Conservation Assessment of Rhodamnia rubescens (Benth.) Miq. (Myrtaceae)
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NSW Threatened Species Scientific Committee

(revised with advice from CTSSC and Qld, October 2018)

***Rhodamnia rubescens* (Benth.) Miq. (Myrtaceae)**
Distribution: NSW, Qld
Current EPBC Act Status: Not listed
Current NSW BC Act Status: Not listed (Preliminary Determination to list as Critically Endangered made under BC Act)

**Summary of Conservation Assessment**
*Rhodamnia rubescens* 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% (CR threshold) over three generations or 10 years (whichever is longer). The effect of *Austropuccinia psidii* (Myrtle Rust) infection on *R. rubescens* is severe across the species entire range based on quantitative evidence from field surveys. An > 80% reduction in the population of *R. rubescens* across Australia over the three generations is projected 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**
*Rhodamnia rubescens* (Benth.) Miq. (family Myrtaceae) is described by PlantNET as:
"Shrub or small tree to 25 m high, bark reddish brown, fissured; young stems densely tomentose. Leaves with lamina ovate to elliptic, 5–10 cm long, 2–4.5 cm wide, shortly acuminate, base cuneate to rounded, upper surface green and sparsely hairy, lower surface paler and sparsely to densely hairy with erect hairs; strongly 3-veined from base, lateral veins transverse; oil glands distinct, moderately dense; petiole 4–9 mm long. Inflorescences 1–3 per axil, each usually 3-flowered; peduncle 5–22 mm long. Hypanthium sparsely pubescent. Sepals 2–3 mm long, caducous. Petals 4–6 mm diam., white. Stamens 3–5 mm long. Style 4–5 mm long. Fruit globose, 5–8 mm diam., red turning black."

Synonyms: *Rhodamnia trinervia* (Sm.) Blume, *Monoxora rubescens* Benth.

Common name: Scrub Turpentine, Brown Malletwood

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

**Distribution and abundance**

*Rhodamnia rubescens* is known to occur from coastal districts of NSW north from Batemans Bay (35.71° S, 150.18° E) to Bundaberg in Queensland (24.86° S, 152.35° E). The distribution of *R. rubescens* occasionally extends inland onto the escarpment up to 600 m a.s.l. in areas with rainfall of 1,000-1,600 mm (Benson & McDougall 1998).

There are 2,740 records associated with the name *R. rubescens* in Australia in the Atlas of Living Australia (http://www.ala.org.au accessed 4/4/2018). Of these records, 329 are associated with

vouchered herbarium specimens and 2,266 with the NSW Office of Environment & Heritage Atlas of NSW Wildlife (BioNet). All records for *R. rubescens* from Herbarium and Atlas databases were accessed and cleaned to remove duplicates and erroneous records. Note that two records from the Wet Tropics region of Queensland were assumed to be incorrectly identified as this species is not known to occur north of Gympie (Floyd 2008).

***Populations***

The number of distinct populations of *Rhodamnia rubescens* is unknown but is expected to be large given the wide distribution of the species. Occurrences of *R. rubescens* are contiguous along the entire range of the species with no significant disjunctions.

No formal estimates of total abundance of *Rhodamnia rubescens* across the range of the species, or of extinction-risk status prior to 2010, have been located (Australian Network for Plant Conservation, *in litt*. April 2016). It is reasonably suspected that given the large geographic range size of *R. rubescens* and its characterisation as a 'common' species (Benson and McDougall 1998; Floyd 2008) that the number of mature individuals may be large (i.e., not < 10,000, the IUCN threshold for Vulnerable). However, there is clear evidence of *R. rubescens* mortality and a lack of successful seedling recruitment due to infection by *Austropuccinia psidii* 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***

*Rhodamnia rubescens* has a large geographic distribution.

The extent of occurrence (EOO) was estimated to be 147,340 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 3,360 km2. This calculation was based on the species occupying 840 (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 and

far north Queensland and has a limited distribution in Victoria, Tasmania and the Northern Territory (Carnegie and Lidbetter 2012; Pegg *et al.* 2014).

