Conservation Assessment of Rhodomyrtus psidioides (G.Don) Benth (Myrtaceae)
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NSW Threatened Species Scientific Committee

***Rhodomyrtus psidioides* (G.Don) Benth (Myrtaceae)**
Distribution: NSW, Qld
Current EPBC Act Status: Not listed
Current NSW BC Act Status: Critically Endangered

Summary of Conservation Assessment
Rhodomyrtus psidioides was found to be eligible for listing as Critically Endangered under the BC Act 2016 under Clause 4.2 (equivalent to IUCN Criteria A3(e)). To be listed as threatened under Clause 4.2 the species must have experienced a population reduction of 80% (CE threshold) over three generations or 10 years (whichever is longer). The effect of *Austropuccinia psidii* (Myrtle Rust) infection on *Rhodomyrtus psidioides* is severe across the species entire range based on quantitative evidence from field surveys. A > 80% reduction in the population of *R. psidioides* across Australia over the three generations is reasonably expected given documented levels of mortality due to *A. psidii* infection and high susceptibility to *A. psidii* in both mature individuals and seedlings.

Description and Taxonomy
Rhodomyrtus psidioides (G.Don) Benth (family Myrtaceae) is described by PlantNET 2017 as a: "Shrub or small tree to 12 m high with brown scaly bark; young branchlets and inflorescences pubescent with pale hairs. Leaves with lamina narrow-ovate to elliptic or oblong, 5–25 cm long, 2.5–6.5 cm wide, apex shortly acuminate, base cuneate, upper surface glabrous and glossy, lower surface paler; lateral veins conspicuous, intramarginal vein absent; oil glands numerous and conspicuous; petiole 15–20 mm long. Flowers 5-merous, in cymes or raceme-like inflorescences; peduncles 10–25 mm long. Petals elliptic, 7–10 mm long, white or pink. Stamens up to 5 mm long. Ovary 4-locular. Berry globose or ovoid, 15–25 mm long, 10–15 mm wide, yellow and fleshy; persistent sepals reflexed near summit".

NOTE: Myrtle rust was previously known as *Puccinia psidii* (see Beenken 2017).

Distribution and abundance

Rhodomyrtus psidioides is known to occur from coastal districts of NSW north from Gosford (33.43° S, 151.34° E) to Maryborough in Queensland (25.52° S, 152.70° E). Occurrence records are typically restricted to coastal and sub-coastal areas of low elevation however the species does occur up to c. 120km inland in the Hunter and Clarence River catchments and along the Border Ranges (B. Makinson *in litt*. April 2016).
There are 763 records associated with the name *R. psidioides* in Australia in the Atlas of Living Australia (http://www.ala.org.au accessed 4/4/2018). Of these records, 208 are associated with vouchered herbarium specimens and 485 with the NSW Office of Environment & Heritage Atlas of NSW Wildlife (BioNet). All records for *R. psidioides* from Herbarium and Atlas databases were accessed and cleaned to remove duplicates and erroneous records. These cleaned records are likely to adequately capture the spatial extent of known populations however some areas of NSW may be under-sampled in the Upper Manning and Forbes River systems (B. Makinson *in litt*. April 2016).

Populations

The number of distinct populations of *R. psidioides* is unknown but is expected to be large given the wide distribution of the species. Occurrences of *R. psidioides* are contiguous along the entire range of the species with no significant disjunctions. Evidence from abundance notes accompanying vouchered herbarium specimens and observations (B. Makinson *in litt.* April 2016) infer that local populations may consist of small patches of a few dozen co-occurring mature plants. Assuming that occurrence records document individual stands a conservative measure of abundance would be approximately > 20,000 mature plants across the range of *R. psidioides* prior to the introduction of key threats affecting current populations. The actual number of *R. psidioides* populations may be or may have been considerably higher. There is clear evidence of high current rates of adult and juvenile mortality and a lack of successful seedling recruitment documented at multiple sites across the species entire range (Carnegie *et al*. 2016; Pegg *et al*. 2017; J. Neldner *in litt*. March 2018).

AOO and EOO estimates

Rhodomyrtus psidioides has a large geographic distribution.

The extent of occurrence (EOO) was estimated to be 134,428 km2. The EOO is estimated 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 884 km2. This calculation was based on the species occupying 221 (2 km x 2 km) grid cells, the spatial scale of assessment recommended by IUCN (2017).

Evidence of population decline

The 'Introduction and establishment of Exotic Rust Fungi of the order Austropucciniales pathogenic on plants of the family Myrtaceae' is listed as a Key Threatening Process under the NSW BC Act (gazetted 15/4/2011). In 2014-2015, the Commonwealth Threatened Species Scientific Committee considered a public nomination to list 'exotic rust fungi of the order Pucciniales that are pathogenic on plants of the family Myrtaceae' as a Key Threatening Process under the Environment Protection and Biodiversity Conservation Act 1999. The Committee decided that such pathogens are encompassed within the existing 'Novel biota and their impact on biodiversity' Key Threatening Process and did not prioritise the assessment.

Austropuccinia psidii was first detected in Australia on the NSW Central Coast in April 2010 and has since established in natural ecosystems throughout coastal NSW, south-east Queensland, far north Queensland (Carnegie and Lidbetter 2012; Pegg *et al.* 2014). *Austropuccinia psidii* also has a limited distribution in Victoria, Tasmania and the Northern Territory (Carnegie *et al.* 2016). *Rhodomyrtus psidioides* is a known host of *A. psidii* (Zauza *et al.* 2010).

Rhodomyrtus psidioides is a known host of *A. psidii* (Zauza *et al.* 2010) and is characterised as 'Extremely Susceptible' to *A. psidii* infection (Pegg *et al.* 2014). All plant parts have been documented as being affected by *A. psidii* infection, including leaves, stems, flowers and fruits (Pegg *et al.* 2014; Carnegie *et al.* 2016). A disease rating system documents species susceptibility to *A. psidii* infection from Relatively Tolerant to Extremely Susceptible (Pegg *et al.* 2014). Highly

susceptible species exhibit "rust sori…on 50–80% of expanding leaves and shoots, evidence of rust on juvenile stems and older leaves, leaf and stem blighting and distortion, multiple sori per leaf/stem" whereas Extremely Susceptible species exhbit "rust sori…on all expanding leaves, shoots and juvenile stems; foliage dieback; evidence of stem and shoot dieback" (Pegg *et al.* 2014).

