

Notice 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 reject a proposal to remove the shrub *Senecio linearifolius* var. *dangarensis* Belcher ex I.Thomps from the Schedules of the Act, and to retain *Senecio linearifolius* var. *dangarensis* Belcher ex I.Thomps as an ENDANGERED SPECIES in Part 2 of Schedule 1 of the Act.

A Conservation Assessment report and Preliminary Determination for *Senecio linearifolius* var. *dangarensis* Belcher ex I.Thomps to remove the species from the schedules of the Act was published from 27 January 2023 to 27 April 2023. Following consideration of advice and submissions received, *Senecio linearifolius* var. *dangarensis* Belcher ex I.Thomps is to be retained as an Endangered species. Listing of Endangered species is provided for by Part 4 of the Act.

Summary of Conservation Assessment

Senecio linearifolius var. *dangarensis* Belcher ex I.Thomps. was found to be Endangered in accordance with the following provisions in the *Biodiversity Conservation Regulation 2017*: Clause 4.3 (b)(d)(e i,iii) because (i) *S. linearifolius* var. *dangarensis* has a very highly restricted Area of Occupancy (AOO) of 8 km² and Extent of Occurrence (EOO) of 23 km²; (ii) *S. linearifolius* var. *dangarensis* is known from two threat-defined locations; and (iii) continuing decline is inferred in the area, extent and quality of habitat, and the number of individuals of *S. linearifolius* var. *dangarensis* due to the effects of increased frequencies of drought and changes in rainfall patterns resulting from climate change, and invasion and competition from *Opuntia stricta*.

The NSW Threatened Species Scientific Committee has found that:

1. *Senecio linearifolius* var. *dangarensis* Belcher ex I.Thomps. (Asteraceae) is an aromatic perennial, often weakly shrubby, to 2 m high. The species *Senecio linearifolius* is described by Thompson (2004) as "glabrous or nearly so except on lower surface of leaves, sometimes glaucous. Stems becoming many-stemmed from base, branching mostly in upper half. Leaves commonly ± thin to coriaceous, rarely somewhat fleshy; leaves in middle to upper third of stems narrow to very narrow-elliptic, narrow--ovate, lanceolate, or linear, 2-20 cm long, 1-40 mm wide, with l:w ratio c. 1.5-30, undivided; base attenuate, truncate, cordate, or variously auriculate, with auricles divided or not, slightly amplexicaul or not; margin entire, denticulate, dentate or serrate; upper surface glabrous, occasionally sparsely appressed-cobwebby, glabrescent, sometimes sparsely and minutely hispid; lower surface glabrous, or variously cobwebby to woolly, with hairs all fine and ± appressed or sometimes spreading; secondary and tertiary venation variably distinct. Unit inflorescences of several to many capitula; peduncles finally to c. 15 mm long. Capitula: calycular bracteoles 2-6, 1.5-3.0 mm long; peduncle and margin of bracteole glabrous or cobwebby at anthesis, sometimes glaucous; involucre cylindrical to weakly campanulate, 2.5-5.5 mm long, 1.5-3.0 mm diam.; phyllaries 7-12(-14); stereome slightly to moderately convex,

NSW Threatened Species Scientific Committee

usually glabrous. Florets 12-30; ligulate florets 4-8, ligules 3-8 mm long, with nerves commonly 4; disc florets 4.0-5.5 mm long; limb mostly slightly longer than tube. Achenes narrow-obloid or narrow oblong-ellipsoid, 1.3-2.5 mm long, brown, glabrous or with papillose hairs in bands, hairs with a l:w ratio of 2-3; carpodium small, slightly exserted. Pappus 4-6 mm long."

