

## 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 *Carmichaelia exsul* F.Muell as a CRITICALLY ENDANGERED SPECIES in Part 1 of Schedule 1 of the Act and, as a consequence, to omit reference to *Carmichaelia exsul* F.Muell from Part 2 of Schedule 1 (Endangered species) of the Act. Listing of Critically Endangered species is provided for by Part 4 of the Act.

### Summary of Conservation Assessment

*Carmichaelia exsul* F.Muell (Fabaceae) was found to be Critically Endangered in accordance with the following provisions in the *Biodiversity Conservation Regulation 2017*: Clauses 4.3 (a)(d)(e i, iii) and 4.4 (a)(e i, ii, B).

The main reasons for this listing are: 1) It has a very highly restricted geographic range (EOO is 16 km<sup>2</sup>); 2) The total number of mature individuals is extremely low (<250); 3) It is found at only a single location, scattered across a small area of ridgeline and cliffs in the Southern Mountains region of Lord Howe Island; and 4) There is inferred continuing decline in habitat quality as a consequence of increased hydrological deficit and landslip driven by climate change and ongoing weed invasion.

The NSW Threatened Species Scientific Committee has found that:

1. *Carmichaelia exsul* (family Fabaceae) was first described by Mueller in 1871, and this classification is supported by Green (1994). A phylogenetic analysis of the genus conducted in 1998 supports the description of *C. exsul* at species level (Heenan 1998). *Carmichaelia exsul* is the only species in the genus occurring in Australia, with all other *Carmichaelia* endemic to New Zealand (Green 1994, NSW Scientific Committee 2002). Green (1994) described *C. exsul* as: ‘...a Broom-like shrub, 1-3 m tall. Adult shoots leafless, flattened, ridged, spreading and drooping. Leaves on juvenile shoots imparipinnate; leaflets 3-5, oblong to obovate, 0.7-2 (-3) cm long, 0.4-1.5 (-2.5) cm broad, apically rounded, emarginate. Inflorescence racemose, 2-5-flowered. Flowers white with purple markings, sweetly scented. Calyx somewhat obliquely campanulate, c. 2.5 mm long; teeth c. 0.5 mm long. Standard petal orbicular, 6-7 mm long; wings and keel c. 4-5 mm long. Pods ellipsoidal, flattened, 10-12 mm long, glabrous, with thickened margins; style persistent; dehiscing by two valves falling away leaving seed attached to replum. Seeds kidney-shaped, 3 mm long, pale orange.’
2. *Carmichaelia exsul* is endemic to subtropical Lord Howe Island (Green 1994, NSW Government Office of Environment and Heritage 2017). *Carmichaelia exsul* is restricted to the Southern Mountains region of Lord Howe Island, encompassing Mount Lidgbird and Mount Gower (NSW Government Office of Environment and Heritage 2017). It is recorded primarily from sites on the north face of Mount Gower including ‘Eddie’s Cave’, the southern precinct of ‘Big Pocket’, and the ‘Black Face’ and ‘Grey Face’ ridges of Mount Lidgbird, although it also occurs across other, less

## NSW Threatened Species Scientific Committee

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accessible patches between these sites (NSW Government Office of Environment and Heritage 2017). *Carmichaelia exsul* plants are scattered across cliff faces and rocky ridges at these sites, generally occurring as single plants or in small patches (NSW Government Office of Environment and Heritage 2017). The maximum distance between Mount Gower and Mount Lidgbird sites is around 2 km (C. Stehn pers. comm. 2022).