*Rhodamnia rubescens* is a known host of *A. psidii* (Zauza *et al.* 2010) and is characterised as 'Highly to Extremely Susceptible' to 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 exhibit "rust sori…on all expanding leaves, shoots and juvenile stems; foliage dieback; evidence of stem and shoot dieback" (Pegg *et al.* 2014). A susceptibility study of wild-collected seed of *R. rubescens* to *A. psidii* inoculation documented 60.5% of *R. rubescens* seedlings as being resistant to infection (Zauza *et al.* 2010). The fungal isolate used in this glasshouse trial (UFV-02 (Race 1; Junghans *et al.* 2003) has not been confirmed as the strain of *A. psidii* that is currently present in Australia. No significant variation in susceptibility of populations of *R. rubescens* has been noted in field surveys (Carnegie *et al.* 2016). However, field surveys have detected relatively healthy individual *R. rubescens* plants in some locations which could be targeted for additional research (J. Willis *in litt.* April 2018).

Extensive field assessments of *A. psidii* damage on *R. rubescens* 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; J. Willis *in litt*. April 2018). Carnegie *et al.* (2016) surveyed forty-three sites to assess for the impact of *A. psidii* on *R. rubescens* 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 Murramarang National Park near Batemans Bay, NSW in the south, to Traveston Crossing near Gympie, Queensland, in the north and are representative of *A. psidii* impacts across the population. Sites were selected for assessment if they contained predominantly native vegetation and approximately 20 individuals of *R. rubescens*. *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. rubescens* 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. rubescens* document large levels of tree mortality across sites. Mortality of *R. rubescens* was recorded across 18 of the 43 sites. Most sites contained only a few dead trees with the following exceptions: five sites had between 20 and 40% mortality, one site with 50% mortality and one site with 75% mortality (Carnegie *et al.* 2016). Across all sites mean crown transparency was 76.3% (standard error 0.8%), with the majority (79%) of trees having greater than 60% transparency. Based on prior knowledge of the species the normal crown transparency in an understorey is approximately 30-35% (Carnegie *et al.* 2016).

Of the 669 trees assessed across the range of *R. rubescens* by Carnegie *et al.* (2016), 12% were dead (77 individuals) equating to an annualised rate of decline (r) of -0.03 across the 3.5-year study period. The generation length of *R. rubescens* is suspected to be at least 30-40 years given the

height (> 25 m) which the species can attain (Floyd 2008). Using a generation time of 30-40 years, *R. rubescens* is projected to decline by 96-99% over 3 generations.

All age classes of trees and plant parts were affected by *A. psidii* infection (Carnegie *et al.* 2016). Disease incidence was greater on immature leaves (average incidence of 56.4% (standard error 2.1%) than on mature leaves (average incidence of 29.8% (standard error 1.2%) and an average disease rating score of 2.4 (0-4 scale; standard error 0.08) was documented. Further observations of *R. rubescens* infection with *A. psidii* since the publication of Carnegie *et al.* (2016) indicate that at two surveyed sites (Bongil Bongil National Park and Royal National Park) mortality has increased from 10% and 23% respectively to > 50% (ANPC *in litt*. April 2016). A new monitoring site in Pine Creek State Forest also has >50% mortality (ANPC *in litt.* April 2016).

Information held by the National Environmental Science Program (NESP) database further confirms the findings of Carnegie *et al.* (2016) that *R. rubescens* is highly impacted by *A. psidii*, with an average damage assessment of c. 4 (4 = 50-90% branch death or branches with 50-90% dieback or >80% crown transparency). The NESP database indicates that the majority of populations where damage has been assessed have disease rating scores of 4 or above (48 of 90 populations), with an additional 24 populations of a disease rating of 3.

In parallel with the whole-of-range field surveys, a three-year disease exclusion trial was performed in a natural stand of *Rhodamnia rubescens* in Olney State Forest on the Central Coast of NSW. This trial "unequivocally showed that repeated, severe infection leads to gradual crown loss and ultimately tree mortality" (Carnegie *et al.* 2016). Significant correlations were found between both incidence ($r = 0.36$; $p > 0.001$) and severity ($r = 0.38$ $p > 0.001$) of *A. psidii* infection and subsequent crown loss (crown transparency). This trial documents the relationship between severe crown loss, dieback and tree mortality observed in *R. rubescens* across its native range and repeated infection by *A. psidii*. Any alternative causal agents have been discounted. This is supported by previous studies (Pegg *et al.* 2014).

