Consultation on Species Listing Eligibility and Conservation Actions

Leucopogon gnaphalioides (Stirling Range beard-heath)

You are invited to provide your views and supporting reasons related to:

1) the eligibility of *Leucopogon gnaphalioides* (Stirling Range beard-heath) for inclusion on the EPBC Act threatened species list in the Critically Endangered category; and

2) the necessary conservation actions for the above species.

The purpose of this consultation document is to elicit additional information to better understand the status of the species and help inform on conservation actions and further planning. As such, the below draft assessment should be considered to be **tentative** as it may change following responses to this consultation process.

Evidence provided by experts, stakeholders and the general public are welcome. Responses can be provided by any interested person.

Anyone may nominate a native species, ecological community or threatening process for listing under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or for a transfer of an item already on the list to a new listing category. The Threatened Species Scientific Committee (the Committee) undertakes the assessment of species to determine eligibility for inclusion in the list of threatened species and provides its recommendation to the Australian Government Minister for the Environment.

Responses are to be provided in writing by email to: species.consultation@awe.gov.au

Please include species scientific name in Subject field.

or by mail to:

The Director Bushfire Affected Species Assessments Section Department of Agriculture, Water and the Environment John Gorton Building, King Edward Terrace GPO Box 858 Canberra ACT 2601

Responses are required to be submitted by 8 July 2022.

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General background information about listing threatened species

The Australian Government helps protect species at risk of extinction by listing them as threatened under Part 13 of the EPBC Act. Once listed under the EPBC Act, the species becomes a Matter of National Environmental Significance (MNES) and must be protected from significant impacts through the assessment and approval provisions of the EPBC Act. More information about threatened species is available on the department's website at: https://www.awe.gov.au/environment/biodiversity/threatened.

Public nominations to list threatened species under the EPBC Act are received annually by the department. In order to determine if a species is eligible for listing as threatened under the EPBC Act, the Threatened Species Scientific Committee (the Committee) undertakes a rigorous scientific assessment of its status to determine if the species is eligible for listing against a set of criteria. These criteria are available on the Department's website at: https://www.awe.gov.au/sites/default/files/env/pages/d72dfd1a-f0d8-4699-8d43-5d95bbb02428/files/tssc-guidelines-assessing-species-2021.pdf.

As part of the assessment process, the Committee consults with the public and stakeholders to obtain specific details about the species, as well as advice on what conservation actions might be appropriate. Information provided through the consultation process is considered by the Committee in its assessment. The Committee provides its advice on the assessment (together with comments received) to the Minister regarding the eligibility of the species for listing under a particular category and what conservation actions might be appropriate. The Minister decides to add, or not to add, the species to the list of threatened species under the EPBC Act. More detailed information about the listing process is at: https://www.awe.gov.au/environment/biodiversity/threatened/nominations.

To promote the recovery of listed threatened species and ecological communities, conservation advices and where required, recovery plans are made or adopted in accordance with Part 13 of the EPBC Act. Conservation advices provide guidance at the time of listing on known threats and priority recovery actions that can be undertaken at a local and regional level. Recovery plans describe key threats and identify specific recovery actions that can be undertaken to enable recovery activities to occur within a planned and logical national framework. Information about recovery plans is available on the department's website at: https://www.awe.gov.au/environment/biodiversity/threatened/recovery-plans.

Privacy notice

The Department will collect, use, store and disclose the personal information you provide in a manner consistent with the Department's obligations under the Privacy Act 1988 (Cth) and the Department's Privacy Policy.

Any personal information that you provide within, or in addition to, your comments in the threatened species assessment process may be used by the Department for the purposes of its functions relating to threatened species assessments, including contacting you if we have any questions about your comments in the future.

Further, the Commonwealth, State and Territory governments have agreed to share threatened species assessment documentation (including comments) to ensure that all States and Territories have access to the same documentation when making a decision on the status of a potentially threatened species. This is also known as the <u>'Common Assessment Method' (CAM)</u>. As a result, any personal information that you have provided in connection with your comments may be shared between Commonwealth, State or Territory government entities to assist with their assessment processes.

The Department's Privacy Policy contains details about how respondents may access and make corrections to personal information that the Department holds about the respondent, how respondents may make a complaint about a breach of an Australian Privacy Principle, and how the Department will deal with that complaint. A copy of the Department's Privacy Policy is available at: <u>https://www.awe.gov.au/about/commitment/privacy</u>.

Information about this consultation process

Responses to this consultation can be provided electronically or in hard copy to the contact addresses provided on Page 1. All responses received will be provided in full to the Committee and then to the Australian Government Minister for the Environment.

In providing comments, please provide references to published data where possible. Should the Committee use the information you provide in formulating its advice, the information will be attributed to you and referenced as a 'personal communication' unless you provide references or otherwise attribute this information (please specify if your organisation requires that this information is attributed to your organisation instead of yourself). The final advice by the Committee will be published on the department's website following the listing decision by the Minister.

Information provided through consultation may be subject to freedom of information legislation and court processes. It is also important to note that under the EPBC Act, the deliberations and recommendations of the Committee are confidential until the Minister has made a final decision on the nomination, unless otherwise determined by the Minister.

<u>CONSULTATION QUESTIONS FOR LEUCOPOGON GNAPHALIOIDES</u> (STIRLING RANGE BEARD HEATH)

SECTION A - GENERAL

- Is the information used to assess the nationally threatened status of the species/subspecies robust? Have all the underlying assumptions been made explicit? Please provide justification for your response.
- 2. Can you provide additional data or information relevant to this assessment?
- 3. Have you been involved in previous state, territory or national assessments of this species/subspecies? If so, in what capacity?

PART 1 – INFORMATION TO ASSIST LISTING ASSESSMENT

<u>SECTION B</u> DO YOU HAVE ADDITIONAL INFORMATION ON THE ECOLOGY OR BIOLOGY OF THE SPECIES/SUBSPECIES? (If no, skip to section C)

Biological information

- 4. Can you provide any additional or alternative references, information or estimates on longevity, average life span and generation length?
- 5. Do you have any additional information on the ecology or biology of the species/subspecies not in the current advice?

<u>SECTION C</u> ARE YOU AWARE OF THE STATUS OF THE TOTAL NATIONAL POPULATION OF THE SPECIES/SUBSPECIES? (If no, skip to section D)

Population size

- 6. Has the survey effort for this taxon been adequate to determine its national adult population size? If not, please provide justification for your response.
- 7. Do you consider the way the population size has been derived to be appropriate? Are there any assumptions and unquantified biases in the estimates? Did the estimates measure relative or absolute abundance? Do you accept the estimate of the total

population size of the species/subspecies? If not, please provide justification for your response.

8. If not, can you provide a further estimate of the current population size of mature adults of the species/subspecies (national extent)? Please provide supporting justification or other information.

If, because of uncertainty, you are unable to provide a single number, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of possible species/subspecies numbers, and also choose the level of confidence you have in this estimate:

Number of mature individuals is estimated to be in the range of:

□ 1-250 □ 250-1000 □ 1000-2500 □ 2500-10,000 □ >10,000

Level of your confidence in this estimate:

 \Box 0–30% - low level of certainty/ a bit of a guess/ not much information to go on

 \Box 31–50% - more than a guess, some level of supporting evidence

□ 51–95% - reasonably certain, information suggests this range

- 95–100% high level of certainty, information indicates quantity within this range
- 99–100% very high level of certainty, data are accurate within this range

SECTION D ARE YOU AWARE OF TRENDS IN THE OVERALL POPULATION OF THE SPECIES/SUBSPECIES? (If no, skip to section E)

9. Does the current and predicted rate of decline used in the assessment seem reasonable? Do you consider that the way this estimate has been derived is appropriate? If not, please provide justification of your response.

Evidence of total population size change

10. Are you able to provide an estimate of the total population size during the early 1990s (at or soon after the start of the most recent three generation period)? Please provide justification for your response.

If, because of uncertainty, you are unable to provide a single number, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the

table below of possible species/subspecies numbers, and also choose the level of confidence you have in this estimate.

Number of mature individuals is estimated to be in the range of:

□ 1-250 □ 250-1000 □ 1000-2500 □ 2500-10,000 □ >10,000

Level of your confidence in this estimate:

 \Box 0–30% - low level of certainty/ a bit of a guess/ not much information to go on

□ 31–50% - more than a guess, some level of supporting evidence

□ 51–95% - reasonably certain, information suggests this range

95–100% - high level of certainty, information indicates quantity within this range

- 99–100% very high level of certainty, data are accurate within this range
- 11. Are you able to comment on the extent of decline in the species/subspecies' total population size over the last approximately 39–69 years (i.e. three generations period)? Please provide justification for your response.

If, because of uncertainty, you are unable to provide an estimate of decline, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of ranges of decline, and also choose the level of confidence you have in this estimated range.

Decline estimated to be in the range of:

□ 1–30% □ 31–50% □ 51–80% □ 81–100% □ 90–100%

Level of your confidence in this estimated decline:

- \Box 0–30% low level of certainty/ a bit of a guess/ not much information to go on
- \Box 31–50% more than a guess, some level of supporting evidence
- \Box 51–95% reasonably certain, suggests this range of decline

- 95–100% high level of certainty, information indicates a decline within this range
- 99–100% very high level of certainty, data are accurate within this range
- 12. Please provide (if known) any additional evidence which shows the population is stable, increasing or declining.