- Carmichaelia exsul* has a highly restricted range, with both an Extent of Occurrence (EOO) and Area of Occupancy (AOO) of only 16 km<sup>2</sup>. It occurs at only one threat-defined location, restricted to small lengths of narrow ridgeline on Mount Gower and Mount Lidgbird (NSW Government Office of Environment and Heritage 2017). The entire known population of *C. exsul* occurs in an area that can be contained within four 2 km x 2 km grid squares the scale recommended for assessing area of occupancy by IUCN (2022). When EOO is less than or equal to AOO, IUCN (2022) recommend EOO estimates be changed to be equal to AOO to ensure consistency with the definition of AOO as an area that fits within EOO.
- The total mature population is estimated to be between 110-140 individuals (NSW Government Saving our Species 2021a). This number is drawn from ongoing monitoring of seven plots (ranging from 5 x 5m to 15 x 15m) at five permanent monitoring sites. The results from these plots are then extrapolated across the area over which *Carmichaelia exsul* is believed to occur to produce a total population estimate (NSW Government Office of Environment and Heritage 2017; NSW Government Saving our Species 2021a).
- Carmichaelia exsul* is restricted to sunny, exposed, north and west facing cliff faces and ridges, generally between 400 and 600m elevation (NSW Government Office of Environment and Heritage 2017). *Carmichaelia exsul* favours open, exposed sites without canopy cover, however they can tolerate more dense vegetation with some low canopy (C. Stehn pers. comm. 2022). *Carmichaelia exsul* shares general habitat with three other threatened plants, *Geniostoma huttonii*, *Xylosma parvifolium* and *Coprosma inopinata*, along with more common species (Hutton 2001, 2005). These plants form dense, stunted communities less than one metre in height (Hutton 2001, 2005; NSW Government Office of Environment and Heritage 2017).
- Carmichaelia exsul* is likely to be insect pollinated both by native species and introduced honeybees that are present on Lord Howe Island. In other *Carmichaelia* species where pollinators have been identified, all are insect pollinated with the exception of *C. williamsii*, which is bird pollinated and notable for its exceptionally large flowers, far larger than those of *C. exsul* (Heenan and de Lange 1999). The fruit of *C. exsul* is a thin flattened pod 12 mm long, with a persistent replum from which the 2 valves fall away, exposing a pale orange kidney-shaped seed (Hutton 2001). This colour is thought to promote seed dispersal by birds by mimicking a fleshy, palatable fruit (Thorsen *et al.* 2009). Given the very restricted range of *Carmichaelia exsul* it is unlikely that the population is severely fragmented, with pollinators likely able to access individuals across its very highly restricted range and birds likely able to disperse seed across suitable habitat.

## NSW Threatened Species Scientific Committee

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7. There has been no formal study into life history in *Carmichaelia exsul*. Other *Carmichaelia* species appear to be relatively long-lived, with studies counting 20 or more growth rings in a range of *Carmichaelia* species from shrubs to trees, with only one exception to this relative longevity (*C. juncea*) (Gruner 2003). Given this general pattern of longevity in *Carmichaelia* it is likely that *C. exsul* is similarly long lived (20+ years). It is unknown how long *Carmichaelia exsul* takes to reach maturity. Given the broad variation in age at maturity for *Carmichaelia* species it is not possible to make inferences as to the likely age at which *C. exsul* becomes mature and able to reproduce. As a consequence, no estimates for generation time can be made for *C. exsul*.
8. *Carmichaelia exsul* shows high long-term seed viability. Seeds collected from a specimen in cultivation outside Lord Howe Island and kept at room temperature were shown to still be viable after 22 years and had a germination rate of 96% (Grüner and Heenan 2001). Seed was collected from the natural population of *C. exsul* in 2019/2020 and sent to the seed bank at the Australian Botanic Garden Mount Annan (NSW Government Saving our Species 2019).
9. During two decades of monitoring, *Carmichaelia exsul* has not been observed to colonise adjacent habitat and appears to struggle to compete with other endemic species and invasive species (C. Stehn pers. comm. 2022).
10. The main threats to *Carmichaelia exsul* are increasing hydrological deficit and habitat loss as a result of climate change, landslips, competition with introduced and native plant species and pathogen infection. 'Anthropogenic Climate Change', 'Infection of Native Plants by *Phytophthora cinnamomi*', and 'Loss and degradation of native plant and animal habitat by invasion of escaped garden plants are listed as Key Threatening Processes under the Act.
11. Ongoing climate change on the Lord Howe Island Group poses a direct threat to *Carmichaelia exsul*. There has been an increase in temperature and a decrease in overall rainfall on Lord Howe Island over the last 50 years, with Auld and Leishman (2015) finding that: "...sea level temperatures around Lord Howe Island have risen by some 0.6°C since 1940... average annual air temperature on Lord Howe Island is expected to rise (compared with 1990 levels) by  $1.3 \pm 0.6^\circ\text{C}$  by 2030, although there is much uncertainty around such estimates...For annual rainfall, we found over the last 50 years there had been a decline of 31% (95% CL 4–79%)...Both minimum and maximum temperatures at sea level increased in the last 50 years...".
12. Plant species on Lord Howe Island depend on consistent and ongoing formation of cloud to provide the high humidity and moisture on which they depend (Auld and Leishman, 2015). Cloud forests serve as a 'bucket', absorbing rain and atmospheric moisture at the summit which then flows down, providing available moisture for plant communities further down the slope (Foster, 2001). Increase in sea temperatures is likely to increase the altitude at which clouds form, increasing moisture deficit at lower altitudes and pushing dependent species further towards the summit, dubbed the 'lift-cloud-base hypothesis' (Auld and Leishman, 2015). Cloud lift poses a direct threat to species that live in cloud forest at the summit of Mount Gower and Mount Lidgbird, as well as species such as *Carmichaelia exsul*

