Conservation Assessment of *Grevillea rivularis* L.A.S.Johnson & McGill. (Proteaceae)

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***Grevillea rivularis* L.A.S.Johnson & McGill. (Proteaceae)**
Distribution: Endemic to NSW
Current EPBC Act Status: Endangered
Current NSW BC Act Status: Critically Endangered

Proposed listing on EPBC Act: Upgrade to Critically Endangered.

Conservation Advice: *Grevillea rivularis*

Summary of Conservation Assessment

Grevillea rivularis was found to be eligible for listing as Critically endangered under Criterion B1ab(iii,v) + B2ab(iii,v).

The main reasons for this species being eligible are: i) it has a very highly restricted geographic distribution with an area of occupancy (AOO) and extent of occurrence (EOO) equal to 4 km^2; ii) the species is known from a single location, based on the combined threats of the combination of fire and flood in close succession, altered hydrologic regime as a result of climate change, possible effects of deer herbivory, and trampling/mechanical damage; iii) the species is considered severely fragmented as it cannot be recolonized from any other population; and iv) continuing decline in habitat quality can be inferred on the basis of the impacts of the above threats.

Description and Taxonomy

Grevillea rivularis is described as a "spreading almost glabrous shrub 1–2 m high. Leaves with secondary or occasionally tertiary divisions, 3–6 cm long, with 3–9 primary lobes each with 3–5 divaricate secondary lobes, ultimate lobes linear to very narrow-triangular, 1–3 cm long, 1–2.5 mm wide, pungent; margins revolute, enclosing most or all of the lower surface except the midvein. Inflorescences secund, 5–6 cm long. Perianth cream becoming pearly pink or grey, glabrous. Gynoecium 27–32 mm long; ovary densely hairy; style cream becoming pearly pink or grey, glabrous, pollen presenter erect to oblique. Follicle hairy with reddish brown stripes or blotches." (PlantNET 2019).

Distribution and Abundance

The NSW Threatened Species Scientific Committee (NSW TSSC) (2017) states that "*Grevillea rivularis* is endemic to New South Wales (NSW) and is only known from Carrington Falls in the Southern Highlands near Robertson, 34 km south-west of Wollongong. The only known population mostly occurs in the area formerly known as Carrington Falls Reserve (NSW NPWS 1998), now part of Budderoo National Park."

The NSW TSSC (2017) states that "*Grevillea rivularis* is confined to the riparian zone in an area receiving 1,000–1,600 mm annual rainfall (Benson and McDougall 2000; Pickup *et al*. 2003). It predominantly grows on moist creek-sides in open wet heath or *Eucalyptus*-dominated woodland or forest on sandstone geology (McGillivray 1975; Benson and McDougall 2000; PlantNET 2019; Pickup *et al*. 2003; OEH 2015). Associated species include *Leptospermum lanigerum*, *Baeckea utilis*, *Acacia longifolia, A. terminalis, Callicoma serratifolia, Ceratopetalum apetalum, Hakea microcarpa, Banksia ericifolia, B. paludosa, Melaleuca squarrosa, Epacris impressa, Persoonia* sp.*, Pomaderris* sp.*, Isopogon* sp.*, Gleichenia* sp. and numerous sedges and rushes (Commonwealth Threatened Species Scientific Committee 2008). Eleven individuals have also been found in woodland > 500 m from the stream edge (OEH 2015) and one isolated plant occurs in an old quarry (J. Devereaux *in litt*. 26 April 2016)."

The geographic distribution of *Grevillea rivularis* is very highly restricted. The area of occupancy (AOO) and extent of occurrence (EOO) were both estimated to be 4 km^2. The AOO is based on a single 2 km x 2 km grid cell, the scale recommended for assessing AOO by IUCN (2017). The EOO is reported as equal to AOO, despite the range of the species, measured by a minimum convex polygon containing all the known sites of occurrence, being less than the AOO. This is to ensure consistency with the definition of AOO as an area within EOO, following IUCN Guidelines (2017).