<u>SECTION E</u> ARE YOU AWARE OF INFORMATION ON THE TOTAL RANGE OF THE SPECIES/SUBSPECIES? (If no, skip to section F)

Current Distribution/range/extent of occurrence, area of occupancy

- 13. Does the assessment consider the entire geographic extent and national extent of the species/subspecies? If not, please provide justification for your response.
- 14. Has the survey effort for this species/subspecies been adequate to determine its national distribution? If not, please provide justification for your response.
- 15. Is the distribution described in the assessment accurate? If not, please provide justification for your response and provide alternate information.
- 16. Do you agree that the way the current extent of occurrence and/or area of occupancy have been estimated is appropriate? Please provide justification for your response.
- 17. Can you provide estimates (or if you disagree with the estimates provided, alternative estimates) of the extent of occurrence and/or area of occupancy.

If, because of uncertainty, you are unable to provide an estimate of extent of occurrence, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of ranges of extent of occurrence, and also choose the level of confidence you have in this estimated range.

Current extent of occurrence is estimated to be in the range of:

 \Box <100 km² \Box 100 – 5000 km² \Box 5000 – 20,000 km² \Box >20,000 km²

Level of your confidence in this estimated extent of occurrence

 \Box 0–30% - low level of certainty/ a bit of a guess/ not much data to go on

 \Box 31–50% - more than a guess, some level of supporting evidence

□ 51–95% - reasonably certain, data suggests this range of decline

95–100% - high level of certainty, data indicates a decline within this range

99–100% - very high level of certainty, data is accurate within this range

If, because of uncertainty, you are unable to provide an estimate of area of occupancy, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of ranges of area of occupancy, and also choose the level of confidence you have in this estimated range.

Current area of occupancy is estimated to be in the range of:

 \Box <10 km² \Box 10 – 500 km² \Box 500 – 2000 km² \Box >2000 km²

Level of your confidence in this estimated extent of occurrence:

 \Box 0–30% - low level of certainty/ a bit of a guess/ not much data to go on

 \Box 31–50% - more than a guess, some level of supporting evidence

□ 51–95% - reasonably certain, data suggests this range of decline

95–100% - high level of certainty, data indicates a decline within this range

 \Box 99–100% - very high level of certainty, data is accurate within this range

<u>SECTION F</u> ARE YOU AWARE OF TRENDS IN THE TOTAL RANGE OF THE SPECIES/SUBSPECIES? (If no, skip to section G)

Past Distribution/range/extent of occurrence, area of occupancy

- 18. Do you consider that the way the historic distribution has been estimated is appropriate? Please provide justification for your response.
- 19. Can you provide estimates (or if you disagree with the estimates provided, alternative estimates) of the former extent of occurrence and/or area of occupancy.

If, because of uncertainty, you are unable to provide an estimate of past extent of occurrence, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of ranges of past extent of occurrence, and also choose the level of confidence you have in this estimated range.

Past extent of occurrence is estimated to be in the range of:

 \Box <100 km² \Box 100 – 5000 km² \Box 5000 – 20,000 km² \Box >20,000 km²

Level of your confidence in this estimated extent of occurrence

- \Box 0–30% low level of certainty/ a bit of a guess/ not much data to go on
- \Box 31–50% more than a guess, some level of supporting evidence
- □ 51–95% reasonably certain, data suggests this range of decline
- 95–100% high level of certainty, data indicates a decline within this range
- 99–100% very high level of certainty, data is accurate within this range

If, because of uncertainty, you are unable to provide an estimate of past area of occupancy, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of ranges of past area of occupancy, and also choose the level of confidence you have in this estimated range:

Past area of occupancy is estimated to be in the range of:

 \Box <10 km² \Box 10 – 500 km² \Box 500 – 2000 km² \Box >2000 km²

Level of your confidence in this estimated extent of occurrence:

- \Box 0–30% low level of certainty/ a bit of a guess/ not much data to go on
- \Box 31–50% more than a guess, some level of supporting evidence
- □ 51–95% reasonably certain, data suggests this range of decline
- \Box 95–100% -high level of certainty, data indicates a decline within this range
- 99–100% very high level of certainty, data is accurate within this range

PART 2 – INFORMATION FOR CONSERVATION ADVICE ON THREATS AND CONSERVATION ACTIONS

<u>SECTION G</u> DO YOU HAVE INFORMATION ON THREATS TO THE SURVIVAL OF THE SPECIES/SUBSPECIES? (If no, skip to section H)

- 20. Do you consider that all major threats have been identified and described adequately?
- 21. To what degree are the identified threats likely to impact on the species/subspecies in the future?
- 22. Are the threats impacting on different populations equally, or do the threats vary across different populations?
- 23. Can you provide additional or alternative information on past, current or potential threats that may adversely affect the species/subspecies at any stage of its life cycle?
- 24. Can you provide supporting data/justification or other information for your responses to these questions about threats?

<u>SECTION H</u> DO YOU HAVE INFORMATION ON CURRENT OR FUTURE MANAGEMENT FOR THE RECOVERY OF THE SPECIES/SUBSPECIES? (If no, skip to section I)

- 25. What planning, management and recovery actions are currently in place supporting protection and recovery of the species/subspecies? To what extent have they been effective?
- 26. Can you recommend any additional or alternative specific threat abatement or conservation actions that would aid the protection and recovery of the species/subspecies?
- 27. Would you recommend translocation (outside of the species' historic range) as a viable option as a conservation actions for this species/subspecies?

<u>SECTION I</u> DO YOU HAVE INFORMATION ON STAKEHOLDERS IN THE RECOVERY OF THE SPECIES/SUBSPECIES?

- 28. Are you aware of other knowledge (e.g. traditional ecological knowledge) or individuals/groups with knowledge that may help better understand population trends/fluctuations, or critical areas of habitat?
- 29. Are you aware of any cultural or social importance or use that the species/subspecies has?
- 30. What individuals or organisations are currently, or potentially could be, involved in management and recovery of the species/subspecies?
- 31. How aware of this species/subspecies are land managers where the species/subspecies is found?
- 32. What level of awareness is there with individuals or organisations around the issues affecting the species/subspecies?
 - a. Where there is awareness, what are these interests of these individuals/organisations?
 - b. Are there populations or areas of habitat that are particularly important to the community?

PART 3 – ANY OTHER INFORMATION

33. Do you have comments on any other matters relevant to the assessment of this species/subspecies?

Conservation Advice for Leucopogon gnaphalioides (Stirling Range beard heath)

This draft document is being released for consultation on the species listing eligibility and conservation actions

The purpose of this consultation document is to elicit additional information to better understand the status of the species and help inform conservation actions, further planning and a potential recovery plan. The draft assessment below should therefore be considered **tentative** at this stage, as it may change as a result of responses to this consultation process.

<u>Note</u>: Specific consultation questions relating to the below draft assessment and preliminary determination have been included in the consultation cover paper for your consideration.

This document combines the approved conservation advice and listing assessment for the Stirling Range beard heath. It provides a foundation for conservation action and further planning.



Leucopogon gnaphalioides © Copyright. Photography by E. Hickman. Image used with the permission of the Western Australian Herbarium, Department of Biodiversity, Conservation and Attractions (https://florabase.dpaw.wa.gov.au/help/copyright). Accessed on Monday, 31 January 2022.

Conservation status

Leucopogon gnaphalioides (Stirling Range beard heath) is currently listed in the Endangered category and is proposed to be transferred to the Critically Endangered category under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) (EPBC Act).

Leucopogon gnaphalioides was assessed by the Threatened Species Scientific Committee to be eligible for listing as Critically Endangered under criterion 2. The Committee's assessment is at Attachment A. The Committee's assessment of the species' eligibility against each of the listing criteria is:

- Criterion 1: Critically Endangered: A4b,c,e
- Criterion 2: Critically Endangered: B1a,b(i,ii,iii,iv,v)
- Criterion 3: Endangered: C1
- Criterion 4: Vulnerable: D
- Criterion 5: Insufficient data

The main factors that make the species eligible for listing are its projected very severe population reduction, very restricted geographic distribution and continuing decline.

Species can also be listed as threatened under state and territory legislation. For information on the current listing status of this species under relevant state or territory legislation, see the <u>Species Profile and Threat Database</u>.

Species information

Taxonomy

Conventionally accepted as *Leucopogon gnaphalioides* Stchegl. (1859). Family: Ericaceae.

Description

The Stirling Range beard heath has densely hairy branches, with dull grey leaves that are dense, erect, ovate to lanceolate in shape and have more than one nerve. The leaf apex is acute. The top of the leaf is hairless with the base of the inside of the leaf having appressed hairs. The leaf margin has long, dense hairs. The inflorescence is comprised of a cluster of short spikes at the end of branches, branchlets are hairy, short bracts are keeled. The flower (calyx) is white, tips acute, margin has long, dense hairs or cilia. Seeds are small and wingless. Stirling Range beard heath differs from *L. elegans* in having larger flowers, hairy bracts and larger, hairy leaves (Stschegleew 1859).