Extensive field assessments of *A. psidii* damage on *Rhodomyrtus psidioides* across its entire range have been, and continue to be, conducted (Carnegie *et al.* 2016; Pegg *et al.* 2017; J. Neldner *in litt*. March 2018; J. Ferris *in litt*. Jan 2018). Eighteen sites in NSW were assessed for the impact of *A. psidii* on *R. psidioides* between January and October 2014, which was approximately 3-3.5 years after *A. psidii* had established across the range of this host species (Carnegie and Lidbetter 2012; Pegg *et al.* 2014). Sites were distributed between Wambina Nature Reserve near Gosford in the south to Tallebudgera Valley near Beechmont in south-east Queensland and are representative of *A. psidii* impacts across the entire range of the species. Sites were selected for assessment if they contained predominantly native vegetation and approximately 20 individuals of *R. psidioides. A. psidii* was detected as present at all sites, and no other plant disease established in Australia presents similar symptoms (Walker 1983). At all sites, approximately 20 individuals of R. psidioides were assessed for crown transparency (Schomaker *et al.* 2007) and the incidence of A. psidii (% infected) on mature leaves, immature leaves, flowers and fruit and a disease rating score of 0–4 (Pegg *et al.* 2012) was allocated. Dead trees were classed as 100% crown transparency.

The comprehensive assessments conducted by Carnegie *et al.* (2016) across the range of *R. psidioides* document very large levels of tree mortality across 15 of the 18 sites. Of the 297 trees assessed across the range of *R. psidioides* 57% surveyed were dead equating to an annualised rate of decline (r) of -0.21 across the 3.5-year study period. The generation length of *R. psidioides* is suspected to be up to 20 years (B. Makinson *in litt.*. April 2016). Using a generation time of 20 years, *R. psidioides* is projected to decline by 99% over 3 generations. Across the sites, four had 50–75% mortality, two 95% mortality, and two 100% mortality (Carnegie *et al.* 2016). Observations from botanists and seed collectors infer that *R. psidioides* populations in many of these locations were healthy prior to *A. psidii* establishment (Shaw 2015). All age classes of trees, as assessed by tree height, were similarly affected by *A. psidii* infection (Carnegie *et al.* 2016). Disease incidence was greater on immature leaves (average incidence of 94.5% (standard error 2.1%) than on mature leaves (average incidence of 38.4% (standard error 3.2%) and an average disease rating score of 3.87 (0–4 scale; standard error 0.05) was documented. *Ad hoc* observations during surveys were also made to identify regenerating seedlings and/or suckers. Few seedlings and regenerating shoots were found and those that were located showed evidence of infection with *A. psidii* and associated dieback (Carnegie *et al.* 2016). Mortality of regenerating seedlings of *R. psidioides* is documented due to *A. psidii* infection at the cotyledon stage (Pegg *et al.* 2014).

Information held by the National Environmental Science Program (NESP) database further confirms the findings of Carnegie *et al.* (2016) that *R. psidioides* is highly impacted by *A. psidii*, with a damage assessment of c. 5 (tree dead but re-sprouting with epicormic growth) (J. Willis *in litt*. April 2018). The NESP database indicates that the majority of populations where damage has been assessed have disease rating scores of 4 or above (67 of 69 populations). The majority of these damaged populations (41) occur as infected "root suckers". These "root suckers" reach a height of about 30cm before becoming infected and their longevity remains unknown. Fourteen of these populations had confirmed mortality (J. Willis *in litt.* April 2018).

Ongoing observations in 2016 of a smaller sub-sample of observed populations from Carnegie *et al.* (2016) since the end of the documented study period (2011-2014) estimate mortality has

increased to over 80% (A. Carnegie *in litt.* July 2016). Ongoing observations also indicate that there has been no evidence of regenerating populations surviving, with all seedlings/suckers observed being killed by *A. psidii* (A. Carnegie *in litt*. July 2016). Mortality in mature *R. psidioides* individuals is continuing to increase in a sub-sample of survey plots and this effect is consistent across much of the native range (A. Carnegie *in litt*. July 2016). An obvious change in species composition following mortality of *R. psidioides* has been detected in a sub-sample of surveyed plots, with the tree *Cupaniopsis anacardioides* replacing this species in some of the coastal areas and a mix of species in inland areas including weeds (including *Lantana camara*) (G. Pegg *in litt.* July 2016). Root sucker regeneration of R. psidioides has been identified at some sites in northern NSW (Shark Bay near Iluka, Shelley Beach near Ballina and Byron Bay). Preliminary findings from the Shark Bay Site have identified 80+ “root suckers" emerging under mature trees killed by *A. psidii.* All have evidence of infection present with 60% showing severe decline with all leaves killed off by *A. psidii* infection at the last assessment (June 2016). No seedlings have been identified from any of the sites (G. Pegg *in litt*. July 2016).

Quantitative findings of very large declines in *R. psidioides* populations reported in Carnegie *et al.* (2016) are supported by field botanists who have encountered the species during routine botanical surveys and seed collecting over multiple years. For example, specific comments reported about the rapid and widespread decline of the taxon in Carnegie *et al.* (2016) include:

" …*R. psidioides* [is] seriously threatened, with significant decline in all stands visited ... the worst area in the Bellinger Valley [NSW] where hundreds of plants have died." (R. Johnstone, Seed Bank Officer/Botanist, The Australian Botanic Garden Mount Annan, pers. comm to the Nominator, July 2014)

"…*R. psidioides* [has not] flowered since 2010, with…all known *R. psidioides* dead at monitoring sites" (D. Holloman, Bush Regeneration Coordinator, National Parks and Wildlife Service, pers. comm to the Nominator, May 2015).