## NSW Threatened Species Scientific Committee

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that are found below the cloud line and receive moisture created by cloud formation at the summit. Ongoing increase in sea temperature, and associated cloud lift and moisture deficit is therefore likely to reduce the quality and availability of habitat for *C. exsul*.

13. *Carmichaelia exsul* is confined to cliffs and ridges at relatively high elevations (~400-600 m), above which habitat is generally unsuitable, largely opening into plateaux dominated by dense vegetation, especially Gnarled Mossy Cloud Forest (C. Stehn pers. comm. 2022). The general lack of adjacent exposed cliffs and ridgelines at higher elevations means that there is limited accessible habitat into which *C. exsul* can move as increasing moisture deficit makes their current habitat less suitable (C. Stehn pers. comm. 2022). As a poor competitor, *C. exsul* is likely to struggle to colonise new habitat that may become available as aridity forces resident plant communities to higher elevations. Even if resident plant communities are pushed from habitat potentially suitable for *C. exsul*, components of these communities, like established trees or generalist weed species, are likely to persist and present an ongoing barrier to colonisation.
14. *Carmichaelia exsul* is threatened by damage or destruction by landslips (NSW Government Saving our Species 2021a). The species is restricted to rocky ridgelines and exposed cliff faces, areas that are commonly susceptible to collapse and slips on Lord Howe Island, particularly following heavy rain (NSW Government Saving our Species, 2021; C. Stehn pers. comms. 2022). In 2020/21 landslips resulted in the loss of at least six individuals, although it is possible some persist but could not be relocated because of the inaccessibility of the sites (NSW Government Saving our Species 2021a). These landslips also made surveys impossible at several sites and hinder ongoing monitoring (NSW Government Saving our Species 2021a). There is currently no way to prevent or mitigate the threat of landslips at sites where *C. exsul* is present (C. Stehn pers. comm. 2022).
15. Climate change may increase the likelihood and severity of sub-tropical storms on and around Lord Howe Island, posing an additional severe threat to plant communities towards the peaks of Mount Gower and Lidgbird (Auld and Leishman 2015). These storms may damage *Carmichaelia exsul* directly, or increase the likelihood of landslips as a result of heavy rain.
16. Invasive weeds pose a severe and ongoing threat to *Carmichaelia exsul* (Lord Howe Island Board, 2016; NSW Government Saving our Species, 2021a). Weeds encroach on the habitat of *C. exsul*, outcompeting existing plants for resources and space and inhibiting recruitment by reducing the likelihood *C. exsul* seeds will find sufficient space and resources to germinate (Lord Howe Island Board, 2016; T. Auld pers. comm. 2022). Of particular concern are *Ageratina adenophora* (Crofton Weed), *Lilium formosanum* (Formosan Lily), *Cenchrus clandestinus* (Kikuyu Grass), *Asparagus aethiopicus* (Ground Asparagus), and *Psidium cattleianum* var. *cattleianum* (Cherry Guava) (Lord Howe Island Board, 2016; T. Auld pers. comm. 2022). These weed species remain common across Lord Howe Island, and threaten multiple endemic plants and communities, including *C. exsul* (Lord Howe Island Board, 2016; NSW Government Saving our Species, 2021; T. Auld pers. comm. 2022). Despite an ongoing intensive weed control program, the overall