Distribution

Stirling Range beard heath is endemic to Koikyenunuruff/Stirling Ranges in the Esperance Plains bioregion (IBRA7) of WA. The species occurs within the South Coast Natural Resource Management Region.

The species occurs in nine subpopulations, all within Stirling Range National Park (Table 1). The most recent estimate of the Stirling Range beard heath population is 144 mature plants and 1521 juveniles (S. Barrett 2022 pers. comm. 4 Jan; Table 1). The species is difficult to survey, with population estimates varying substantially depending on survey intensity and methods (S. Barrett 2022 pers. comm. 4 Jan). Ongoing browsing by *Setonix brachyurus* (quokka) has been observed to reduce growth and maturation rates thereby keeping many plants in a 'juvenile' non-reproductive state (S. Barrett 2022 pers. comm. 4 Jan). Inter-fire recruitment has also been observed in most populations (S. Barrett 2022 pers. comm. 4 Jan).

Subpopulation	Date	No mature	No juvenile &/or seedlings or non-reproductive	Confidence level
1 Isongerup	2/12/2021	75	900	Medium
	23/2/2021	6	650	Medium
	2017	550	70	Medium
	2016	600	75	Medium
	2014	600	150	Medium
	2013	350	400	Medium
	2011	300	500	Medium
	2008	>200	300-500	
	2002	>50	>50	
2 Mondurup	15/3/2021	66 (fire escapes)	110	High
	9/5/2019	136 (pop extended)		High
	2011	25*	>15*	
	2004		>520*	
	2000	12*	5*	
3 Bluff Knoll	19/2/2021	2	200	Medium
	2018	450	750 (browsed / interfire recruits)	Medium
	2017	450	1000 (browsed / interfire recruits)	Medium
	2015	500	2000 (browsed / interfire recruits)	Medium
	2011	500	2000 (browsed / interfire recruits)	Medium
	2002	>100	>600	
	2001		>350	Low
	1996	1000		
4 Ellen Peak	16/4/2020	0	30	High
	2002	0	0	High
	2000	30	0	High
	1995	50		
5 Toolbrunup	29/10/2021	1	16	High
	04/8/2021	3 (fire escapes)	16 (browsed / interfire recruits)	High
	2007	0	0	High
	1999	2	0	High
	1996	15		

Table 1 Recent monitoring data for Stirling Range beard heath

Subpopulation	Date	No mature	No juvenile &/or seedlings or non-reproductive	Confidence level
6 Pyungoorup	5/1/2021	0	180	Medium
	2017	45	400 (browsed / interfire recruits)	Medium
	2015	45	700 (browsed / interfire recruits)	Medium
	2011		100	
	2002	6	>400	
7 Coyanerup	4/11/2021	0	50	
	2017	20	30 (browsed / interfire recruits)	
	2015		50	
	2011	1		
	2000	>5		
8 East Bluff	31/3/2021	0	0	High
	2017	25	15	High
	2015	30	20	High
	2012	0	20	
	2004	0	1	
9 Bakers Knob	23/2/2021	0	35	
	2019	0	5	
	2014	0	0	
	2012	0	4	
	2011		5	
	2009		5	

*additional areas of plants at subpopulation 2 were discovered in 2019, meaning earlier counts are likely underestimate the number of plants at this subpopulation.

Source: S. Barrett 2022 pers. comm. 4 January; DOEE 2017.

Table 2 Monitoring data for subpopulation 3: density of plants per m² in 1 x 1 m quadrats

Year	2002	2008	2011	2012
Density (per m ²)	12.4	8	4.4	0.4

Source: S. Barrett 2022 pers. comm. 4 January



Map 1 Modelled distribution of Stirling Range beard heath

Source: Base map Geoscience Australia; species distribution data <u>Species of National Environmental Significance</u> database. **Caveat:** The information presented in this map has been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything contained herein.

Species distribution mapping: The species distribution mapping categories are indicative only and aim to capture (a) the habitat or geographic feature that represents to recent observed locations of the species (known to occur) or habitat occurring in close proximity to these locations (likely to occur); and (b) the broad environmental envelope or geographic region that encompasses all areas that could provide habitat for the species (may occur). These presence categories are created using an extensive database of species observations records, national and regional-scale environmental data, environmental modelling techniques and documented scientific research.

Cultural and community significance

The cultural, customary and spiritual significance of species and the ecological communities they form are diverse and varied for Indigenous Australians and their stewardship of Country. This section describes some examples of this significance but is not intended to be comprehensive or applicable to, or speak for, Indigenous Australians. Such knowledge may be held by Indigenous Australians who are the custodians of this knowledge and have the rights to decide how this knowledge is shared and used.

Stirling Range beard heath occurs on the traditional lands of the Ganeang, Goreng and Minang dialectals groups of the Noongar Nation. Koikyenunuruff (Stirling Range) is a culturally significant site to Noongars and features in Dreaming stories (DPAW 2016; South West Aboriginal Land & Sea Council 2022). Bluff Knoll, where Stirling Range beard heath occurs, is the location where the spirits of Ganeang, Goreng and Minang Traditional Owners go after death

(South West Aboriginal Land & Sea Council 2022). An Aboriginal Heritage Place, Kojaneerup (5145), has been registered with the Western Australian Department of Planning, Lands and Heritage in or adjacent to lands where Stirling Range beard heath occurs (DPLH 2022). Additionally, the Wagyl Kaip & Southern Noongar Aboriginal Corporation Indigenous Land Use Agreements (2018), executed by the Western Australian Government and the Noongar Nation, includes lands in or adjacent to lands where Stirling Range beard heath occurs.

The cultural significance of Stirling Range beard heath is currently unknown. However, given the acknowledged importance to Aboriginal peoples of Connection to Country and the widespread importance of Caring for Country (which includes biodiversity, 'place', custom and totemic elements) it is considered likely that the species has or is associated with some cultural and/or community significance. Ascertaining the cultural significance of this species is a priority in the Conservation and Recovery Actions.

Relevant biology and ecology

Habitat

Stirling Range beard heath inhabits thick scrub/heath on shallow, brown, sandy clay over schist on the peaks of Koikyenunuruff/Stirling Ranges. Associated species may include *Actinotus rhomboideus*, *Sphenotoma* spp., *Acacia drummondii* (Drummond's wattle), *Kunzea montana* (mountain kunzea), *Calothamnus montanus*, *Beaufortia anisandra* (dark beaufortia), *Taxandria floribunda*, *Lepidosperma* spp., *Xerochrysum macranthum*, *Leucopogon atherolepis* and *Goodenia brendannarum* (DOEE 2017).

The species is part of the Eastern Stirling Range Montane Heath and Thicket Threatened Ecological Community, which is listed as Endangered under the EBPC Act and Critically Endangered under WA Minister Environmentally Sensitive Areas list in policy (DPAW 2016).

Reproductive Ecology

Little is known about the reproductive ecology of Stirling Range beard heath, and as a result, this section draws largely on published literature from congeneric species.

Flowering occurs typically from October to December (Western Australian Herbarium 2022). *Leucopogon* species have unspecialised flowers and are mainly pollinated by bees, but are also visited by a range of other insects including flies, wasps, butterflies and moths (DOEE 2017). *Leucopogon* species have seed dispersed by ants and birds, including *Dromaius novaehollandiae* (emu) (Tangney 2013; Ooi 2019).

Seeds of Stirling Range beard heath have orthodox seed storage behaviour, and can be dried to low moisture contents without damage enabling long term ex situ storage (Kew Botanic Gardens 2022). Germination of Stirling Range beard heath occurs both following fire events and during the inter-fire period (S. Barrett 2022 pers. comm. 4 Jan). In a study of three *Leucopogon* species from New South Wales, Ooi et al. (2006) found that primary dormancy was morphophysiological, with seasonal temperature changes overcoming primary dormancy and controlling the timing of germination. Fire cues did not break primary dormancy, but smoke enhanced germination once this dormancy was overcome. Recruitment appears to be staggered following fire, with considerable additional germination observed in subpopulation 1 in December 2021, three and a half years post-fire. This corresponds with observations of delayed post-fire germination from other *Leucopogon* species (Ooi et al. 2004; Ooi 2010).

Leucopogon species associate with Ericoid mycorrhizal fungi in their roots that assist in the uptake of nitrogen and phosphorus (Midgley et al. 2004).

The length of the primary juvenile period has been observed to be about six to seven years based upon 50 percent flowering although browsing may have influenced this estimate (S. Barrett 2022 pers. comm. 3 February). The maximum longevity of adult plants is unknown, but is more than 20 years and likely longer in the absence of disease (S. Barrett 2022 pers. comm. 3 February).

Fire ecology

Stirling Range beard heath is an obligate seeder (S. Barrett 2022 pers. comm. 4 January). Seeds of Stirling Range beard heath persist in a soil seed bank (S. Barrett 2022 pers. comm. 4 January). Seed of other *Leucopogon* species form seed banks with half-lives of 3.5 to 5.5 years (Ooi et al. 2007). Minimum and maximum tolerable fire intervals are unknown.