Large reductions in population size across the range of *R. psidioides* since infection with *A. psidii* have been documented over a short period of time (57% mortality over a period of 3-3.5 years (2011 -2014)) relative to the generation length of the species. The generation length of *R. psidioides* is suspected to be up to 20 years (B. Makinson *in litt*. April 2016). Soil-stored seed banks are unlikely to be extensive for this species given its affinity for rainforest environments with high litter decomposition rates. The inferred median time to germination of seed is 3 months being described as “1-6 months” in Benson and McDougall (1998).

Based on tree mortality data from extensive field surveys (Carnegie *et al.* 2016), *ad hoc* observations of infection and mortality in regenerating shoots and seedlings (various pers. comm) and expert opinion about the apparent health of populations prior to the spread of *A. psidii* and recent declines it is estimated that *R. psidioides* has already undergone a population reduction of approximately 10% in less than five years. However, given the suspected generation length of the species and high susceptibility to *A. psidii* infection across all age-classes of the species it is reasonably suspected that declines of greater than 80% of individuals may occur within three generations.

Multiple factors indicate that the rapid decline of *R. psidioides* is likely to continue into the future. These factors include:

Lack of effective or practical control

No effective or practical chemical, biological or management control is currently available for protecting populations of *R. psidioides* in natural ecosystems from *A. psidii* infection. Repeated monthly application of registered fungicides (e.g. triadimenol) for extremely high value assets concentrated in small local areas may be feasible but is impractical for widespread control. Where triadimenol has been used in experimental trials of *A. pisdii* control in natural populations of *R. psidioides* applications repeated at longer than a monthly interval did not control infection (Carnegie *et al.* 2016). In the absence of an effective control strategy for *A. psidii* further rapid reductions of *R. psidioides* populations and individuals are highly likely.

The ubiquity of susceptible species in the family Myrtaceae in the Australian landscape makes broad-scale eradication or containment of *A. psidii* unlikely (Glen *et al.* 2007). Surviving plants and populations of *R. psidioides* will continue to be subject to spore load (whether as wind-borne spores or by other vectors) from other species which severely reduces the likelihood of population recovery (ANPC *in litt.*. April 2016). Whilst some biological control agents have been trialled in other countries to control *A. psidii* in *Eucalyptus* the plantations likelihood that these controls will become viable options for eradication in Australia in the time frame relevant to the regeneration capacity of *R. psidioides* are negligible (Glen *et al.* 2007). Manipulation of the environment via management actions (e.g. fire management) to control *A. psidii* on established trees would likely lead to high infection rates on highly susceptible resprouting leaf material (Carnegie *et al.* 2016).

Inadequate ex-situ collections

No adequate ex-situ collections of *R. psidioides* material exist (advice received G. Errington *in litt*. October 2016). Current holdings of wild-collected seed at the NSW Seedbank number < 50 seeds from few accessions, of which more than half are immature and probably non-viable, and a small number from a self-pollinated cultivated plant (the Nominator *in litt*. April 2016). A small number of *P. psidii* affected, poor quality seeds were located on a single plant of *R. psidioides* by NSW Seedbank collectors working in populations across the range of the species in NSW in recent years (G. Errington *in litt.* October 2016). Tissue culture collections are currently held within the NSW PlantBank at the Australian Botanic Garden, Mount Annan NSW. The Australian Seed Bank partnership reports that the conservation seed bank at Mt Coot-tha, Brisbane, has one batch of *R. psidioides* seed, and the Australian National Botanic Gardens, Canberra, has one batch stored since 1983 (L. Sutherland pers. comm to the ANPC April 2016).

On the basis field observations of fruit production decline since 2012, NSW Seedbank collectors do not expect to be able to find significant collectable quantities of fruit or seed of *R. psidioides* now or in the future (R. Johnstone pers. comm to the Nominator, October 2014). There are currently c. 130 root suckers being grown in at the Brisbane Herbarium (J. Willis *in litt*. April 2018).

Ecology

Rhodomyrtus psidioides flowers in late spring to early summer and produces fruits in summer (PlantNET, 2018). *R. psidioides* has been described as a pioneer species in disturbed environments (Williams and Adam 2010). The habitat of *R. psidioides* is likely to include the following vegetation types: Subtropical Rainforests, Warm Temperate Rainforests, Littoral

Rainforest, and Wet Sclerophyll Forests (Keith 2004; Floyd 2008). The species may be found in the adjoining margins of sclerophyll vegetation associated with any of these rainforest formations.

Rhodomyrtus psidioides is listed as a characteristic species in the Final Determination for the Endangered Ecological Community (EEC) 'Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Comer Bioregions' under the Act. The species is also highly likely to occur in the followings EECs listed under the Act (though is not listed as a characteristic species): 'Lowland Rainforest in the NSW North Coast and Sydney Basin Bioregions', 'Lowland Rainforest on Floodplain in the New South Wales North Coast Bioregion', and 'Subtropical Coastal Floodplain Forest of the New South Wales North Coast Bioregion'. The species may possibly occur in the following EECs listed under the TSC Act (though is not listed as a characteristic species): ''Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregion', 'River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions' and 'Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions'.

Threats

Mortality caused by infection by *Austropuccinia psidii* (see ***'Evidence of population decline'***).

It is reasonably suspected that some populations of *R. psidioides* may also have undergone decline as a result of threatening processes in the past, such as land-clearing (particularly in rainforest clearing efforts in northern NSW for agriculture), fragmentation of populations, and weed invasion. These threats have been documented as causes of decline in the EEC 'Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions' where *R. psidioides* is a named as a characteristic species (Adam 1987, 1992; Floyd 1990; Mills 1996).