There is considered to be only a single location for this species as the only known site is highly geographically restricted and the entire population is subject to a range of threats (see threat section).

The NSW TSSC (2017) states that "The total number of mature individuals of *Grevillea rivularis* is low. There are currently estimated to be fewer than 1,000 plants (J. Devereaux *in litt.* December 2016) of which around half are mature. Repeat surveys across part of the known distribution in 1999 and 2015 indicated a ~60% reduction in abundance of plants (this includes mature plants, juveniles and seedlings) (J. Devereaux *in litt.* October 2016)." The reduction in the number of mature plants was 47% (J. Devereaux *in litt.* October 2016). This change in abundance may reflect a natural decline in numbers due to senescence with increasing time since fire and/or a reduction in habitat quality brought about by human-related factors. However, in a part of the population, a large proportion of seedlings that had emerged following a fire were eliminated by flooding. This is indicative of an actual decline as both the soil seed bank and the number of future mature adult plants has been reduced in that part of the population.

Ecology

The NSW TSSC (2017) states that "*Grevillea rivularis* is subject to periodic disturbance from floods (Pickup *et al.* 2003). Damage to *G. rivularis* individuals is evident post-flood but mortality of adult plants appears to be rare (J. Devereaux *in litt.* April 2016). However, there have been recent observations of seedling mortality due to flooding (J. Devereaux pers. comm. October 2016). *Grevillea rivularis* habitat is also subject to periodic fire. Most of the habitat was last burnt in 1982–1983, apart from a small area burnt during hazard reduction in March 2016 (J. Devereaux pers. comm. October 2016). *Grevillea rivularis* is an obligate seeder, with plants killed by fire and the species relying on regeneration from a soil-stored seedbank (Pickup *et al.* 2003)." Whilst germination of seeds appears to be promoted by fire, germination is not reliant on fire as seedlings have been observed in areas that have not been recently burnt (Pickup *et al*. 2003). The NSW TSSC (2017) states that "In the habitat last burnt in 1982–1983, there is a dense canopy layer that shades much of the understorey. Within the understorey, ferns, grasses and sedges may compete with *G. rivularis* seedlings such that successful establishment is rare unless there is a disturbance that partly opens the canopy. In long-unburnt habitat, seedling mortality rates are high and few young *G. rivularis* plants are successfully recruited into the mature population (OEH 2015). Seedling recruitment events have been observed in response to fires, flood events and soil disturbance by heavy machinery (Pickup *et al*. 2003)."

Threats

The NSW TSSC (2017) states that "A number of threats to *Grevillea rivularis* have been identified including habitat disturbance, adverse fire and flood regimes, impacts of weeds and introduced herbivores, climate change and drought (Department of Environment 2015; J. Devereaux *in litt*. April 2016). About 25% of the population occurs adjacent to tracks or roads (J. Devereaux *in litt*. April 2016). The risk of damage to *G. rivularis* is considered to be low along track edges but much greater near roads that are subject to maintenance or re-alignment (J. Devereaux *in litt*. April 2016). Illegal vehicle use on a gated trail, trampling by visitors, road verge maintenance and dumping of household and industrial waste are also threats to *G. rivularis* (Department of the Environment 2015; J. Devereaux *in litt*. April 2016). High frequency fire is considered a potential threat because the species is an obligate seeder, the population is restricted to one location and it only contains a small number of individuals (OEH 2015; J. Devereaux *in litt*. April 2016). In addition, *G. rivularis* has been reported to have a long primary juvenile period (>5 years) (OEH 2010). A combination of fire and flood in close succession may also be a threat as evidenced by the March 2016 flood destroying numerous seedlings which had emerged following a fire (J. Devereaux pers. comm. November 2016). Feral deer are present in the area and browsing is considered a threat to seedling survival (J. Devereaux *in litt*. April 2016). Since *G. rivularis* is largely restricted to riparian habitats, it is inferred that

a drier climate, increased fire frequency and increased severe weather events (including droughts) are current and future threats (CSIRO 2015)."