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 50% (A. Carnegie *in litt.* July 2016). Ongoing observations also indicate that there has been no evidence of regenerating populations surviving, with no seedlings observed (A. Carnegie *in litt.* July 2016). Mortality in mature *R. rubescens* 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). At one monitoring site the average canopy transparency rating, indicating dieback levels has increased to 88% (June 2016) from 72% in (2014) in >50 trees assessed (G. Pegg *in litt*. July 2016). A small trial was established at Tucki Tucki Nature Reserve in northern NSW to examine the impact of *A. psidii* infection on flower and fruit production and survival. Branches with flowers were sprayed with fungicide monthly and survival compared to untreated branches. While fruit were produced on the untreated branches, all became infected and none survived until maturity (G. Pegg *in litt*. July 2016).

An obvious change in species composition following mortality of *R. rubescens* has been detected in a sub-sample of surveyed plots. The tree *Cupaniopsis anacardioides* has replaced *R. rubescens* in some of the coastal areas as have a mix of species in inland areas including weeds (including *Lantana camara*) (G. Pegg *in litt*. July 2016).

Monitoring has also documented declines in the population of *Rhodamnia rubescens* in the north western corner of Bongil Bongil National Park in East Boambee, 10 km south of Coffs Harbour, NSW (M. Smith *in litt*. Aug 2016). This monitoring survey assessed the impact of *A. psidii* infection on 30 *R. rubescens* plants between 2011-2014 and documented mortality of > 80% over this time period (25 of the 30 plants dead, all with severe levels of infection). Return surveys in Aug 2016 document mortality in the five remaining plants (i.e. 100% mortality between 2012-2016). A nearby population of 11 plants was monitored for infection with *A. psidii* between 2014-2016. Three of the 11 plants have died in the last two years, three have severely declined (foliage loss over two years of between 80-95% of 2014 levels), two have suffered decline in foliage coverage of around 50% from 2012 levels. All these three plants displayed active and abundant *A. psidii* spores during this recent inspection. The remaining three plants have stabilised their foliage loss (M. Smith *in litt.* Aug 2016). Resurveys of many of these sites and popualtions have documented continuing decline and mortality (J. Willis *in litt.* April 2018).

Quantitative findings of large declines in *Rhodamnia rubescens* populations are supported by field botanists who have conducted extensive surveys during routine botanical surveys and seed collecting over many years. Specific comments reported about the rapid and widespread decline of the in Carnegie *et al.* (2016) include:

"... all sites of *R. rubescens* visited since 2010 are in serious decline ... with no flowering or seed observed"

" ... *R. rubescens* [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. rubescens* [has not] flowered since 2010, with at least half of *R. rubescens* dead…at monitoring sites"

Large reductions in population size across the range of *R. rubescens* since infection with of *A. psidii* have been documented over a short period of time (10% mortality over a period of 3-3.5 years (2011 -2014)) relative to the generation length of the species. The generation length of *R. rubescens* is suspected to be at least 30-40 years given the height (> 25 m) which the species can attain (Floyd 2008). 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 1.5 months being described as “1-2 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. rubescens* has already undergone a population reduction of approximately 10% in less than five years. However, given the relatively long, 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. rubescens* 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 *Rhodamnia rubescens* 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. rubescens* 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. rubescens* 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. rubescens* 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* plantations the likelihood that these controls will become viable options for eradication in Australia in the time frame relevant to the regeneration capacity of *R. rubescen*s 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. rubescens* material exist (G. Errington *in litt*. October 2016). For example, current holdings of wild-collected seed at the NSW Seedbank number < two hundred seeds from two accessions. Tests on these holdings have shown extremely variable rates of seed fill (ranging from less than 1% to about 70%) (ANPC *in litt.* April 2016). Soft-fruited Myrtaceae from rainforest environments are characterised by seeds which are desiccation-intolerant and, therefore, not suited to long-term conservation storage (Sommerville and Offord 2014). The Australian Seed Bank partnership reports that the conservation seed bank at Mt Coot-tha, Brisbane, has one batch of *R. rubescens* seed of unknown quantity (ANPC *in litt*. April 2016). Tissue culture collections are currently held within the NSW PlantBank at the Australian Botanic Garden, Mount Annan NSW.

On the basis field observations of fruit production decline since 2012, NSW Seedbank collectors only expect to be able to find significant collectable quantities of fruit or seed of R. rubescens at some locations for another couple of years (ANPC *in litt*. April 2016).