2. *Senecio linearifolius* var. *dangarensis* is distinguished from the other seven varieties of the species by Thompson (2004) by "plants glaucous, in parts strongly so, on stems, lower surface of leaves, peduncles and capitula ± glabrous. Upper-stem leaves narrow to very narrow-elliptic, with l:w ratio 5-8; base cuneate to broad-cuneate; auricles absent; margin denticulate; lower surface glabrous; secondary venation ± distinct; tertiary venation distinct. Inflorescences: peduncles glabrous, or rarely cobwebby, at anthesis. Capitula: involucre 3.5-5.0 mm long, 2.0-2.8 mm diam.; phyllaries mostly c. 12. Florets 20-31; ligulate florets mostly 7-9; disc florets 13-22. Achenes c. 2.0 mm long, with appressed papillose hairs in bands."
3. *Senecio linearifolius* var. *dangarensis* has a very highly restricted geographic distribution, found only on two basalt peaks in the Hunter Valley region in NSW. The two known sites are at Mount Dangar in Goulburn River National Park, and an unnamed small peak approximately 30 km southeast in northern Wollemi National Park referred to as 'Woodlands' (Bell and Lamrock 2021). If one of these populations became extinct then the probability of recolonization is low, and so each is considered a separate subpopulation as per the definition in IUCN (2022).
4. The geographic distribution of *Senecio linearifolius* var. *dangarensis* is very highly restricted. The Area of Occupancy (AOO) is 8 km² based on 2 x 2 km grid cells, the scale recommended for assessing area of occupancy by IUCN (2022). The Extent of Occurrence (EOO) is 23 km² based on a minimum convex polygon enclosing all mapped occurrences of the species, the method of assessment recommended by IUCN (2022).
5. Prior to the 2017-2019 drought, the estimated size of the subpopulation at Mount Dangar was 10,000 plants and the subpopulation at Woodlands was estimated to be approximately 15,000 plants (plausible range 11,800 – 23,700 plants), giving a total population size of approximately 25,000 plants (Zimmer 2018). Population size fluctuates widely across seasons, making an accurate estimate difficult (S. Bell pers. comm. August 2018). The Woodlands site supports more plants than Mount Dangar, despite Woodlands being a considerably smaller hill in size (Bell 2018).
6. Overall, a decline of approximately 50% since 2016 has been recorded in total plant numbers at Mount Dangar, though this has been offset by an increase in total plants of 150% over the same period at Woodlands (Bell and Lamrock 2021). This means that the current estimate of mature individuals at Mount Dangar is approximately 5,000, and at Woodlands it is 22,500, giving an overall population estimate of 27,500 individuals. While all recorded plants since 2019 have been seedlings given almost all standing mature plants disappeared from the above-ground flora through the 2017–2019 drought, the rapid maturity time of

NSW Threatened Species Scientific Committee

12-18 months (Bell and Lamrock 2021) means that these plants are also likely now all mature.

7. *Senecio linearifolius* var. *dangarensis* flowers as early as seven months post-emergence, but more commonly between 12 and 18 months after germination (Bell and Lamrock 2021). Seedling recruitment events have been recorded when there has been a preceding annual rainfall >70% of the annual average (Bell and Lamrock 2021). Severe drought causes above-ground parts of *S. linearifolius* var. *dangarensis* to die off and appear absent from the vegetation (Bell and Lamrock 2021). When rainfall returns, *S. linearifolius* var. *dangarensis* resprouts from woody stems after partial dieback and many seedlings germinate. As *S. linearifolius* var. *dangarensis* is quick to flower and fruit, the seed bank is continually replenished. *S. linearifolius* var. *dangarensis* response to fire is uncertain, although other related species respond positively (Wapstra *et al.* 2008).
8. A study of seed ecology by Mackenzie and Auld (2020) found that the seeds of *Senecio linearifolius* var. *dangarensis* were found to have a high level of fill and viability (~70%), which was found to decline >50% after one year of burial. The magnitude of decline suggests a relatively short-lived seed bank in the absence of regular inputs of new seeds. Field observations suggest the soil seedbank can still retain high numbers of viable seeds over several years at least, with seedlings germinating abundantly after a severe three-year drought in 2017–2019 (S. Bell *in litt.* August 2022). *Senecio linearifolius* var. *dangarensis* has also remained on Mount Dangar despite numerous other major droughts (>3 yrs) since at least 1825, suggesting the soil seedbank can retain enough viable seeds to provide for significant germination events across a period of several years of drought. However, moisture must remain available over the successive years to prevent desiccation and allow continued growth of emergent seedlings (Bell and Lamrock 2021). This early emergent stage, where plants transition from the seedbank to seedlings, has been shown to be a highly sensitive period in other shrubby Asteraceae that exhibit similar life history traits (e.g., *Olearia flocktoniae*; Gross and Mackay 2014), indicating that *S. linearifolius* var. *dangarensis* may be similarly sensitive at this stage.
9. Mackenzie and Auld (2020) found that fresh and buried seed are apparently non-dormant and have a germination that is strongly temperature dependant, faster and greater in winter and independent of fire cues. Germination and emergence were also found to occur at other times given sustained soil moisture. As in some other species of *Senecio* (e.g., *S. macrocarpus*; Davies 2009), fire does not appear to be a necessary stimulant to promote germination.
10. Increased knowledge of the demography and ecology of *Senecio linearifolius* var. *dangarensis* is revealing that increased drought events, and changes in rainfall driven by climate change may be causing continuing decline in the number of mature individuals, especially at Mount Dangar (Bell and Lamrock 2021). This is now considered the most serious plausible threat to *S. linearifolius* var. *dangarensis* and future climate projections indicate that decline through this threat may become exacerbated over the long-term. Weeds such as *Opuntia stricta* and adverse fire regimes are also considered threats to the species.