Habitat critical to the survival

Stirling Range beard heath inhabits thick scrub/heath on shallow, brown, sandy clay over schist on the peaks of Koikyenunuruff/Stirling Ranges.

At this point in time there is insufficient information available to describe, with spatial information, areas of habitat that are critical to the survival of the species. Further research is needed to do this (see conservation actions). Until such information is available, all habitat for this species should be considered habitat critical for the species' long-term survival.

No Critical Habitat as defined under section 207A of the EPBC Act has been identified or included in the Register of Critical Habitat.

Important populations

In this section, the word population is used to refer to subpopulation, in keeping with the terminology used in the EPBC Act and state/territory environmental legislation.

There is sufficient evidence through the species eligibility for listing as Critically Endangered to consider all populations/the national population as important populations of this species under particular pressure of survival and which therefore require protection to support the recovery of the species.

Threats

The most serious threats to Stirling Range beard heath are dieback caused by *Phytophthora cinnamomi*, inappropriate fire regimes, herbivory and changes to temperature and precipitation patterns.

Threat	Status and severity ^a	Evidence
Disease		
Dieback caused by <i>Phytophthora</i> spp. infection	• Timing: current	<i>Phytophthora cinnamomi</i> is an introduced soil-borne plant pathogen that results in plant death through the destruction of root systems (DPAW 2014). 'Dieback caused by the root-

Table 3 Threats impacting Stirling Range beard heath

Threat	Status and severity ^a	Evidence
	 Confidence: known Likelihood: almost certain Consequence: catastrophic Trend: stable Extent: across the entire range 	rot fungus <i>Phytophthora cinnamomi</i> ' is listed as a Key Threatening Process under the EPBC Act (DOEE 2018). Stirling Range beard heath is highly susceptible to <i>P. cinnamomi</i> , based on sampling of dying wild plants and experimental inoculation of ex situ plants (Barrett et al. 2008; S. Barrett 2022 pers. comm. 4 January). The species recorded 100% mortality in experimental inoculation trials (Barret et al. 2008). The pathogen is present across all of the species' habitat (S. Barrett 2022 pers. comm. 4 January). Phosphite has been applied to subpopulations 1, 2, 3, 6, 7, 8 and 9 on a regular basis to limit mortality from the pathogen (S. Barrett 2022 pers. comm. 4 January). The effects of interactions between the pathogen and fire on Stirling Range beard heath are not well understood, but fire has been demonstrated to increase the severity and extent of <i>P. cinnamomi</i> disease in Koikyenunuruff/Stirling Range (Moore et al. 2015). Fire also places burnt populations at greater risk of the disease. Fire kills adult plants, reducing seed production. It also stimulates germination of soil-stored seed, with subsequent seedlings then vulnerable to <i>P. cinnamomi</i> . Dieback caused by <i>Phytophthora</i> spp. is likely to continue to degrade the species' habitat by removing susceptible species, with possible indirect negative impacts on Stirling
		Range beard heath (e.g. through impacts on insect pollinators; Wills 1993).
Habitat loss, disturbance a	nd modifications	
Fire regimes that cause decline in biodiversity	 Timing: current Confidence: known Likelihood: likely Consequence: catastrophic Trend: increasing Extent: across the entire range 	 Stirling Range beard heath is an obligate seeder (S. Barrett 2022 pers. comm. 4 January), with adult plants killed by fire and recruiting from seed. Subpopulations 1, 3, 4, 7 and 8 were burnt by fire in May 2018, subpopulations 2 and 5 were part-burnt in December 2019, and subpopulations 6 and 9 were part-burnt in both the 2018 and 2019 fires, with small areas of overlap that were double-burnt (S. Barrett 2022 pers. comm. 4 January). Historically, subpopulation 2 was burnt in 1983, subpopulations 1, 3 and 7 in 1991, and subpopulation 5 in 1996 (DEC 2013). A fire which occurred in October-November 2000 burnt most subpopulations of Stirling Range beard heath, except subpopulation 5 (CALM 2001). The 2018 fire was the result of escaped prescribed burns in the area. Strong winds resulted in prescribed burns on private property and crown land growing out of control and becoming bushfires (BOM 2018; OBRM 2018). There are a number of mechanisms by which the fire regime impacts a species with obligate seeding traits (Keith 1996; DAWE 2021a). These include the frequency of fire (high vs low); the severity of fires (high vs low); the season of fire; and the interactions between fire and climate change and other threats (herbivory, disease, etc.). Stirling Range beard heath may be sensitive to high fire frequency, low fire severity, out of season fires, and interactions between fire and climate change, fire and disease, and potentially fire and pollinator availability. Too frequent fires Obligate seeders require a minimum time between successive fires to allow time for the species to accumulate sufficient soil-stored seed to ensure population persistence (Keith 1996, DAWE 2021a). This is termed the minimum fire interval. The length of the primary juvenile period of Stirling

Threat	Status and severity a	Evidence
		seven years based upon 50 percent flowering although browsing may have influenced this estimate (S. Barrett 2022 pers. comm. 3 February). The minimum fire interval for the species could be in the order of 10–15 years or longer, as the species likely requires several flowering seasons to restore the soil seed bank to pre-fire levels, and threats such as herbivory keep plants in an immature state, while dieback from <i>P. cinnamomi</i> reduces fecundity. Stirling Range beard heath often occurs with other species that have longer minimum fire intervals (DPAW 2016).
		Alternatively, in the long absence of fire, non-sprouting fire recruiting plants may senesce and die before there is an opportunity for regeneration (Whelan 1995; Bond & van Wilgen 1996). The lifespan of Stirling Range beard heath is unknown, although is more than 20 years (S. Barrett 2022 pers. comm. 4 January). However, the species is capable of recruiting in the absence of fire (S. Barrett 2022 pers. comm. 4 Jan). Therefore, fire exclusion is unlikely to pose a significant threat to the population.
		Prescribed burning can also increase the frequency of fire. For example, a widespread fire in 2018 was the result of an escaped prescribed burn and was followed 18 months later by a wildfire in 2019 (OBRM 2018). There were small areas of overlap between the two fires in Stirling Range beard heath subpopulations, which affected parts of subpopulations 6 and 9. The impacts of being double-burnt by these two fires are difficult to interpret in subpopulation 9 due to the very small number of plants. However, post-fire recruitment at subpopulation 6 appears to have been poor, with 0 mature individuals and 180 seedlings recorded in 2021 where there had been a pre-fire population of 45 mature plants and 400 immature plants. It is possible that the impact of being double-burnt at least partly explains the poor post-fire recruitment at this subpopulation.
		Low severity fires
		Temperature-sensitive obligate seeders require soil temperatures to be sufficient to break seed dormancy (either physically or physiologically) and initiate germination (Auld & O'Connel 1991; Auld & Ooi 2009). Failure to do this can result in a low rate of recruitment and subsequent population decline (Regan et al. 2003). Low severity fires can occur when fuel loads are low, e.g., because previous fire has reduced vegetation load, or when fires occur out-of- season. Although it is unknown if Stirling Range beard heath has temperature-sensitive dormancy, low severity fires are a risk to the species, until further research suggests otherwise.
4		Out of season fires
		When fire occurs out of season there are a number of mechanisms that lead to recruitment failure and reduce the recovery potential of species following fire (DAWE 2021a). These include:
		1) seedling mortality due to desiccation as a consequence of the interaction between out of season fires and fire- hydrological interactions, particularly by temperate region obligate seeders (Miller et al. 2019),
		2) low rate of seed production due to sub-optimal flowering cues (Morgan 1995) and/or dormancy cues (Ooi et al. 2007), particularly by species that rely on seasonal pollinators or specific flowering conditions, and

Threat	Status and severity a	Evidence
		3) disruption to processes that facilitate post-fire recovery and limit dispersal (Jasinge et al. 2018; Keith et al. 2020), particularly by species with seasonal growing conditions or that require high temperatures during fire to stimulate germination.
		Stirling Range beard heath is adapted to seasonal fire regimes consisting of fire during the dry dormant summer periods followed by moist conditions during the growing and reproductive period. If fires occur during the growing season, standing plants will be killed before seed is produced, inhibiting the population from being replenished.
		Seasonal seed dormancy mechanisms in <i>Leucopogon</i> spp. mean that winter fires can cause delayed emergence, leading to increases in primary juvenile period (Ooi 2019). A long primary juvenile period may limit population persistence because plants are more likely to be killed by subsequent fire before maturation, with seasonal dormancy cues amplifying the effects of this interval squeeze (Ooi 2019).
		Out-of-season fires are also usually of low severity, and prescribed burning at any time of year places obligate seeders at risk of bushfire events that occur in the immediate future, by putting the population in a fire- sensitive juvenile state. This effects of this have been documented for the nearby population of <i>Banksia montana</i> (Stirling Range Dryandra; DAWE 2021b).
		Fire interactions
		There are a range of mechanisms by which fire interacts with other threats and impacts the species recovery potential following fire (DAWE 2021a).
		For Stirling Range beard heath, the interaction between fire and herbivory is of serious concern. Herbivory has been observed to prevent plants from maturing and producing seed by keeping them in an immature state. For example at Bluff Knoll from 2002 to 2012 no plants became reproductive due to browsing by quokka (Rathbone & Barrett 2017 ; S. Barrett 2022 pers. comm. 4 Jan). This places subpopulations at risk of decline or extinction from subsequent fires.
		Interactions between climate change and the fire regime could also lead to significant impacts on the population. Climate change can increase the frequency of fire through changes in the landscape moisture levels, increasing the risk of localised extinctions (Gallagher et al. 2021). For example, climate change is predicted to increase the number of days of elevated temperatures and increase the Forest Fire Danger Index in south-west Australia (DIICCSRTE 2013; Dowdy et al. 2019; CSIRO & BOM 2020). This indicates a potential subsequent reduction in the fire-free interval (Enright et al. 2015; Gallagher 2020; Gallagher et al. 2021).
		Climate associated warming and drying can also reduce the species' resilience by interacting with natural hydrological cycles (see climate change section). Climate associated threat pathways can act in concert through processes such as 'interval squeeze', whereby climate change drives increased pressure via higher fire frequency, while also reducing resilience via slower rates of maturation and lower fecundity (Enright et al. 2015; Henzler et al. 2018).
		Other potential fire-related threats include potential fire- disease and possibly fire-pollinator interactions. For example, fire has been demonstrated to increase the severity