## Ecology

*Rhodamnia rubescens* commonly occurs in all rain forest subforms except cool temperate rainforest. The species occupies a range of volcanically derived and sedimentary soils and is a common pioneer species in eucalypt forests (Floyd 2008). Populations and individuals of *R. rubescens* are often found in wet sclerophyll associations in rainforest transition zones (including open forest of *Eucalyptus tereticornis* and *E. bosistoana* in the Sydney region) and creekside riparian associations (Benson and McDougall 1998).

*R. rubescens* flowers from late winter through spring, with a peak in October and fruits appear in December in the Sydney region. The species is able to resprout from rootstock after fire and produce suckers which may develop into thickets (Benson and McDougall 1998). The species is characterised as a common understory tree (M. Smith *in litt.* Aug 2016).

The habitat of *R. rubescens* is likely to include the following vegetation classes: Subtropical Rainforests, Northern Warm Temperate Rainforests, Littoral Rainforest, North Coast Wet Sclerophyll Forests, Northern Hinterland WSF, Northern Escarpment WSF, Southern Lowland WSF, and probably the northern patches of South Coast WSF and Southern Escarpment WSF, and perhaps easterly patches of Northern Tableland WSF. It may also occur as a pioneer in adjacent areas of dry sclerophyll and grassy woodland associations (Keith 2004; Floyd 2008).

Under the BC Act, *R. rubescens* 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'. *Rhodamnia spp*. are listed as characteristic species for the in the Final Determination EEC 'Lowland Rainforest in the NSW North Coast and Sydney Basin Bioregions' and the distribution of *R. rubescens* coincides with the spatial currently documented spatial extent of this EEC.

The species is also highly likely to occur in the followings EECs listed under the BC Act (though is not listed as a characteristic species): 'Lowland Rainforest on Floodplain in the New South Wales North Coast Bioregion', 'Subtropical Coastal Floodplain Forest of the New South Wales North Coast Bioregion' and 'Illawarra Subtropical Rainforest in the Sydney Basin 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 Bioregions', 'River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions', 'Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions', 'Kurnell Dune Forest in the Sutherland Shire and City of Rockdale', 'Milton Ulladulla Subtropical Rainforest in the Sydney Basin Bioregion' and 'Pittwater and Wagstaffe Spotted Gum Forest in the Sydney Basin Bioregion'.

**Threats**

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

It is reasonably suspected that some populations of *R. rubescens* 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. rubescens 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 *Rhodamnia rubescens* 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% (CR threshold) over three generations or 10 years (whichever is longer). The effect of *Austropuccinia psidii* (Myrtle Rust) infection on *Rhodamnia rubescens* is severe across the species entire range based on quantitative evidence from field surveys. All age classes of *R. rubescens* 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. rubescens* are projected to continue to decline rapidly as a consequence of infection by *A. psidii*. Within three generations, assuming a generation time of 30-40 years, a quantitative estimate of decline of 96-99% has been made based on documented rates of mortality across the range.

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| **(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)<br>~~(b)~~<br>~~(c)~~ | for<br>critically endangered species<br>~~endangered species~~<br>~~vulnerable species~~ | a very large reduction in population size.<br>~~a large reduction in population size~~<br>~~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: *Rhodamnia rubescens* has a large geographic range.

Extent of Occurrence: The extent of occurrence (EOO) for *Rhodamnia rubescens* is estimated to be 147,340 km$^2$.

Area of Occupancy: The area of occupancy (AOO) for *Rhodamnia rubescens* is estimated to be 3,360 km$^2$ (based on the species occupying 840 (2 x 2 km) cells, the scale of measurement recommended by IUCN 2017).

| | | | |
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| **The geographic distribution of the species is**: | | | |
| | ~~(a)~~<br>~~(b)~~<br>~~(c)~~ | ~~for~~<br>~~critically endangered~~<br>~~endangered species~~<br>~~vulnerable species~~ | ~~very highly restricted~~<br>~~highly restricted~~<br>~~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 *Rhodamnia rubescens* is unknown, it is reasonably suspected that given the large geographic range size of the species and its characterisation as a 'common' species (Benson and McDougall 1998; Floyd 2008) that the number of mature individuals may be large (i.e. exceeding the threshold for VU (≥ 10,000 mature individuals).