## NSW Threatened Species Scientific Committee

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number of juvenile weeds may be increasing (NSW Government Saving our Species, 2021a). This increase is possibly driven by drought and increasing aridity, with generalist weed species on Lord Howe Island likely more successful than endemics in changing environments, and by the removal of rats (discussed below) (Lord Howe Island Board, 2016; NSW Government Saving our Species, 2021b).

17. Introduced rodents, in particular the ship rat (*Rattus rattus*) and house mouse (*Mus musculus*), have had a devastating effect on native flora of Lord Howe Island and have been the driving factor in the extinction of at least two Lord Howe Island plant species (Department of Environment and Climate Change (NSW) 2007). An extensive program of rodent eradication on the main island began in 2019 (Harper *et al.*, 2020). This program appears to have been successful and rodents (rats and mice) have been eradicated from the island. The program has not yet been officially declared successful and ongoing monitoring is in place, both for rodents and to quantify the benefits and/or ecosystem changes resulting from the pest eradication. Historically rodents have not been considered a direct threat to *Carmichaelia exsul* because of its inaccessible habitat (Lord Howe Island Board, 2017). However, there are indications that rodent control has inadvertently removed predation pressures from weed populations, as well as from native vegetation. In the absence of rodents, weed populations may increase and spread, posing a more significant threat to *C. exsul* (NSW Government Saving our Species, 2021; C. Stehn pers. comm. 2022).
18. *Phytophthora cinnamomi* is an introduced water mould (oomycetes) pathogen that causes catastrophic dieback in many species and is listed as the Key Threatening Process ‘Infection of native plants by *Phytophthora cinnamomi*’ in the Act. *Phytophthora cinnamomi* affects a huge variety of plants across families, including Fabaceae and so may pose a threat to *Carmichaelia exsul* (Government of South Australia Phytophthora Technical Group, 2006; NSW Department of Environment and Climate Change, 2008). *Phytophthora cinnamomi* was detected in a small orchard on Lord Howe Island in 2003 and is now considered a resident threat (Auld and Hutton, 2004). It has so far been contained, however movement of residents and tourists across the island risk its spread in the future.
19. *Carmichaelia exsul* F.Muell (Fabaceae) 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 Conservation Regulation 2017*:

# NSW Threatened Species Scientific Committee

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## Assessment against *Biodiversity Conservation Regulation 2017* criteria.

The Clauses used for assessment are listed below for reference.

### Overall Assessment Outcome:

*Carmichaelia exsul* was found to be Critically Endangered under Clause 4.3 (a)(d)(e iii) and Clause 4.4 (a)(e i, ii, A, I).

### Clause 4.2 – Reduction in population size of species

(Equivalent to IUCN criterion A)

**Assessment Outcome: Data Deficient**

<b>(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:</b>		
	(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.
<b>(2) - The determination of that criteria is to be based on any of the following:</b>		
	(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)**

<b>The geographic distribution of the species is:</b>		
	(a) for critically endangered species	very highly restricted, or
	(b) for endangered species	highly restricted, or
	(c) for vulnerable species	moderately restricted.
<b>and at least 2 of the following 3 conditions apply:</b>		
	(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.	

# NSW Threatened Species Scientific Committee

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

**Assessment Outcome: Critically Endangered under Clause 4.4 (a) (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: Endangered under Clause 4.5 (b).**

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.

# NSW Threatened Species Scientific Committee

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

(Equivalent to IUCN criterion D2)

**Assessment Outcome: Clause 4.7 is not met.**

For vulnerable species,	the geographic distribution of the species or the number of locations of the species is very highly restricted such that the species is prone to the effects of human activities or stochastic events within a very short time period.
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Senior Professor Kristine French  
Chairperson  
NSW Threatened Species Scientific Committee

### Supporting Documentation:

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## NSW Threatened Species Scientific Committee

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## NSW Threatened Species Scientific Committee

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