Assessment against BC Act/ IUCN Red List criteria

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

Clause 4.2 – Reduction in population size of species (Equivalent to IUCN criterion A)

Assessment Outcome: Clause/Criterion met at Critically endangered threshold.
Justification: To be listed as threatened under Clause 4.2/IUCN Criteria A the species must have experienced a population reduction of 80% (CE threshold) over three generations or 10 years (whichever is longer). The effect of *Austropuccinia psidii* (Myrtle Rust) infection on *Rhodomyrtus psidioides* is severe across the species entire range based on quantitative evidence from field surveys. All age classes of *R. psidioides* have been documented to be affected by *A. psidii* (Carnegie *et al.* 2016) which severely reduces the capacity of infected populations to recover through time. Populations of *R. psidioides* are projected to continue to decline rapidly as a consequence of infection by *A. psidii*. Within three generations, assuming a generation time of 20 years, a quantitative estimate of decline of 99% has been made based on documented rates of mortality across the range.

(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) ~~(b)~~ ~~(c)~~	for critically endangered species ~~endangered species~~ ~~vulnerable species~~	a very large reduction in population size. ~~a large reduction in population size~~ ~~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: Clause/Criterion not met.

Justification: *Rhodomyrtus psidioides* has a moderately restricted geographic range but does not meet the combination of subclauses required.

Extent of Occurrence: The extent of occurrence (EOO) for *Rhodomyrtus psidioides* is estimated to be 134,428 km^2.

Area of Occupancy: The area of occupancy (AOO) for *Rhodomyrtus psidioides* is estimated to be 884 km^2 (based on the species occupying 221 (2 km x 2 km) cells, the scale of measurement recommended by IUCN 2017).

The geographic distribution of the species is:			
	~~(a)~~ ~~(b)~~ (c)	~~for~~ ~~critically endangered~~ ~~endangered species~~ vulnerable species	~~very highly restricted~~ ~~highly restricted~~ 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.~~

IUCN sub clauses

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

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

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.

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

Assessment Outcome: Clause/Criterion not met.

Justification: Although the total population of *Rhodomyrtus psidioides* is unknown, it is reasonably suspected that given the large geographic range size of the species the number of mature individuals is more than 100,000, which would exceed the threshold for VU (≥ 10,000 mature individuals).

The estimated total number of mature individuals of the species is:						
	~~(b)~~	~~for~~ ~~critically endangered species~~ ~~endangered species~~ ~~vulnerable species~~			~~very low~~ ~~low~~ ~~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):~~				
		~~(ii)~~	~~for~~ ~~critically endangered species~~ ~~endangered species~~ ~~Vulnerable species~~		~~Very large~~ ~~Large~~ ~~moderate, or~~	
	~~(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:~~		
				~~(II)~~	~~for~~ ~~critically endangered species~~ ~~endangered species~~ ~~Vulnerable species~~	~~Extremely low~~ ~~very low~~ ~~low, or~~
			~~(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.~~		

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

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

C2. An observed, estimated, projected or inferred continuing decline

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).

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

b. Extreme fluctuations in the number of mature individuals

Clause 4.5 - Low total numbers of mature individuals of species (Equivalent to IUCN criterion D)

Assessment Outcome: Clause/Criterion not met.

Justification: The total number of mature individuals of *Rhodomyrtus psidioides* is unknown but is estimated to be more than 100,000. To be listed under Criterion D1 a species must have <1000 mature individuals.

The total number of mature individuals of the species is:			
	~~(b)~~	~~for~~ ~~critically endangered species~~ ~~endangered species~~ ~~Vulnerable species~~	~~Extremely low~~ ~~very low~~ ~~low.~~

IUCN sub clauses
To be listed as Vulnerable, a species must meet at least one of the two following conditions:

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

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.

Clause 4.6 - Quantitative analysis of extinction probability

Assessment Outcome: Data Deficient.

Justification: Currently there is not enough data to undertake a quantitative analysis to determine the extinction probability of *Rhodomyrtus psidioides*

The probability of extinction of the species is estimated to be:			
	~~(b)~~	~~for~~ ~~critically endangered species~~ ~~endangered species~~ ~~Vulnerable species~~	~~Extremely high~~ ~~very high.~~ ~~High~~

Conservation and Management Actions

There is no current NSW Saving Our Species site-managed program for *Rhodomyrtus psidioides*. The following actions are derived from threat information.

Habitat loss, disturbance and modification

- Develop hygiene protocols to minimise spread of Myrtle Rust.

Invasive species

- Weed control measures at known sites must ensure adequate hygiene protocols to minimise spread of Myrtle Rust.

Ex situ conservation

- Support continued seed storage enablement study in train at NSW PlantBank.
- Secure germplasm (high quantity, geographically and genetically representative).
- Secure germplasm of any detected or suspected resistant individuals.

Stakeholder Management

- Inform land owners and managers of sites, particularly private land holders, mining and State Forests, where there are known populations and consult with these groups regarding options for conservation management and protection of the species and identification of occurrence of myrtle rust.
- Provide up to date information on best phytosanitory practices for reducing risk of spread of myrtle rust.

Survey and Monitoring priorities

- Establish permanent monitoring sites to track decline (utilising Carnegie *et al.* (2016) sites and permanent plot/transect sites).
- Conduct field survey for, and monitoring of, populations exhibiting low levels of Myrtle Rust infection or resistance (especially inland occurrences near and on the Great Escarpment).

Information and Research priorities

- Seek resources for genetic and physiological research into the resistance and susceptibility of *Rhodomyrtus psidioides to Austropuccinia psidii*.
- Understand the best techniques for long term seed and tissue storage. Investigate and implement options for tissue culture and/or inter-situ live collections (in sites amenable to fungicidal management), as alternatives to seed banking if the species proves storage-intolerant, and/or as resources for seed production and resistance studies.

References

Adam P (1987) New South Wales rainforests. The nomination for the World Heritage List. NPWS, Sydney.

Adam P (1992) 'Australian rainforests'. (Oxford University Press: Oxford, UK).

Beenken L (2017) *Austropuccinia*: a new genus name for the myrtle rust *Puccinia psidii* placed within the redefined family Sphaerophragmiaceae (Pucciniales). Phytotaxa 297 doi: 10.11646/phytotaxa.297.1.5

Benson D, McDougall L (1998) Ecology of Sydney plants. Part 6: Dicotyledon family Myrtaceae. Cunninghamia 5, 809–986.