Threat	Status and severity a	Evidence
		and extent of <i>P. cinnamomi</i> disease in Koikyenunuruff/Stirling Range (Moore et al. 2014). Fire may interact with pollination if pollinator communities are negatively impacted by inappropriate fire regimes, which is poorly understood at present.
Invasive and native species	5	
Browsing by invasive and native species	 Timing: current Confidence: known Likelihood: almost certain Consequence: catastrophic Trend: stable Extent: across the entire range 	Seven of the nine subpopulations of Stirling Range beard heath are substantially impacted by herbivory by quokka (DOEE 2017; Rathbone & Barrett 2017; S. Barrett 2022 pers. comm. 4 Jan). European rabbit (<i>Oryctolagus cuniculus</i>) also occur within subpopulations of Stirling Range beard heath, although evidence suggests it rarely browses Stirling Range beard heath, with quokka responsible for almost all herbivory (Rathbone & Barrett 2017). Browsing by the native quokka is a natural ecosystem process that may not be in equilibrium due to alteration of the montane ecosystem by multiple threatening processes (Rathbone & Barrett 2017). Subpopulations 1 and 2 are least impacted by browsing, with approximately 9% of plants flowering in quadrats in subpopulation 1 in 2021 in the absence of heavy browsing (S. Barrett 2022 pers. comm. 4 Jan). In contrast, at Bluff Knoll from 2002 to 2012 no plants became reproductive due to browsing by quokka (Rathbone & Barrett 2017; S. Barrett 2022 pers. comm. 4 Jan). Plants have been individually caged or fenced since 2014 (mainly in subpopulation 3 but also in 6, 7 and 8; S. Barrett 2022 pers. comm. 4 Jan).
Climate Change		
Changes to temperature and precipitation patterns	 Timing: current Confidence: inferred Likelihood: almost certain Consequence: major Trend: increasing Extent: across the entire range 	The CSIRO & Bureau of Meteorology (2020) predict southwest Western Australia will experience decreased precipitation and increased average temperatures, as well as greater frequency of droughts. This is likely to cause substantial changes to the unique climate in which the Stirling Range beard heath occurs (Monks et al. 2019). Precipitation on the mountains of the eastern Stirling Range may be up to double that on the surrounding plains, and the peaks can have temperatures approximately five degrees less than the surrounding plains (Gilfillan et al. 2008). The onset of drier conditions in the Holocene may have caused the contraction of some species like Stirling Range beard heath to upland slopes and gullies. The drier, hotter conditions projected under climate change could accelerate this process, reducing the area of habitat suitable for Stirling Range beard heath (Monks et al. 2019). The species' habitat occurs in the highest elevational niche possible in Koikyenunuruff/Stirling Ranges. Therefore, suitable climate refugia may not exist for this species. Declines in rainfall may negatively affect the species, particularly if they occur post-fire when juveniles are more susceptible to low soil moisture (Henzler et al. 2018). Drought impacts were observed at subpopulation 3 in 2019/20 with post-fire recruits negatively impacted (S. Barrett 2022 pers. comm. 4 Jan). The interaction between fire and drought is a threat to many obligate seeders, including Stirling Range beard heath (Burgman & Lamont 1992).

^aTiming—identifies the temporal nature of the threat

Confidence—identifies the nature of the evidence about the impact of the threat on the species

Likelihood—identifies the likelihood of the threat impacting on the whole population or extent of the species Consequence—identifies the severity of the threat

Trend—identifies the extent to which it will continue to operate on the species Extent—identifies its spatial context in terms of the range of the species

Categories for likelihood are defined as follows:

Almost certain – expected to occur every year Likely – expected to occur at least once every five years Possible – might occur at some time Unlikely –known to have occurred only a few times Unknown – currently unknown how often the threat will occur **Categories for consequences are defined as follows:** Not significant – no long-term effect on individuals or populations Minor – individuals are adversely affected but no effect at population level Moderate – population recovery stable or declining Major – population decline is ongoing Catastrophic – population trajectory close to extinction

Each threat has been described in Table 3 in terms of the extent that it is operating on the species. The risk matrix (Table 4) provides a visual depiction of the level of risk being imposed by a threat and supports the prioritisation of subsequent management and conservation actions. In preparing a risk matrix, several factors have been taken into consideration, they are: the life stage they affect; the duration of the impact; and the efficacy of current management regimes, assuming that management will continue to be applied appropriately. The risk matrix and ranking of threats has been developed in consultation with experts and using available literature.

Likelihood	Consequences				
	Not significant	Minor	Moderate	Major	Catastrophic
Almost certain				Changes to temperature and precipitation patterns	Dieback caused by <i>Phytophthora</i> spp. infection Browsing by invasive and native species
Likely					Fire regimes that cause decline in biodiversity
Possible					
Unlikely					
Unknown					

Table 4 Stirling Range beard heath risk matrix

Risk Matrix legend/Risk rating:

Low Risk	Moderate Risk	High Risk	Very High Risk
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Categories for likelihood are defined as follows:

Almost certain - expected to occur every year

Likely - expected to occur at least once every five years

Possible – might occur at some time

Unlikely - such events are known to have occurred on a worldwide bases but only a few ties

Unknown - currently unknown how often the incident will occur

Categories for consequences are defined as follows: Not significant – no long-term effect on individuals or populations Minor – individuals are adversely affected but no effect at population level Moderate – population recovery stalls or reduces Major – population decreases Catastrophic – population extirpation/extinction

Priority actions have then been developed to manage the threat particularly where the risk was deemed to be 'very high' (red shading) or 'high' (orange shading). For those threats with an unknown or low risk outcome (green and blue shading respectively) it may be more appropriate to identify further research or maintain monitoring.

Conservation and recovery actions

Primary conservation objective

By 2030, the population of Stirling Range beard heath will have increased in abundance and viable subpopulations are sustained in habitats where threats are managed effectively.

Conservation and management priorities

Habitat loss, disturbance and modifications impacts

- Ensure that the locations of all subpopulations are recorded on relevant state databases, including those used by land management and fire response agencies.
- Do not construct new fire breaks, tracks or paths in or near Stirling Range beard heath sites or habitat.
- Avoid all further loss and fragmentation of habitat, including during firefighting operations.

Fire impacts

- Develop and implement a fire management strategy that optimises the survival of Stirling Range beard heath.
 - Avoid planned burns in all habitat of known subpopulations until the fire-response and the minimal fire-interval period of Stirling Range beard heath are better understood.
 - Take the likelihood of increasingly frequent bushfires into account when developing prescribed burning programs, to avoid excessive, frequent burning of any localities.
 - If planned fire impacts subpopulations, managers must ensure that subsequent fires do
 not occur within the critical regeneration period to allow the species to rebuild its soil
 seed bank to sustain the population through the next fire event.
 - Provide maps of known occurrences to local and State Rural Fire Services.

Invasive and native species (including threats from browsing, trampling, predation)

- Install and maintain cages or fencing to protect the majority of plants in subpopulations 3, 6 and 7 from herbivory by quokka, and in subpopulations 1 and 2 if substantial herbivory impacts are observed.
- Monitor the population size and trend of quokka in subpopulations of Stirling Range beard heath, and impacts of herbivory on Stirling Range beard heath.

- Maintain the European rabbit control program and continue baiting with 1080-laced oats in areas with a high European rabbit.
- Assess the impact of RHDV1-K5 calicivirus on European rabbit subpopulations at the two sites where it was released. The virus was released in 2017 and 2018, and post-fire in 2020 and 2021 (S Barrett pers. comm. 2021 cited in DAWE 2021b).
- Monitor and mitigate herbivore impacts post-fire.

