*.

Monitor for evidence of disease.

Survey potential areas for the presence of *Gaultheria viridicarpa,* and areas that may be suitable to establish new wild population/s.

Information and Research priorities

Undertake research into understanding recruitment, seedling survival, and pollination. Undertake seed germination and propagation trials.

Undertake research into the ecological requirements of the species including the impact of fire.

References

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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: Endangered via 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: Vulnerable via Clause 4.4 (c)(e i ii A(lll)).

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: Clause 4.6 is 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.~~