Carnegie AJ, Lidbetter JR (2012) Rapidly expanding host range for Austropuccinia psidii sensu lato in Australia. *Australasian Plant Pathology* **41**, 13–29.

Carnegie AJ, Kathuria A, Pegg GS, Entwistle P, Nagel M, Giblin FR (2016) Impact of the invasive rust Austropuccinia psidii (myrtle rust) on native Myrtaceae in natural ecosystems in Australia. *Biological Invasions* **18**, 127–144.

Floyd AG (2008) 'Rainforest trees of mainland south-eastern Australia. (Terania Rainforest Publishing: Lismore, New South Wales).'

Floyd AG (1990) Australian rainforests in New South Wales. Surrey Beatty and Sons, Sydney.

Glen M, Alfenas AC, Zauza EA V, Wingfield MJ, Mohammed C (2007) Austropuccinia psidii: a threat to the Australian environment and economy- a review. *Australasian Plant Pathology* **36**, 1–16

Harden G (1991) Flora of New South Wales. Volume 2. (UNSW Press: Sydney, NSW).

IUCN Standards and Petitions Subcommittee (2016) Guidelines for Using the IUCN Red List Categories and Criteria. Version 12. Prepared by the Standards and Petitions Subcommittee. http://www.iucnredlist.org/documents/RedListGuidelines.pdf.

IUCN (2001) 'IUCN Red List Categories and Criteria: Version 3.1.' (IUCN Species Survival Commission: Switzerland)

Junghans DT, Alfenas AC, Brommonshenckel SH, Oda S, Mello EJ, Grattapaglia D (2003) Resistance to rust (*Austropuccinia psidii* Winter) in *Eucalyptus*: mode of inheritance and mapping of a major gene with RAPD markers. Theoretical and Applied Genetics **108,**175-180.

Keith D (2004) 'Ocean shores to desert dunes - the native vegetation of New South Wales and the ACT'. (NSW Department of Environment and Conservation: Hurstville, NSW).

Mills K (1996) Littoral Rainforests in Southern NSW: inventory, characteristics and management. Revised version of 1988 Illawarra Vegetation Studies, Paper 1.

Pegg GS, Perry S, Carnegie AJ, Ireland K, Giblin F (2012) Understanding myrtle rust epidemiology and host specificity to determine disease impact in Australia. Cooperative Research Centre for National Plant Biosecurity Report, CRC70186.

Pegg GS, Giblin FR, McTaggart AR, Guymer GP, Taylor H, Ireland KB, Shivas RG, Perry S (2014) *Austropuccinia psidii* in Queensland, Australia: disease symptoms, distribution and impact. *Plant Pathology* **63**, 1005–1021.

Schomaker ME, Zarnoch SJ, Bechtold WA, Latelle DJ, Burkman WG, Cox SM (2007) Crown-condition classification: a guide to data collection and analysis. General Technical Report SRS-102. U.S. Department of Agriculture, Forest Service, Southern Research Station, Asheville

Sommerville KD, Offord CA (2014) Ex situ conservation techniques for Australian rainforest species. In XXIX International Horticultural Congress on Horticulture: Sustaining Lives, Livelihoods and Landscapes IV 1101 (pp. 75–80).

Walker J (1983) Pacific mycogeography: deficiencies and irregularities in the distribution of plant parasitic fungi. *Australian Journal of Botany* **10**, 89–136

Williams G, Adam P (2010) 'The flowering of Australia's rainforests: a plant and pollination miscellany (CSIRO Publishing: Clayton, Victoria)

Zauza EA, Alfenas AC, Old K, Couto MM, Graça RN, Maffia LA (2010) Myrtaceae species resistance to rust caused by *Austropuccinia psidii*. *Australasian Plant Pathology* **39**, 406–411.

Databases accessed

AVH (2017). Australia's Virtual Herbarium, Council of Heads of Australasian Herbaria, http://avh.chah.org.au. Accessed (23/3/2017).

Atlas of Living Australia website at http://www.ala.org.au (23/3/2017).

PlantNET (The NSW Plant Information Network System) Royal Botanic Gardens and Domain Trust, Sydney
http://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&lvl=sp&name=Rhodomyrtus~psidioides (accessed 23/3/2017)

Expert Communications

Angus Carnegie, July 2016

Graeme Errington, October 2016

Geoffrey Pegg, July 2016

M. Smith, August 2016

John Neldner, March 2018

Jason Ferris, January 2018

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Exhibition period: 01/02/19 – 29/03/19 Proposed Listing date: 01/02/19

Notice of and reasons for the Final Determination

The NSW Threatened Species Scientific Committee, established under the *Biodiversity Conservation Act 2016* (the Act), has made a Final Determination to list the tree *Rhodomyrtus psidioides* (G.Don) Benth. as a CRITICALLY ENDANGERED SPECIES in Part 1 of Schedule 1 of the Act. Listing of Critically Endangered species is provided for by Part 4 of the Act.

Summary of Conservation Assessment

Rhodomyrtus psidioides is eligible for listing as Critically endangered under Clause 4.2 (a) (e) because: i) the species is projected to experience a population reduction of > 80% (CR threshold) over three generations or 10 years due to the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.

The NSW Threatened Species Scientific Committee has found that:

1. *Rhodomyrtus psidioides* (G.Don) Benth. (family Myrtaceae) is described as a: "Shrub or small tree to 12 m high with brown scaly bark; young branchlets and inflorescences pubescent with pale hairs. Leaves with lamina narrow-ovate to elliptic or oblong, 5–25 cm long, 2.5–6.5 cm wide, apex shortly acuminate, base cuneate, upper surface glabrous and glossy, lower surface paler; lateral veins conspicuous, intramarginal vein absent; oil glands numerous and conspicuous; petiole 15–20 mm long. Flowers 5-merous, in cymes or raceme-like inflorescences; peduncles 10–25 mm long. Petals elliptic, 7–10 mm long, white or pink. Stamens up to 5 mm long. Ovary 4-locular. Berry globose or ovoid, 15–25 mm long, 10–15 mm wide, yellow and fleshy; persistent sepals reflexed near summit" (PlantNET 2018).