| | | | | | | |
|---|---|---|---|---|---|---|
| **The estimated total number of mature individuals of the species is:** | | | | | | |
| | ~~(b)~~ | ~~for~~<br>~~critically endangered species~~<br>~~endangered species~~<br>~~vulnerable species~~ | | ~~very low~~<br>~~low~~<br>~~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~~<br>~~critically endangered species~~<br>~~endangered species~~<br>~~Vulnerable species~~ | ~~Very large~~<br>~~Large~~<br>~~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~~<br>~~critically endangered species~~<br>~~endangered species~~<br>~~Vulnerable species~~ | ~~Extremely low~~<br>~~very low~~<br>~~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 *Rhodamnia rubescens* 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~~<br>~~critically endangered species~~<br>~~endangered species~~<br>~~Vulnerable species~~ | ~~Extremely low~~<br>~~very low~~<br>~~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 *Rhodamnia rubescens.*

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

**Conservation and Management Actions**

There is no currently NSW Saving Our Species site-managed program for *Rhodamnia rubescens*. 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 *Rhodamnia rubescens 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.

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**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

Jarrah Wills, April 2018

David Keith, August 2018

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 *Rhodamnia rubescens* (Benth.) Miq. 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

Rhodamnia rubescens 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. *Rhodamnia rubescens* (Benth.) Miq. (family Myrtaceae) is described as a "Shrub or small tree to 25 m high, bark reddish brown, fissured; young stems densely tomentose. Leaves with lamina ovate to elliptic, 5–10 cm long, 2–4.5 cm wide, shortly acuminate, base cuneate to rounded, upper surface green and sparsely hairy, lower surface paler and sparsely to densely hairy with erect hairs; strongly 3-veined from base, lateral veins transverse; oil glands distinct, moderately dense; petiole 4–9 mm long. Inflorescences 1–3 per axil, each usually 3-flowered; peduncle 5–22 mm long. Hypanthium sparsely pubescent. Sepals 2–3 mm long, caducous. Petals 4–6 mm diam., white. Stamens 3–5 mm long. Style 4–5 mm long. Fruit globose, 5–8 mm diam., red turning black." (PlantNET 2018).

2. *Rhodamnia rubescens* is currently known to occur in coastal districts north from Batemans Bay in New South Wales (NSW), approximately 280 km south of Sydney, to areas inland of Bundaberg in Queensland. Populations of *R. rubescens* typically occur in coastal regions and occasionally extend inland onto escarpments up to 600 m a.s.l. in areas with rainfall of 1,000-1,600 mm (Benson and McDougall 1998).

3. *Rhodamnia rubescens* flowers in late winter through to spring, with a peak in October, and fruits typically begin to appear in December (PlantNET 2018). Populations and individuals of *R. rubescens* are often found in wet sclerophyll associations in rainforest transition zones and creekside riparian vegetation (Benson and McDougall 1998). *Rhodamnia rubescens* commonly occurs in all rainforest subforms except cool temperate rainforest. The species occupies a range of volcanically derived and sedimentary soils and is also a common pioneer species in eucalypt forests (Floyd 2008). Suitable habitat for *R. rubescens* is likely to occur in the following vegetation types: Subtropical Rainforests, Warm Temperate Rainforests, Littoral Rainforests, and Wet Sclerophyll Forests. It may also occur as a pioneer in adjacent areas of dry sclerophyll and grassy woodland associations (Keith 2004; Floyd 2008;). *Rhodamnia rubescens* has been documented occurring in association with *Acacia melanoxylon*, *Acmena smithii*, *Breynia oblongifolia*, *Corymbia intermedia*, *Endiandra discolor*, *Eucalyptus bosistoana*, *E. tereticornis*, *Glochidion sumatranum, Guioa semiglauca, Lophostemon suaveolens* and *Mallotus philippensis.*

4. In NSW, *Rhodamnia rubescens* 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'. *Rhodamnia* spp. are listed as characteristic species for the Final Determination of the EEC 'Lowland Rainforest in the NSW North Coast and Sydney Basin Bioregions' and the distribution of *R. rubescens* coincides with the documented spatial extent of this EEC. The species is also highly likely to occur in the followings EECs listed under the Act (although is not listed as a characteristic species): 'Lowland Rainforest on Floodplain in the New South Wales North Coast Bioregion', 'Subtropical Coastal Floodplain Forest of the New South Wales North Coast Bioregion' and 'Illawarra Subtropical Rainforest in the Sydney Basin Bioregion'. *Rhodamnia rubescens* may possibly occur in the following EECs listed under the Act (although is not listed as a characteristic species): 'Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions', 'River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions', 'Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions', 'Kurnell Dune Forest in the Sutherland Shire and City of Rockdale', 'Milton Ulladulla Subtropical Rainforest in the Sydney Basin Bioregion' and 'Pittwater and Wagstaffe Spotted Gum Forest in the Sydney Basin Bioregion'.