Disease impacts

- Minimise the impacts associated with the transformation of landscapes because of *P. cinnamomi* infestation by implementing mitigation measures in the area adjacent to, and surrounding, subpopulations where *P. cinnamomi* presents a threat. Consider the localised use of a biodegradable, systemic fungicide such as phosphite or other alternatives, that minimise potential off-target impacts that may result from the build-up of phosphorus in low-nutrient soils (Lambers et al. 2013; Hopper et al. 2021).
- Ensure appropriate hygiene and management measures are undertaken to reduce the impact of *Phytophthora* spp. on Stirling Range beard heath and its habitat. Refer to DOEE (2018) and DBCA (2020) for guidelines.
- Determine which lineages of *P. cinnamomi* are present in Stirling Range beard heath habitat.
- Promote research and development of treatments of *P. cinnamomi* dieback, including alternatives to phosphite.

Climate change and severe weather impacts

- Spread the risk to the species associated with climate change and fire by establishing multiple translocated populations (see Ex situ recovery actions).
- Identify (see Information and research priorities) and protect any current or future habitat likely to remain or become suitable habitat due to climate change and ensure impacts of other threats to this habitat are minimised.
- Investigate options for maintaining in situ persistence as the climate changes, for example by minimising other population pressures, enhancing resilience and promoting recruitment or supplementing existing subpopulations.

Ex situ recovery actions

- To manage the risk of losing genetic diversity, undertake appropriate seed collection and storage, and monitor the viability of stored seed. For species where few seed are produced, seed quality is low, or seeds are difficult to store long-term, undertake alternative ex situ storage such as tissue culture and cryopreservation, vegetative propagation or cultivation of living collections. Seed/tissue collection and storage should be conducted in accordance with best practice guidelines and procedures (refer to Martyn Yenson et al. 2021 or Commander 2021).
- If appropriate, investigate the feasibility of establishing translocated subpopulations that will improve the conservation outlook of the species. Translocations should be conducted in accordance with best practice guidelines and procedures (refer to Commander et al. 2018), including monitoring translocated subpopulations through to recruitment to ensure they are viable.

• Investigate the identity and ecological role of Ericoid mycorrhizal fungal communities in Stirling Range beard heath and options for storage.

Stakeholder engagement/community engagement

- Engage and involve Traditional Owners in conservation actions, including surveying for new populations and management actions. Work with Traditional Owners to divulge any traditional knowledge associates with the species ensuring the practices to record, store and share this knowledge are mutually supported.
- Liaise with relevant land managers to ensure that subpopulations are not accidentally damaged or destroyed. The approval and assistance of land managers should also be sought to implement recovery actions, and recent population data should inform management.
- Engage community groups by encouraging participation in surveys or monitoring for the species.
- Promote public awareness of biodiversity conservation and protection through dissemination of information through print and digital media.

Survey and monitoring priorities

- Maintain a monitoring program to:
 - monitor species recruitment and plant health after fire and drought events;
 - determine population size and trends;
 - document post-fire recovery and causes of recruitment failure;
 - determine threats and their impacts; and,
 - monitor the effectiveness of management actions and the need to adapt them if necessary.

Information and research priorities

- Develop effective, alternative treatments to prevent dieback caused by *P. cinnamomi*.
- Increase knowledge surrounding the ecology of Stirling Range beard heath. This includes improving understanding of recruitment and soil-seed bank dynamics (e.g. seed bank longevity), appropriate fire regimes, seed and plant longevity, genetic structure, and minimum viable population size.
- Identify the pollinator(s) of Stirling Range beard heath, and better understand the degree of pollinator specificity, the ecological requirements of pollinators, and how pollinators respond to threats, including the impacts of drought, fire or vegetation change resulting from *Phytophthora* spp. disease.
- Ascertain the cultural significance of Stirling Range beard heath.
- Investigate the impact of drought on Stirling Range beard heath.
- Determine habitat critical to the survival of Stirling Range beard heath.
- Undertake vulnerability assessments of the species' sensitivity and adaptive capacity to changing climatic conditions which draw on genetic, physiological or ecological evidence.

• If vulnerability assessments indicate the species has a high likelihood of extinction due to climate change, undertake research to identify climate refuges that may be suitable for translocations, including both modelling and experimental approaches (e.g. trial translocations). Consideration should be given to the benefits to the species in mitigating climate change related threats, as well as the risks to the recipient site (e.g. introduction of diseases, pests and/or pathogens, and invasiveness of the species).

Links to relevant implementation documents

Approved Conservation Advice for *Leucopogon gnaphalioides* (Stirling Range beard heath). Department of the Environment and Energy, Canberra (2008).

<u>Draft listing assessment for Key Threatening Process 'fire regimes that cause biodiversity loss'</u> (2021)

<u>Stirling Range Beard heath (*Leucopogon gnaphalioides*) Interim Recovery Plan 2013–2018. Department of Environment and Consdervation, Western Australia (2013).</u>

<u>Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* (2018)</u>

Threat abatement plan for competition and land degradation by rabbits (2016)

Conservation Advice and Listing Assessment references

ALA (2022) Leucopogon gnaphalioides *species information page. Atlas of Living Australia*. Commonwealth Scientific and Industrial Research Organisation, Canberra. Viewed: 12 January 2022. Available at:

https://biocache.ala.org.au/occurrences/search?taxa=leucopogon+gnaphalioides#tab_map_ View

- Auld TD & O'Connel MA (1991) Predicting patterns of post-fire germination in 35 eastern Australian Fabaceae. *Australian Journal of Ecology* 16, 53–70.
- Auld TD & Ooi MKJ (2009) Heat increases germination of water-permeable seeds of obligateseeding *Darwinia* species (Myrtaceae). *Plant Ecology* 200, 117–127.

Barrett S (2022) Personal communication via email, 4 January 2022.

- Barrett S, Shearer BL, Crane CE, Cochrane A (2008) An extinction-risk assessment tool for flora threatened by *Phytophthora cinnamomi. Australian Journal of Botany* 56, 477–486.
- BOM (Bureau of Meteorology) (2018) *Report into the Meteorological Aspects of the Fires in the Stirling Ranges and near the South Coast of Western Australia May 2018*. Viewed: 9 July 2021. Available on the internet at: <u>https://dfes.wa.gov.au/waemergencyandriskmanagement/obrm/Documents/Appendix-4 Meteorological Aspects Stirling Ranges South Coast Fires Report-Final-2018.pdf</u>

Bond WJ & van Wilgen BW (1996) *Fire and plants*. Chapman and Hall, London.

- Burgman MA & Lamont BB (1992) A stochastic model for the viability of Banksia cuneata populations: environmental, demographic and genetic effects. *Journal of Applied Ecology*, 719-727.
- CALM (2001) *Stirling Range beard heath (*Leucopogon gnaphalioides) *Interim Recovery Plan 2001–2003.* Department of Conservation and Land Management, Western Australia.
- Calviño-Cancela M, Dunn RR, Van Etten E, Lamont BB (2006) Emus as non-standard seed dispersers and their potential for long-distance dispersal. *Ecography* 29, 632–640.
- Calviño-Cancela M, He T, Lamont BB (2008) Distribution of myrmecochorous species over the landscape and their potential long-distance dispersal by emus and kangaroos. *Diversity and Distributions* 14, 11–17.
- Commander L (2018) *Guidelines for the translocation of threatened plants in Australia.* Australian Network for Plant Conservation.
- Commander LE (Ed.) (2021) Florabank Guidelines best practice guidelines for native seed collection and use. 2nd edn. Florabank Consortium Australia. Available at <u>https://www.florabank.org.au/guidelines</u>
- CSIRO & Bureau of Meteorology (2020) *Climate Change in Australia Information for Australia's Natural Resource Management Regions.* Technical Report, CSIRO and Bureau of Meteorology, Australia.
- Davies SJJF, Beck MWR, Kruiskamp JP (1971) The results of banding 154 emus in Western Australia. *CSIRO Wildlife Research* 16, 77–79.
- DAWE (2021a) *Draft listing assessment for 'Fire regimes that cause biodiversity decline' as a key threatening process.* Department of Agriculture, Water and Environment, Canberra.
- DAWE (2021b) *Draft conservation advice and listing assessment for* Banksia montana *(Stirling Range dryandra)*. Department of Agriculture, Water and Environment, Canberra.
- DBCA (2020) Phytophthora Dieback Management Manual, October 2020, Department of Biodiversity, Conservation and Attractions, Perth. Viewed: 13 January 2022. Available at: <u>https://www.dpaw.wa.gov.au/images/documents/conservation-management/pests-diseases/disease-risk-areas/DBCA%20PDMM%20v1.2%20October%202020.pdf</u>
- DEC (2013) *Stirling Range Beard Heath* (Leucopogon gnaphalioides) *Interim Recovery Plan* 2013–2017. *Interim Recovery Plan No. 334*. Department of Environment and Conservation, Western Australia.
- DIICCSRTE (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education) (2013) *The Critical Decade 2013: Climate change, science, risks and responses*. Commonwealth of Australia.
- DOEE (2017) *Conservation Advice* Leucopogon gnaphalioides *(Stirling Range beard heath)*. Department of the Environment and Energy, Canberra.