2. *Rhodomyrtus psidioides* is currently known to occur from Broken Bay, approximately 90 km north of Sydney, New South Wales (NSW), to Maryborough in Queensland. Populations are typically restricted to coastal and sub-coastal areas of low elevation however the species does occur up to c. 120 km inland in the Hunter and Clarence River catchments and along the Border Ranges in NSW.

3. *Rhodomyrtus psidioides* flowers in late spring to early summer, producing fruits in summer (PlantNET 2018). *Rhodomyrtus psidioides* is known to occur in rainforest and adjoining margins of sclerophyll vegetation, often near creeks and drainage lines. The species has been described as a pioneer species in disturbed environments (Williams and Adam 2010) and is locally common in disturbed areas, such as regrowth and rainforest margins. Suitable habitat for *R. psidioides* is likely to occur in the following vegetation types: Subtropical Rainforests, Warm Temperate Rainforests, Littoral Rainforests, and Wet Sclerophyll Forests (Keith 2004; Floyd 2008). The species has been documented occurring in association with *Acacia bakeri*, *Archontophoenix cunninghamiana*, *Argyrodendron* spp., *Calamus* spp., *Cryptocarya laevigata*, *Elaeocarpus grandis*, *Elaeocarpus kirtonii*, *Glochidion sumatranum*, *Livistona australis*, *Lophostemon confertus*, *Orites excelsa* and *Pilidiostigma rhytispermum*.

4. *Rhodomyrtus psidioides* is listed as a characteristic species in the Final Determination for the Endangered Ecological Community (EEC) 'Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions' under the Act. The species is also highly likely to occur in the followings EECs listed under the Act (though is not listed as a

characteristic species): 'Lowland Rainforest in the NSW North Coast and Sydney Basin Bioregions', 'Lowland Rainforest on Floodplain in the New South Wales North Coast Bioregion', and 'Subtropical Coastal Floodplain Forest of the New South Wales North Coast Bioregion'. The species may possibly occur in the following EECs listed under the Act (though is not listed as a characteristic species): 'Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregion', 'River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions' and 'Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions'.

5. *Rhodomyrtus psidioides* has moderately restricted geographic range. The estimated extent of occurrence (EOO) of *R. psidioides* is 134,428 km^2. The EOO is based on a minimum convex polygon enclosing all occurrences of the species, the method of assessment recommended by IUCN (2017). The area of occupancy (AOO) is estimated as 884 km^2 based on 2 km x 2 km grid cells, the scale recommended for assessing AOO by IUCN (2017).

6. The number of mature individuals of *Rhodomyrtus psidioides* is currently unknown, but reasonably expected to be > 20,000 individuals. No formal estimates of total abundance of *R. psidioides* across its range or of extinction-risk status prior to 2010 have been located (B. Makinson *in litt*. April 2016). Evidence from abundance notes accompanying vouchered herbarium specimens and field observations (B. Makinson *in litt*. April 2016) infer that local populations may consist of small patches of a few dozen co-occurring mature plants.

7. The survival of *Rhodomyrtus psidioides* is severely threatened by infection from the exotic rust fungus *Austropuccinia psidii* (Myrtle Rust). The 'Introduction and establishment of Exotic Rust Fungi of the order Austropucciniales pathogenic on plants of the family Myrtaceae' is listed as a Key Threatening Process under the Act. *Austropuccinia psidii* was first detected in Australia on the NSW Central Coast in April 2010 and has since established in natural ecosystems throughout coastal NSW, south-east Queensland and far north Queensland (Carnegie and Lidbetter 2012; Pegg et al. 2014). *Austropuccinia psidii* also has a limited distribution in Victoria, Tasmania and the Northern Territory (Carnegie *et al*. 2016).

8. *Rhodomyrtus psidioides* is a known host of *Austropuccinia psidii* (Zauza *et al*. 2010) and is characterised as 'Extremely Susceptible' to *A. psidii* infection (Pegg *et al*. 2014). All plant parts have been documented as being affected by *A. psidii* infection, including leaves, stems, flowers and fruits (Pegg *et al*. 2014; Carnegie *et al.* 2016). The disease rating system of Pegg *et al*. (2014) documents species susceptibility to *A. psidii* infection along a continuum from 'Relatively Tolerant' to 'Extremely Susceptible'. 'Extremely Susceptible' species exhibit "rust sori…on all expanding leaves, shoots and juvenile stems; foliage dieback; evidence of stem and shoot dieback" (Pegg *et al.* 2014).

9. Extensive field assessments of *Austropuccinia psidii* damage on *Rhodomyrtus psidioides* across its entire range show infection is widespread and severe (Carnegie *et al*. 2016; J. Willis *in litt*. April 2018). Carnegie *et al*. (2016) assessed 18 sites for the impact of *A. psidii* on *R. psidioides* between January and October 2014, approximately 3–3.5 years after *A. psidii* had established across the range of this host species. Sites were distributed between Wambina Nature Reserve, near Gosford in NSW, to Tallebudgera Valley, near Beechmont, in south-east Queensland. Sites were a mixture of locations where *A. psidii* infection on *R. psidioides* was already known to occur, and sites where no known infection had been documented (A. Carnegie *in litt*. July 2016). *Austropuccinia psidii* was detected as present on *R. psidioides*

plants in a range of age classes at all sites, and no other plant disease established in Australia presents similar symptoms (Walker 1983). At all sites, approximately 20 individuals of *R. psidioides* were assessed for crown transparency using the scheme of Schomaker *et al*. (2007), the incidence of *A. psidii* (% infected) on mature leaves, immature leaves, flowers and fruit and rated for disease prevalence using the scheme in Pegg *et al.* (2012). Individuals were considered dead when crown transparency reached 100%. These comprehensive assessments of populations document mortality in *R. psidioides* across 15 of the 18 sites. Of the 297 trees assessed, 57% surveyed were dead (100% crown transparency), with four sites having 50–75% mortality, two sites with 95% mortality, and two sites with 100% mortality (Carnegie *et al*. 2016). Observations from botanists and seed collectors infer that *R. psidioides* populations in many of these locations were healthy prior to *A. psidii* establishment (Shaw 2015). All age classes of trees, as assessed by tree height, were similarly affected by *A. psidii* infection (Carnegie *et al.* 2016). Disease incidence was greater on immature leaves (average incidence of 94.5%; standard error 2.1%) than on mature leaves (average incidence of 38.4%; standard error 3.2%) and an average disease rating score of 3.87 (0–4 scale; standard error 0.05) was documented. *Ad hoc* observations during surveys were also made to identify regenerating seedlings and/or suckers. Few seedlings and regenerating shoots of *R. psidioides* were found and those that were located showed evidence of infection with *A. psidii* and associated dieback (Carnegie *et al*. 2016).