5. *Rhodamnia rubescens* has a large geographic range. The estimated extent of occurrence (EOO) of *R. rubescens* across Australia is 147,340 $km^2$. The EOO is based on a minimum convex polygon enclosing all occurrences of the species, the method of assessment recommended by IUCN (2016). The area of occupancy (AOO) is estimated as 3,360 $km^2$ based on 2 km x 2 km grid cells, the scale recommended for assessing AOO by IUCN (2016).

6. The number of mature individuals of *Rhodamnia rubescens* is currently unknown. No formal estimates of total abundance of the species across its range prior to 2010 has been located (B. Makinson *in litt*. April 2016). However, it is reasonably suspected that given the large geographic range size of *R. rubescens* and its characterisation as a common species (Benson and McDougall 1998; Floyd 2008) that a large number of mature individuals may have existed prior to 2010.

7. The survival of *Rhodamnia rubescens* is severely threatened by infection from the exotic rust fungus *Austropuccinia psidii* (myrtle rust). *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). The 'Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae' is listed as a Key Threatening Process under the Act.

8. *Rhodamnia rubescens* is a known host of *Austropuccinia psidii* (Zauza *et al*. 2010) and is characterised as 'Highly to Extremely Susceptible' to 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'. '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 exhibit "rust sori…on all expanding leaves, shoots and juvenile stems; foliage dieback;

evidence of stem and shoot dieback" (Pegg *et al*. 2014). Results of field trials designed to actively prevent infection of *R. rubescens* by *A. psidii* establish a clear relationship between the incidence/severity of *A. psidii* infection and subsequent crown loss (% crown transparency) in this species (Carnegie *et al*. 2016). Any alternative causal agents of crown loss have been discounted. A similar, but smaller, trial was established at Tucki Tucki Nature Reserve in northern NSW to examine the impact of *A. psidii* infection on flower and fruit production and survival in *R. rubescens*. Branches with flowers were sprayed with fungicide monthly and survival compared to untreated branches. While fruit were produced on the untreated branches, all became infected and none survived until maturity (G. Pegg *in litt.* July 2016). Approximately 17 populations of *R. rubescens* have been identified as having lower incidence of damage from *A. psidii* and these may be useful targets for germplasm collection (J. Willis *in litt*. April 2018).

9. Extensive field assessments of *Austropuccinia psidii* infection on *Rhodamnia rubescens* 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 43 sites for the impact of *A. psidii* on *R. rubescens* 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 Murramarang National Park, near Batemans Bay in NSW, to Traveston Crossing, near Gympie, Queensland. Sites were a mixture of locations where *A. psidii* infection on *R. rubescens* was already known to occur, and where no known infection had been documented (A. Carnegie *in litt*. July 2016). *Austropuccinia psidii* was detected as present on *R. rubescens* 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. rubescens* 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 from Pegg *et al.* (2012). Individuals were considered dead when crown transparency reached 100%. These comprehensive assessments of populations document mortality in *R. rubescens* across 18 of the 43 sites surveyed, where 12% of all the 669 surveyed trees were dead. Most sites contained only a few dead trees with the following exceptions: five sites had between 20 and 40% mortality, one site with 50% mortality and one site with 75% mortality (Carnegie *et al.* 2016). Across all sites mean crown transparency was 76.3% (standard error 0.8%), with the majority (79%) of trees having greater than 60% transparency. Based on prior knowledge of the species the normal crown transparency in an understorey is approximately 30-35% (Carnegie *et al*. 2016). All age classes of trees, as assessed by tree height, were similarly affected by *A. psidii* infection (Carnegie *et al*. 2016). Across all sites surveyed, disease incidence was greater on immature leaves (average incidence of 56.4%; standard error 2.1%) than on mature leaves (average incidence of 29.8%; standard error 1.2%) and an average disease rating score of 2.4 (0-4 scale; standard error 0.08) was documented.