DOEE (2018) *Threat abatement plan for disease in natural ecosystems caused by* Phytophthora cinnamomi. Department of the Environment and Energy (Cwth), Canberra. Viewed: 12 December 2021. Available at:

https://www.awe.gov.au/environment/biodiversity/threatened/publications/threatabatement-plan-disease-natural-ecosystems-caused-phytophthora-cinnamomi-2018

- Dowdy AJ, Ye H, Pepler A, Thatcher M, Osbrough SL, Evans JP, Di Virgilio, G & McCarthy N (2019) Future changes in extreme weather and pyroconvection risk factors for Australian wildfires. *Scientific Reports* 9, 10073.
- DPAW (2016) Montane heath and thicket of the south west botanical province, above approximately 900 m above sea level (Eastern Stirling Range Montane Heath and Thicket Community). Interim recovery plan 2016-2021 for interim recovery plan no. 370. Department of Parks and Wildlife, Perth.
- DPLH (2022) *Aboriginal heritage inquiry system*. Accessed: 13 January 2022. Available at: <u>https://www.dplh.wa.gov.au/ahis</u>
- Enright NJ, Fontaine JB, Bowman DM, Bradstock RA, Williams RJ (2015) Interval squeeze: altered fire regimes and demographic responses interact to threaten woody species persistence as climate changes. *Frontiers in Ecology and the Environment* 13, 265–272.
- Frankham R, Bradshaw CJ, Brook BW (2014) Genetics in conservation management: revised recommendations for the 50/500 rules, Red List criteria and population viability analyses. *Biological Conservation* 170, 56-63.
- Gallagher RV (2020) *National prioritisation of Australian plants affected by the 2019-2020 bushfire season.* Report to Department of Agriculture, Water and Environment (Cwth), Canberra. Accessed 3 December 2020. Available on the Internet at: <u>http://www.environment.gov.au/biodiversity/bushfire-recovery/priority-plants</u>.
- Gallagher RV, Allen S, Mackenzie BDE, Yates CJ, Gosper CR, Keith DA, Merow C, White MD, Wenk E, Maitner BS, He K, Adams VN & Auld TD (2021) High fire frequency and the impact of the 2019–2020 megafires on Australian plant diversity. *Diversity and Distributions* 27, 1166–1179.
- Gilfillan S, Barrett S, Hartley R & Yates C (2008) Stirling Range dryandra (*Dryandra montana*) Recovery Plan. Viewed: 30 September 2020. Available on the internet at: <u>https://www.environment.gov.au/system/files/resources/2ad52ee4-0334-451c-beea-a2f2743c6bc7/files/dryandra-montana.pdf</u>
- He T, Lamont BB, Krauss SL, Enright NJ, Miller BP, Gove AD (2009). Ants cannot account for interpopulation dispersal of the arillate pea *Beard heath triflora*. *New Phytologist* 181, 725–733.
- Henzler J, Weise H, Enright NJ, Zander S & Tietjen B (2018) A squeeze in the suitable fire interval: Simulating the persistence of fire killed plants in a Mediterranean-type ecosystem under drier conditions. *Ecological Modelling* 389, 41–49.

- Hopper SD, Lambers H, Silveira FAO & Fiedler PL (2021) OCBIL theory examined: reassessing evolution, ecology and conservation in the world's ancient, climatically buffered and infertile landscapes. *Biological Journal of the Linnean Society* 133, 266–296.
- IUCN (2019) *Guidelines for Using the IUCN Red List Categories and Criteria. Version 14.* Prepared by the Standards and Petitions Committee. Viewed: 17 June 2021. Available on the internet at: <u>http://www.iucnredlist.org/documents/RedListGuidelines.pdf</u>.
- Jasinge NU, Huynh T, & Lawrie AC (2018) Changes in orchid populations and endophytic fungi with rainfall and prescribed burning in *Pterostylis revoluta* in Victoria, Australia. *Annals of Botany* 121, 321–334.
- Keith D (1996) Fire-driven extinction of plant populations: a synthesis of theory and review of evidence from Australian vegetation. *Proceedings of the Linnean Society of New South Wales* 116, 37–78.
- Keith DA, Dunker B, Driscoll DA (2020). Dispersal: The eighth fire seasonality effect on plants. *Trends in Ecology and Evolution*, 35, 305–307.
- Kew Botanic Gardens (2022) *Leucopogon gnaphalioides* search result, Seed Information Database. Kew Botanic Gardens, England. Accessed: 16 March 2022. Available at: <u>https://data.kew.org/sid/SidServlet?ID=48530&Num=vKj</u>.
- Lambers H, Ahmedi I, Berkowitz O, Dunne C, Finnegan PM, Hardy GESJ, Jost R, Laliberté E, Pearse SJ & Teste FP (2013) Phosphorus nutrition of phosphorus-sensitive Australian native plants: threats to plant communities in a global biodiversity hotspot. *Conservation Physiology* 1, cot010.
- Martyn Yenson AJ, Offord CA, Meagher PF, Auld T, Bush D, Coates DJ, Commander LE, Guja LK, Norton SL, Makinson RO, Stanley R, Walsh N, Wrigley D, Broadhurst L (2021) *Plant Germplasm Conservation in Australia: strategies and guidelines for developing, managing and utilising ex situ collections. Third edition.* Australian Network for Plant Conservation, Canberra.
- Midgley DJ, Chambers SM, Cairney JW (2004) Inorganic and organic substrates as sources of nitrogen and phosphorus for multiple genotypes of two ericoid mycorrhizal fungal taxa from Woollsia pungens and Leucopogon parviflorus (Ericaceae). Australian Journal of Botany 52, 63–71.
- Miller G, Tangney R, Enright NJ, Fontaine JB, Merritt DJ, Ooi MKJ, Ruthrof KX & Miller BP (2019) Mechanisms of fire seasonality effects on plant populations. *Trends in Ecology and Evolution* 34, 1104–1117.
- Monks L, Barrett S, Beecham B, Byrne M, Chant A, Coates D, Cochrane JA, Crawford A, Dillon R & Yates C (2019) Recovery of threatened plant species and their habitats in the biodiversity hotspot of the southwest Australian floristic region. *Plant Diversity* 41, 59–74.
- Moore N, Barrett S, Howard K, Craig MD, Bowen B, Shearer B, Hardy G (2015) Time since fire and average fire interval are the best predictors of *Phytophthora cinnamomi* activity in heathlands of south-western Australia. *Australian Journal of Botany* 62, 587–593.

- Morgan JW (1995). Ecological studies of the endangered *Rutidosis leptorrhynchoides. I.* Seed production, soil seed bank dynamics, population density and their effects on recruitment. *Australian Journal of Botany* 43, 1–11.
- Nolan RH, Collins L, Leigh A, Ooi MK, Curran TJ, Fairman TA, Víctor Resco de Dios, Bradstock R (2021). Limits to post-fire vegetation recovery under climate change. *Plant, cell & environment* 44, 3471–3489.
- OBRM (2018) Report of the circumstances that led to the escapes of planned burns in the south west and great southern regions of Western Australia on 24 and 25 may 2018. Office of Bushfire Risk Management, Perth.
- Ooi MK (2010) Delayed emergence and post-fire recruitment success: effects of seasonal germination, fire season and dormancy type. *Australian Journal of Botany* 58, 248–256.
- Ooi MJ (2019) The importance of fire season when managing threatened plant species: A long-term case-study of a rare *Leucopogan* species (Ericaceae). *Journal of Environmental Management* 236, 17–24.
- Ooi MK, Auld TD, Whelan RJ (2004) Delayed post-fire seedling emergence linked to season: a case study with *Leucopogon* species (Epacridaceae). *Plant Ecology* 174, 183–196.
- Ooi MKJ, Auld TD, Whelan RJ (2006) Dormancy and the fire-centric focus: germination of three *Leucopogon* species (Ericaceae) from south-eastern Australia. *Annals of Botany* 98, 421–430.
- Ooi MK, Auld TD, Whelan RJ (2007) Distinguishing between persistence and dormancy in soil seed banks of three shrub species from fire-prone southeastern Australia. *Journal of Vegetation Science* 18, 405–412.
- Rathbone DA & Barrett S (2017) Vertebrate browsing impacts in a threatened montane plant community and implications for management. *Ecological Management & Restoration* 18, 164–171.
- Regan HM, Auld TD, Keith DA, Burgman MA (2003) The effects of fire and predators on the longterm persistence of an endangered shrub, *Grevillea caleyi*. *Biological Conservation* 109, 73–83.
- South West Aboriginal Land & Sea Council (2022) About the Wagyl Kaip and Southern Noongar region. Available at: <u>https://www.noongarculture.org.au/wagyl-kaip/</u>. Viewed: 13 January 2022.
- Stschegleew SS (1859) Bulletin de la Societe Imperiale des Naturalistes de Moscou 32, 14.
- Tangney RJ (2013) The genetic consequences of emus as a vector for the long distance dispersal of seed in *Leucopogon* nutans. Doctoral dissertation, Murdoch University.
- Western Australian Herbarium (2022) *Florabase—the Western Australian Flora*. Department of Biodiversity, Conservation and Attractions, Western Australia. Available at: <u>https://florabase.dpaw.wa.gov.au/</u>. Viewed: 9 February 2022.
- Whelan RJ (1995) *The ecology of fire*. Cambridge University Press, Cambridge.