Assessment against IUCN Red List criteria

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

Criterion A Population size reduction

Assessment Outcome: Data Deficient.

Justification: There has been an observed reduction of 47% in the number of mature individuals of *Grevillea rivularis* in the last 15 years. This was estimated by plot data sampled in 1999 and again in 2015. There was also a decline where post-fire seedlings were lost to subsequent flooding. However, an estimate of the overall rate of decline cannot be made as there is uncertainty about how much of the observed decline could represent a natural fluctuation.

Criterion B Geographic range

Assessment Outcome: Critically Endangered under Criterion B1ab(iii,v)+2ab(iii,v).

Justification: *Grevillea rivularis* has an estimated area of occupancy of 4 km^2, based on one 2 km x 2 km grid cell, the scale recommended by the IUCN (2017). The extent of occurrence (EOO) is also estimated to be 4 km^2. Both of these estimates meet the thresholds for Critically Endangered (<100 km^2 (B1) and 10 km^2 (B2).

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.

   Assessment Outcome: Sub criterion met at Critically Endangered threshold.

   Justification: There is only one location for *Grevillea rivularis*. The threats of adverse interaction of fire and flood, trampling/mechanical damage and the possible effects of deer herbivory are impacting the whole population of *G. rivularis* at the one known site. The species is considered severely fragmented as it cannot be recolonized from any other population.

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

   Assessment Outcome: Sub criterion met for (iii, v).

   Justification: Continuing decline in habitat quality and the number of mature individuals can be inferred on the basis of evidence of reduced effective recruitment after a fire (in 2016, in part of the distribution of the species, a large proportion of seedlings that emerged post-fire were eliminated by flooding), trampling/mechanical damage and the possible effects of deer herbivory. There is a risk of increasing adverse interactions between fires and floods should there be changes to fire frequency and hydrologic regimes as a result of climate change.

c) Extreme fluctuations.

   Assessment Outcome: Sub criterion data deficient.

Justification: While there may be fluctuations in response to both fires and floods, there is currently no documented evidence of extreme fluctuations for *Grevillea rivularis*.

Criterion C Small population size and decline

Assessment Outcome: Endangered under Criterion C2a(ii).

Justification: There are estimated to be fewer than 1000 mature individuals of *Grevillea rivularis.* In terms of the population thresholds established for this criterion (<250 (CR), <2500 (EN), 10000 (VU) mature individuals), *G. rivularis* meets the threshold for listing as endangered (<2500 mature individuals).

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

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

Assessment Outcome: Data Deficient.

Justification: There has been an observed reduction in the number of mature individuals of *Grevillea rivularis* in the last 15 years. This was estimated by plot data sampled in 1999 and again in 2015. There was also a decline where post-fire seedlings were lost to subsequent flooding. However, an estimate of the overall rate of decline cannot be made as there is uncertainty about how much of the observed decline represents natural fluctuations.

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

Assessment Outcome: Sub criterion met.

Justification Continuing decline in the number of mature individuals can be inferred on the basis of evidence of reduced effective recruitment after a fire (*i.e.* in 2016, in part of the distribution of the species, a large proportion of seedlings that emerged post-fire were eliminated by flooding soon after fire), trampling/mechanical damage and possible effects of deer herbivory. There is a risk of increasing adverse interactions between fires and floods should there be changes to fire frequency and hydrologic regimes as a result of climate change.

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

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

Assessment Outcome: Sub criterion met at Vulnerable threshold.

Justification: The one subpopulation has less than 1000 mature individuals.

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

Assessment Outcome: Sub criterion met at Critically Endangered threshold.