NSW Threatened Species Scientific Committee

11. When the threat of increased frequency of drought and changes in rainfall patterns resulting from climate change is considered, the two subpopulations of *Senecio linearifolius* var. *dangarensis* can be considered two threat-defined locations, as per the IUCN definition (IUCN 2022). This is due to increased frequency of drought and changes in rainfall patterns resulting from climate change being the most serious plausible threat that results in the lowest number of locations for the taxon. Current long-term rainfall regimes and averages are different for both locations (Bell and Lamrock 2021), and so this means that the effect of changes in local rainfall patterns, and the likelihood and severity of droughts, will also likely differ at each location into the future.
12. Continuing decline is inferred in the area, extent and quality of habitat, and the number of individuals of *Senecio linearifolius* var. *dangarensis*. This is due to the effects of increased frequencies of drought and changes in rainfall patterns resulting from climate change, and invasion and competition from *Opuntia stricta*.
13. During the 2017-2019 drought, there was a dramatic decline in mature individuals at both known locations of *S. linearifolius* var. *dangarensis* (Bell and Lamrock 2021). While numbers of *Senecio linearifolius* var. *dangarensis* appear to be rebounding at Woodlands to replenish pre-drought numbers, plant numbers at Mount Dangar had reduced by approximately 50% of pre-drought numbers by 2021 (Bell and Lamrock 2021) with further declines noted in 2022 (S. Bell *in litt.* August 2022). This indicates that the species is sensitive to drought and changes in rainfall, given that Mount Dangar received substantially less rainfall over the course of 2018 and 2019 compared to Woodlands (Bell and Lamrock 2021). Given that the Hunter Region in which *S. linearifolius* var. *dangarensis* occurs is projected to become hotter, have fewer colder nights under 2°C annually, and more hot days over 35°C annually (CSIRO and BOM 2022; AdaptNSW 2023), and the time spent in drought is projected to increase on the East Coast through the 21st century (CSIRO 2023), it is highly plausible that more frequent and severe droughts driven by these changes in climate will impact *S. linearifolius* var. *dangarensis* in the future. Furthermore, the Hunter Region is also projected to see changes in the seasonality of rainfall into the future, which may further influence the germination rates and seedling survivorship of *Senecio linearifolius* var. *dangarensis*. Cool season rainfall from April to October has decreased by 10% since the late 1990's and this trend is projected to continue into the future (CSIRO and BOM 2022; AdaptNSW 2023; CSIRO 2023), limiting moisture at key stages of the species' lifecycle.
14. It is inferred that *Opuntia stricta* is contributing to continuing decline in the quality and extent of habitat for *Senecio linearifolius* var. *dangarensis*. While a biological control agent, the Cochineal Beetle *Dactylopius opuntiae*, appears to have stabilized the infestation of *O. stricta* at Mount Dangar, the weed is still present (over 300 cladodes in a 10 x 10 m plot) at that site (Bell and Lamrock 2021) and is similarly notable at Woodlands (G. Phillips pers. obs. September 2018). The Cochineal introduction is unlikely to ever eliminate *O. stricta* from Mount Dangar, and so the current levels of infestation are likely to persist without additional management effort (Bell and Lamrock 2021). Additionally, Cochineal are highly susceptible to heavy rainfall events which may detach the sessile organisms from

NSW Threatened Species Scientific Committee

the *O. stricta* cladodes and cannot return to the cladode and perish (A. McConnachie pers. comm. 2019 in Bell and Lamrock 2021). This means that increased incidences of heavy rainfall as projected for the NSW North Coast (CSIRO and BOM 2022) may diminish the abundance of Cochineal and their impacts on *O. stricta*, while the weed biomass increases again with increased soil moisture (Bell and Lamrock 2021). This means that while *O. stricta* is currently unlikely to be significantly impacting numbers and/or persistence of *S. linearifolius* var. *dangarensis*, it is inferred to be contributing to declines in habitat extent and quality, and the possibility of this threat increasing once again in the future cannot be dismissed so long as the weeds persist at the sites.

15. *Senecio linearifolius* var. *dangarensis* Belcher ex I.Thomps is not eligible to be listed as a Critically endangered species.
16. *Senecio linearifolius* var. *dangarensis* Belcher ex I.Thomps is eligible to be listed as an Endangered species as, in the opinion of the NSW Threatened Species Scientific Committee, it is facing a very high risk of extinction in Australia in the near future as determined in accordance with the following criteria as prescribed by the *Biodiversity Conservation Regulation 2017*:

Assessment against *Biodiversity Conservation Regulation 2017* criteria

The Clauses used for assessment are listed below for reference.