10. Ongoing observations in 2016 of a smaller sub-sample of observed populations from Carnegie *et al*. (2016) since the end of the documented study period (2011–2014) estimate mortality has increased to over 80% (A. Carnegie *in litt.* July 2016). Ongoing observations also indicate that there has been no evidence of regenerating populations surviving, with all seedlings/suckers observed being killed by *A. psidii* (A. Carnegie *in litt*. July 2016). Root sucker regeneration of *R. psidioides* has been identified at some sites in northern NSW (e.g. Shark Bay near Iluka, Shelley Beach near Ballina) (G. Pegg *in litt*. July 2016). However, of the >80 root suckers at the Shark Bay population 60% showed severe decline with all leaves lost to *A. psidii* infection at the last assessment (June 2016). No seedlings have been identified from any of the sites. The continued, rapid decline of mature plants and lack of successful regeneration severely threaten the long-term viability of *R. psidioides* in the wild.

    Populations of *Rhodomyrtus psidioides* are projected to continue to decline rapidly due to infection by *Austropuccinia psidii*. Large reductions in population size across the range of *R. psidioides* since infection from *A. psidii* have been documented over a short period of time (57% mortality over a period of 3–3.5 years (2011–2014)) relative to the estimated generation length of the species of 20 years (B. Makinson *in litt*. April 2016). Soil-stored seed banks are unlikely to be extensive for this species given its affinity for rainforest environments with high litter decomposition rates. Under documented rates of decline due to infection by *A. psidii*, *R. psidioides* is projected to undergo a 99% reduction in population size across its range within three generations. All age classes of *R. psidioides* have been documented to be affected by *A. psidii* (Carnegie *et al*. 2016) which severely reduces the capacity of infected populations to recover through time.

11. Quantitative findings of very large declines in *Rhodomyrtus psidioides* populations due to *Austropuccinia psidii* infection reported in Carnegie *et al*. (2016) are supported by field botanists who have encountered the species during routine botanical surveys and seed collecting over multiple years (B. Makinson *in litt*. April 2016; J. Willis *in litt*. April 2018).

12. There has been little evidence of resistance to *Austropuccinia psidii* infection in populations of *Rhodomyrtus psidioides* to date (Pegg *et al*. 2014; J. Willis *in litt*. April 2018). Three individual plants in the Gold Coast region of Queensland have shown some evidence of resistance to *A. psidii* infection (J. Willis *in litt*. April 2018), however the prospect for naturally selected resistance emerging before the collapse of populations is currently considered small.

13. No effective or practical chemical, biological or management control is currently available for protecting populations of *Rhodomyrtus psidioides* in natural ecosystems from *Austropuccinia psidii* infection. Repeated monthly application of registered fungicides (e.g. triadimenol) for extremely high value assets concentrated in small local areas may be feasible, but is impractical for widespread control. Where triadimenol has been used in experimental trials of *A. psidii* control in natural populations of *R. psidioides*, applications repeated at longer than a monthly interval did not control infection (Carnegie *et al*. 2016). Whilst some biological control agents have been trialled to control *A. psidii* in Eucalyptus plantations overseas the likelihood that these controls will become viable options for eradication in Australia in the time frame relevant to the regeneration capacity of *R. psidioides* is negligible (Glen *et al*. 2007). Manipulation of the environment via management actions (e.g. fire management) to control *A. psidii* on *R. psidioides* would likely lead to high infection rates on resprouting leaf material which is known to be highly susceptible to infection (Carnegie *et al*. 2016). In the absence of an effective control strategy for *A. psidii* further rapid declines of *R. psidioides* populations and individuals are highly likely.

14. The ubiquity of susceptible species in the family Myrtaceae in the Australian landscape makes broad-scale eradication or containment of *Austropuccinia psidii* unlikely (Glen *et al*. 2007). The predominantly airborne nature of the rust spores and inadvertent dispersal by human activity (Carnegie and Cooper 2011) infers that *Rhodomyrtus psidioides* populations and individuals in conservation reserves may be no more secure than any other land tenure. It is expected that surviving plants and populations of *R. psidioides* will continue to be subject to a significant spore load, whether as wind-borne spores or by other vectors. This continued exposure severely reduces the likelihood of population recovery in *R. psidioides* (B. Makinson *in litt*. April 2016).

15. No adequate *ex-situ* collections of *Rhodomyrtus psidioides* material exist (G. Errington *in litt*. October 2016). Current holdings of wild-collected seed at the NSW Seedbank number < 50 seeds from few accessions, of which more than half are immature and probably non-viable, and a small number from a self-pollinated cultivated plant (B. Makinson *in litt*. April 2016). The Australian Seed Bank partnership reports that the conservation seed bank at Mt Coot-tha, Brisbane, has one batch of *R. psidioides* seed, and the Australian National Botanic Gardens, Canberra, has one batch stored since 1983 (B. Makinson *in litt.* April 2016). On the basis that field observations show a severe decline in fruit production since 2012, NSW Seedbank collectors do not expect to be able to find significant collectable quantities of fruit or seed of *R. psidioides* now or in the future (R. Johnstone *in litt*. October 2014). Some tissue culture collections are currently held within the NSW PlantBank at the Australian Botanic Garden, Mount Annan NSW.