10. Ongoing observations in 2016 of a smaller sub-sample of populations from Carnegie *et al*. (2016) since the end of the documented study period (2011–2014) estimate mortality has increased to over 50% at Bongil Bongil National Park and Royal National Park (A. Carnegie *in litt.,* July 2016). Greater than 50% mortality has also been observed at a new monitoring site in Pine Creek State Forest on the mid-north coast of NSW (B. Makinson *in litt*. April 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). The continued decline of mature plants and lack of successful regeneration threaten the long-term viability of *R. rubescens* in the wild.

11. Populations of *Rhodamnia rubescens* are projected to continue to rapidly decline due to infection by *Austropuccinia psidii*. Reductions in population size across the range of *R. rubescens* since infection from *A. psidii* have been documented over a short period of time (12% mortality over a period of 3–3.5 years (2011–2014)) relative to the inferred generation length of at least 30–40 years (Floyd 2008). 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. rubescens* is projected to undergo a 96–99% reduction in population size across its range within three generations. All age classes of *R. rubescens* 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.

12. Quantitative findings of very large declines in *Rhodamnia rubescens* 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).

13. There has been no confirmed evidence of resistance to *Austropuccinia psidii* infection in field populations of *Rhodamnia rubescens* to date (Pegg *et al*. 2014). Approximately 17 populations assessed across the range of *R. rubescens* have relatively low damage following infection by *A. psidii* (J. Willis *in litt*. April 2018). These populations may be important sources of naturally resistant germplasm. However, the prospect for naturally selected resistance emerging before the collapse of populations is currently considered small.

14. No effective or practical chemical, biological or management control is currently available for protecting populations of *Rhodamnia rubescens* 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. pisdii* control in natural populations of *R. rubescens*, 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. rubescens* is negligible (Glen *et al*. 2007). Manipulation of the environment via management actions (e.g. fire management) to control *A. psidii* on *R. rubescens* 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. rubescens* populations are highly likely.

15. 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 *Rhodamnia rubescens* 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. rubescens* 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. rubescens* (B. Makinson *in litt*. April 2016).

16. No adequate *ex-situ* collections of *Rhodamnia rubescens* material exist (G. Errington *in litt*. October 2016). Current holdings of wild-collected seed at the NSW Seedbank number < 20

seeds from two accessions. Tests on these seed-lots have shown extremely variable rates of seed fill (ranging from less than 1% to about 70%) (B Makinson *in litt*. April 2016). Soft-fruited Myrtaceae from rainforest environments are characterised by seeds which are desiccation-intolerant and, therefore, not suited to long-term conservation storage (Sommerville and Offord 2014). The Australian Seed Bank partnership reports that the conservation seed bank at Mt Coot-tha, Brisbane, has one batch of *R. rubescens* seed (B. Makinson *in litt.* April 2016). On the basis that field observations have shown 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. rubescens* 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.

17. It is reasonably suspected that some populations of *Rhodamnia rubescens* 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. rubescens* is named as a characteristic species (Adam 1987; 1992; Floyd 1990; Mills 1996).

18. *Rhodamnia rubescens* (Benth.) Miq. 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 1 (a), 2 (e).

| | | | |
|---|---|---|---|
| **(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 |
| | ~~(b)~~ | ~~endangered species~~ | ~~a large reduction in population size~~ |
| | ~~(c)~~ | ~~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: Clause/Criterion not met.

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

| | | | | | | |
|---|---|---|---|---|---|---|
| **The estimated total number of mature individuals of the species is:** | | | | | | |
| | ~~(b)~~ | ~~for~~<br>~~critically endangered species~~<br>~~endangered species~~<br>~~vulnerable species~~ | | ~~very low~~<br>~~low~~<br>~~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~~<br>~~critically endangered species~~<br>~~endangered species~~<br>~~Vulnerable species~~ | ~~Very large~~<br>~~Large~~<br>~~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~~<br>~~critically endangered species~~ | ~~Extremely low~~ |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | ~~endangered species~~<br>~~Vulnerable species~~ | ~~very low~~<br>~~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~~<br>~~critically endangered species~~<br>~~endangered species~~<br>~~Vulnerable species~~ | ~~Extremely low~~<br>~~very low~~<br>~~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~~<br>~~critically endangered species~~<br>~~endangered species~~<br>~~Vulnerable species~~ | ~~Extremely high~~<br>~~very high.~~<br>~~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, | <u>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.</u> |

Dr Marco Duretto
Chairperson
NSW Threatened Species Scientific Committee

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