Overall Assessment Outcome: Endangered under Clause 4.3(b)(d)(e i,iii).

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

Assessment Outcome: Not met

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

Clause 4.3 - Restricted geographic distribution of species and other conditions (Equivalent to IUCN criterion B)

Assessment Outcome: Endangered under Clause 4.3 (b)(d)(e i,iii)

NSW Threatened Species Scientific Committee

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: Not met

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,

NSW Threatened Species Scientific Committee

		(B)	all or nearly all mature individuals of the species occur within one population,
		(C)	extreme fluctuations occur in an index of abundance appropriate to the species.

**Clause 4.5 - Low total numbers of mature individuals of species
(Equivalent to IUCN criterion D)
Assessment Outcome: Not met**

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

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

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

**Clause 4.7 - Very highly restricted geographic distribution of species–vulnerable species
(Equivalent to IUCN criterion D2)
Assessment Outcome: Not met**

For vulnerable species,	the geographic distribution of the species or the number of locations of the species is very highly restricted such that the species is prone to the effects of human activities or stochastic events within a very short time period.
-------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Senior Professor Kristine French
Chairperson
NSW Threatened Species Scientific Committee

Supporting Documentation:

NSW Threatened Species Scientific Committee

Phillips GP, Wong V (2023) Conservation Assessment of *Senecio linearifolius* var. *dangarensis* Belcher ex I.Thomps (Asteraceae). NSW Threatened Species Scientific Committee.

References:

AdaptNSW (2023) Interactive climate change projections map. Available at: <https://www.climatechange.environment.nsw.gov.au/projections-map?region=south-east-and-tablelands&climateprojection=tasmean&range=0> (accessed on 26 September 2023).

Bell, SAJ (2018) Mt Dangar Multi-species Saving our Species Project: Year 2 (2017-2018) Summary Report. Unpublished Report to NSW National Parks and Wildlife Service. October 2018. Eastcoast Flora Survey.

Bell SAJ, Lamrock P (2021) Mt Dangar Multi-species Saving our Species Project: Year 5 (2020-2021) Summary Report. Unpublished DRAFT Reportv2 to NSW National Parks and Wildlife Service. August 2021. Eastcoast Flora Survey.

CSIRO (2023). Climate Change in Australia: East Coast South projection summaries. URL: <https://www.climatechangeinaustralia.gov.au/en/projections-tools/regional-climate-change-explorer/sub-clusters/?current=ECSC&tooltip=true&popup=true> (Accessed 26 September 2023).

CSIRO and the Bureau of Meteorology (BOM) (2022). State of the Climate 2022. CSIRO and the Bureau of Meteorology, Commonwealth of Australia. URL: <http://www.bom.gov.au/state-of-the-climate/2022/documents/2022-state-of-the-climate-web.pdf> (Accessed 26 September 2023).

Davies RJP (2009). *The Monitoring of the Impact of Fire and Hydrological Change on the Nationally Threatened Daisy Senecio macrocarpus in Messent Conservation Park in the Upper South East of South Australia, 1992-2009*. Consultants report prepared for South East Region, Department for Environment & Heritage, South Australia.

Gross CL, Mackay D (2014). Two decades of demography reveals that seed and seedling transitions limit population persistence in a translocated shrub. *Annals of Botany* **114**: 85-96.

IUCN Standards and Petitions Subcommittee (2022). Guidelines for Using the IUCN Red List Categories and Criteria. Version 15.1 (July 2022). Standards and Petitions Committee of the IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.

Mackenzie BDE, Auld TD (2020) Seed Ecology of *Senecio linearifolius* var. *dangarensis*: Year 1 Progress Report (Oct 2018-Dec 2019).

NSW Threatened Species Scientific Committee

Mickaill LN, Bell SA, Beranek CT (2020) Dispersal potential in two restricted and five wide-ranging *Senecio* (Asteraceae) taxa from central eastern New South Wales, Australia. *Australian Journal of Botany*, **68(5)**, 333–344.

Thompson IR (2004) Taxonomic studies in Australian *Senecio* (Senecioneae - Asteraceae). II. The shrubby discoid species and the allied radiate species *Senecio linearifolius*. *Muelleria* **20**, 67–110.

Wapstra M, Thompson IR, Buchanan AM (2008) An illustrated and annotated key to the Tasmanian species of *Senecio* (Asteraceae). *The Research Journal of the Tasmanian Museum and Art Gallery*, **3(2)**, 49.

Zimmer H (2018) Conservation Assessment of *Senecio linearifolius* var. *dangarensis*. NSW Threatened Species Scientific Committee.