16. It is reasonably suspected that some populations of *Rhodomyrtus psidioides* may also have undergone significant decline because of other past and current threats, such as land-clearing (particularly in rainforest clearing efforts in northern NSW for agriculture), fragmentation of populations, and weed invasion. These threats have been documented as causes of decline in the EEC 'Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South

East Comer Bioregions' where *R. psidioides* is a named as a characteristic species (Adam 1987, 1992; Floyd 1990; Mills 1996).

17. *Rhodomyrtus psidioides* (G.Don) Benth. is eligible to be listed as a Critically Endangered species as, in the opinion of the NSW Threatened Species Scientific Committee, it is facing an extremely high risk of extinction in Australia in the immediate future as determined in accordance with the following criteria as prescribed by the *Biodiversity Regulation 2017*:

Clause 4.2 – Reduction in population size of species
(Equivalent to IUCN criterion A)
Assessment Outcome: Critically endangered under Clause 4.2 (a).

(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, or~~
(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: not met.

The geographic distribution of the species is:			
	~~for~~ ~~(a)~~ ~~(b)~~ (c)	~~for~~ ~~critically endangered~~ ~~endangered species~~ vulnerable species	~~very highly restricted~~ ~~highly restricted~~ 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: not met.

The estimated total number of mature individuals of the species is:						
	~~(b)~~	~~for~~ ~~critically endangered species~~ ~~endangered species~~ ~~vulnerable species~~			~~very low~~ ~~low~~ ~~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):~~				
		~~(ii)~~	~~for~~ ~~critically endangered species~~ ~~endangered species~~ ~~Vulnerable species~~		~~Very large~~ ~~Large~~ ~~moderate, or~~	
	~~(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:~~		
				~~(II)~~	~~for~~ ~~critically endangered species~~ ~~endangered species~~ ~~Vulnerable species~~	~~Extremely low~~ ~~very low~~ ~~low, or~~
			~~(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:			
	~~(b)~~	~~for~~ ~~critically endangered species~~ ~~endangered species~~ ~~Vulnerable species~~	~~Extremely low~~ ~~very low~~ ~~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:			
	~~(b)~~	~~for~~ ~~critically endangered species~~ ~~endangered species~~ ~~Vulnerable species~~	~~Extremely high~~ ~~very high.~~ ~~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.~~

Dr Marco Duretto
Chairperson
NSW Threatened Species Scientific Committee

References:

Adam P (1987) New South Wales Rainforests. National Parks & Wildlife Service of NSW.

Adam P (1992) 'Australian rainforests'. (Oxford University Press: Oxford, UK).

Carnegie AJ, Cooper K (2011) Emergency response to the incursion of an exotic myrtaceous rust in Australia. *Australasian Plant Pathology* **40**, 346–359.

Carnegie AJ, Lidbetter JR (2012) Rapidly expanding host range for *Austropuccinia psidii* sensu lato in Australia. *Australasian Plant Pathology* **41**, 13–29.

Carnegie AJ, Kathuria A, Pegg GS, Entwistle P, Nagel M, Giblin FR (2016) Impact of the invasive rust *Austropuccinia psidii* (myrtle rust) on native Myrtaceae in natural ecosystems in Australia. *Biological Invasions* **18**, 127–144.

Floyd AG (1990) Australian rainforests in New South Wales. Surrey Beatty and Sons, Sydney.

Floyd AG (2008) Rainforest trees of mainland south-eastern Australia. (Terania Rainforest Publishing: Lismore, New South Wales).

Glen M, Alfenas AC, Zauza EAV, Wingfield MJ, Mohammed C (2007) *Austropuccinia psidii*: a threat to the Australian environment and economy- a review. *Australasian Plant Pathology* **36**, 1–16.

IUCN Standards and Petitions Subcommittee (2016) Guidelines for Using the IUCN Red List Categories and Criteria. Version 12. Prepared by the Standards and Petitions Subcommittee. http://www.iucnredlist.org/documents/RedListGuidelines.pdf

Keith D (2004) 'Ocean shores to desert dunes - the native vegetation of New South Wales and the ACT'. (NSW Department of Environment and Conservation: Hurstville, NSW).

Mills K (1996) Littoral Rainforests in Southern NSW: inventory, characteristics and management. Revised version of 1988 Illawarra Vegetation Studies, Paper 1.

Pegg GS, Perry S, Carnegie AJ, Ireland K, Giblin F (2012) Understanding myrtle rust epidemiology and host specificity to determine disease impact in Australia. Cooperative Research Centre for National Plant Biosecurity Report, CRC70186.

Pegg GS, Giblin FR, McTaggart AR, Guymer GP, Taylor H, Ireland KB, Shivas RG, Perry S (2014) *Austropuccinia psidii* in Queensland, Australia: disease symptoms, distribution and impact. *Plant Pathology* **63**, 1005–1021.

PlantNET (The NSW Plant Information Network System) Royal Botanic Gardens and Domain Trust, Sydney. http://plantnet.rbgsyd.nsw.gov.au (accessed 4th April, 2018).

Shaw S (2015) Focus on Flora: *Rhodomyrtus psidioides*, Native Guava. Sunshine Coast Bush Hands, Summer 2015, p 3. http://www.sunshinecoast.gld.gov.au/sitePage.cfm?code=bushhands

Schomaker ME, Zarnoch SJ, Bechtold WA, Latelle DJ, Burkman WG, Cox SM (2007) Crown-condition classification: a guide to data collection and analysis. General Technical Report SRS-102. U.S. Department of Agriculture, Forest Service, Southern Research Station, Asheville

Walker J (1983) Pacific mycogeography: deficiencies and irregularities in the distribution of plant parasitic fungi. *Australian Journal of Botany* **10**, 89–136

Williams G, Adam P (2010) 'The flowering of Australia's rainforests: a plant and pollination miscellany' (CSIRO Publishing: Clayton, Victoria)

Zauza EA, Alfenas AC, Old K, Couto MM, Graça RN, Maffia LA (2010) Myrtaceae species resistance to rust caused by *Austropuccinia psidii*. *Australasian Plant Pathology* **39**, 406–411.