Justification: There is a single subpopulation in which all mature individuals occur.

b. Extreme fluctuations in the number of mature individuals

Assessment Outcome: Data Deficient

Justification: While there may be fluctuations in response to both fires and floods, there is currently no documented evidence of extreme fluctuations for *Grevillea rivularis*.

Criterion D Very small or restricted population

Assessment Outcome: Vulnerable under Criterion D1, D2.

Justification: There are estimated to be fewer than 1000 mature individuals of *Grevillea rivularis.* This meets the threshold for Vulnerable (<1000).

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

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

Assessment Outcome: Sub criterion met.

Justification: *Grevillea rivularis* is estimated to have fewer than 1000 individuals based on direct counts in the recent survey in 2015.

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

Assessment Outcome: Sub criterion met.

Justification: With an AOO of 4 km^2, only one location, and plausible threats due to the interaction between fire and flooding events, altered hydrologic regime as a result of climate change, trampling/mechanical damage and possible effects of deer herbivory, *Grevillea rivularis* meets all the criteria for listing under D2.

Criterion E Quantitative Analysis

Assessment Outcome: Data Deficient

Justification: There are insufficient data to quantify the extinction risk for this species.

Conservation and Management Actions

There is a NSW Saving our Species (SoS) program for this species but no National Recovery Plan. The following is derived from the NSW SoS program and threat information.

Habitat loss, disturbance and modification

- Prevent habitat disturbance during road maintenance and fire trail maintenance.
- Prevent disturbance and trampling by visitors.
- Ensure threats are monitored at the site and note any increases in disturbance from people, weeds or feral animals that could potentially impact plants (*e.g.* compete with or smother seedlings).

Invasive species

- Identify and remove weed species.

Ex situ conservation

- Develop a targeted seed collection program for *ex situ* seed banking.
- Establish *ex situ* insurance population by propagating from cuttings or seed if possible.
- Explore options for translocation to create additional wild populations.

Stakeholder Management

- Inform NSW Rural Fire Service and NSW NPWS of known location and fire requirements of the population in the event that they are involved in any fire control activities in the area.
- Negotiate with local council and associated contractors to minimise any adverse impacts from road maintenance.

Survey and Monitoring priorities

- Monitor changes to the population abundance (mortality, new recruitment, existing plant survival) over time and in relation to major disturbances (fire and flood).
- Conduct targeted monitoring post-fire and post-flooding to detect mortality rate and recruitment.

Information and Research priorities

- Research into the seed ecology of the species to determine germination requirements, dormancy mechanisms and factors promoting germination after fire or flood.
- Research into determining the length of the primary juvenile period.
- Research into the length of time the species takes to replenish its soil seed bank after fire or flood (including time to first flowering, magnitude of flowering over time, seed mortality to predators, seed dispersal, seed accumulation in the soil).

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Expert Communications

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APPENDIX

Assessment against BC Act criteria

Overall Assessment Outcome (Clause(s) with the highest category of threat)
Critically Endangered under Clause 4.3 (a)(d)(e)(i,iii).

Clause 4.2 – Reduction in population size of species
(Equivalent to IUCN criterion A)
Assessment Outcome: Data Deficient.

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

Clause 4.3 - Restricted geographic distribution of species and other conditions
(Equivalent to IUCN criterion B)
Assessment Outcome: Critically Endangered under Clause 4.3 (a)(d)(e)(i,iii).

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

Clause 4.4 - Low numbers of mature individuals of species and other conditions
(Equivalent to IUCN criterion C)
Assessment Outcome: Endangered under Clause 4.4 (b)(e)(i,ii)(B).

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

Clause 4.5 - Low total numbers of mature individuals of species
(Equivalent to IUCN criterion D)
Assessment Outcome: Vulnerable under Clause 4.5.

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

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

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

Clause 4.7 - Very highly restricted geographic distribution of species–vulnerable species
(Equivalent to IUCN criterion D2)
Assessment Outcome: Assessment Outcome: Vulnerable under Clause 4.7.

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.