Wills RT (1993) The ecological impact of *Phytophthora cinnamomi* in the Stirling Range National Park, Western Australia. *Australian Journal of Ecology* 18, 145–159.

Attachment A: Listing Assessment for Leucopogon gnaphalioides

Reason for assessment

This assessment follows prioritisation of a nomination from the TSSC.

Assessment of eligibility for listing

This assessment uses the criteria set out in the <u>EPBC Regulations</u>. The thresholds used correspond with those in the <u>IUCN Red List criteria</u> except where noted in criterion 4, subcriterion D2. The IUCN criteria are used by Australian jurisdictions to achieve consistent listing assessments through the Common Assessment Method (CAM).

Key assessment parameters

Table 5 includes the key assessment parameters used in the assessment of eligibility for listing against the criteria.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Number of mature individuals	649	398	719	The most recent estimate of the Stirling Range beard heath population is 144 mature plants and 1521 juveniles (S. Barrett 2022 pers. comm. 4 Jan; Table 1). However, as all subpopulations were burnt or part-burnt in fires in 2018 and/or 2019, the majority of the population is in a state of post- fire recovery. Therefore, it is necessary to project the number of mature individuals when the current cohort of juveniles/seedlings reach maturity (IUCN 2019).
				The length of the primary juvenile period has been observed to be about six to seven years (S. Barrett 2022 pers. comm. 3 February). As all subpopulations have monitoring data from 2020/21, it is possible to use these estimates and project the population size six years into the future (i.e. the primary juvenile period) <u>in the year 2027</u> . This is eight to nine years following the 2018 and 2019 fires, and so the majority of post-fire juveniles should have had time to mature by this time, even accounting for some delayed post-fire germination.
				The majority of plants are from the Isongerup and Bluff Knoll subpopulations. Both of these subpopulations have monitoring data for the period 2011–2017.
				At Bluff Knoll, there were 500 mature individuals and 2000 juveniles in 2011. By 2017 this had declined to 450 mature individuals and 1000 juveniles (Table 1). This suggests that during this six year period, 10% of mature plants had died, 0% of juveniles had matured and 50% of juveniles had died (assuming no new germination of seed during this period). This is plausible considering that no plants became reproductive

Table 5 Key assessment parameters

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
				due to browsing between 2002 and 2012 (S. Barrett 2022 pers. comm. 4 Jan).
				The population trends at Bluff Knoll are likely to be applicable to other populations with very low seedling survival and maturation rates, such as subpopulations 3, 4, 5, 6, 7, 8 and 9. In 2021 in these subpopulations, there were three adult plants and 511 juveniles. Therefore, applying the 2011–2017 trends from Bluff Knoll, <u>in 2027 there</u> <u>may be three mature plants and 256 juveniles in</u> <u>subpopulations 3, 4, 5, 6, 7, 8 and 9.</u>
				Isongerup and Mondurup (subpopulations 1 and 2) are the least impacted by <i>P. cinnamomi</i> and herbivory (S. Barrett 2022 pers. comm. 4 Jan) and thus seedling survival/maturation is higher at these subpopulations (Table 1). At Isongerup there were 300 mature plants and 500 juveniles in 2011, and by 2017 there were 550 mature plants and 70 juveniles. Assuming no mortality of mature plants and no new germination of seed during this period, this indicates that of the 500 juveniles in 2011, 50% had matured, 36% had died, and 14% remained in a juvenile state.
				In subpopulations 1 and 2 in 2021 there were 141 mature plants and 1010 juveniles (Table 1). Applying the 2011–2017 trends from Isongerup, a plausible projection of subpopulations 1 and 2 in 2027 could be 646 mature plants (141 + $[1010*0.5] = 646$), and 141 juveniles (1010*0.14=141).
				Therefore, <u>a plausible estimate of the population</u> <u>size of Stirling Range beard heath could be 649</u> mature individuals (3 + 646 = 649)
				If the remaining 141 juveniles at subpopulations 1 and 2 were to continue to reach maturity (e.g. if juveniles were not supressed by browsing), it is possible that a maximum estimate could include an additional 70 mature individuals (141*0.5=70), i.e. <u>a maximum estimate across the</u> entire population of 719 mature individuals.
				Alternatively if rates of juvenile survival and maturation at subpopulations 1 and 2 are lower in future due to increasing impacts from threats, the maturation rate of 50% applied to the current cohort of juveniles at these subpopulations may be an overestimate. If the maturation rate was 25% (e.g. an average between the rates at subpopulations 1 and 3), it is possible that a minimum estimate of subpopulations 1 and 2 could be 394 mature plants (141 + [1010*0.25] = 394), meaning <u>a minimum estimate across the entire population of 398 mature individuals</u> .
Trend	declining			In 2011 there were an estimated 972 mature individuals, and in 2027 there are projected to be 649 mature individuals, suggesting a decline of 33 percent over this period (see justification in Criterion 1).
Generation time (years)	14-21	~14	~21	The generation length of Stirling Range beard heath is not documented.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
				The length of the primary juvenile period has been observed to be about six to seven years and the minimum longevity of adult plants is at least 20 years, probably longer in the absence of disease or fire (S. Barrett 2022 pers. comm. 4 Jan). Therefore, the generation length of Stirling Range beard heath could be in the order of 14–21 years (see justification under Criterion 1).
Extent of occurrence	63 km ²	~45 km²	~70 km ²	The extent of occurrence (EOO) is based on the mapping of available point records from 2001 to 2021. The EOO was calculated using a minimum convex hull, based on the IUCN Red List Guidelines (IUCN 2019). The minimum bound represents an estimate if the species is less widespread than current records suggest (e.g. if subpopulations 4, 5, 7, 8, or 9 become extinct). The species is unlikely to be more widespread due to it spatially-limited habitat.
Trend	contracting At least five subpopulations are very close textinction (Table 1). The extinction of these other subpopulations would cause a contration in the EOO of the species.			At least five subpopulations are very close to extinction (Table 1). The extinction of these or other subpopulations would cause a contraction in the EOO of the species.
Area of Occupancy	28 km ²	~16 km²	~30 km ²	The AOO is estimated based on the mapping of available point records from 2001 to 2021. The AOO is calculated using a 2x2 km grid cell method, based on the IUCN Red List Guidelines (IUCN 2019). The minimum bound represents an estimate if the species is less widespread than current records suggest (e.g. if subpopulations 4, 5, 7, 8, or 9 become extinct). The species is unlikely to be more widespread due to its spatially-limited habitat.
A00 is a standardised s projected to be current thresholds. The resolut the spatial scale of three fine-scale estimate of th existing populations of	patial measure of ly occupied by the ion (grid size) the ats than by the sp ne actual area occ a taxon (e.g. bree	f the risk of exti e taxon. It is est at maximizes th atial scale at wl upied. In some ding sites for m	nction, that rep imated using a e correlation be hich AOO is esti cases, AOO is th igratory specie	resents the area of suitable habitat known, inferred or 2 x 2 km grid to enable comparison with the criteria etween AOO and extinction risk is determined more by mated or shape of the taxon's distribution. It is not a se smallest area essential at any stage to the survival of s).
Trend	contracting At least five subpopulations are very close to extinction (Table 1). The extinction of these or other subpopulations would cause a contraction in the AOO of the species.			
Number of subpopulations	9	~4	9	The number of subpopulations of the species is nine (Table 1). The minimum bound represents an estimate if the species is less widespread than current records suggest (e.g. if subpopulations 4, 5, 7, 8, or 9 become extinct). The species is unlikely to be more widespread due to it spatially-limited habitat.
Trend	declining			At least five subpopulations are very close to extinction (Table 1). The extinction of these or other subpopulations would cause a decline in the number of subpopulations of the species.
Basis of assessment of subpopulation number	See justification	on under 'Nun	nber of subpo	pulations' above

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
No. locations	used in the assessment	plausible value	plausible value ~9	The most significant threats to the species are dieback caused by <i>P. cinnamomi</i> , inappropriate fire regimes, herbivory, climate change and interactions among these threats. Of these, dieback caused by <i>P. cinnamomi</i> , inappropriate fire regimes and interactions among the above threats are likely to result in a single location. The species is an obligate seeder with a likely primary juvenile period of six to seven years and a generation length of 14–21 years. <i>Phytophthora cinnamomi</i> is present in all subpopulations and Stirling Range beard heath is highly susceptible (Barrett et al. 2008; S. Barrett 2022 pers. comm. 4 January). Dieback from <i>P. cinnamomi</i> infection is a major cause of observed population decline, and it is plausible that it could cause the rapid elimination of all subpopulations within one generation (14–21 years), particularly if the use of phosphite was to cease without any additional measures taken to limit the impact of dieback from <i>P. cinnamomi</i> . Inappropriate fire regimes is another threat to Stirling Range beard heath that could cause the rapid elimination of any or all of the species' subpopulations. All subpopulations were burnt or part-burnt by either the 2018 or 2019 fires, illustrating the capacity for fire to affect the entire population of the species in a short space of time. The primary juvenile period of Stirling Range beard heath is likely to be about six to seven years, although herbivory may have influenced this assessment, and is keeping the majority of plants in a juvenile state well beyond this length of time at some populations (S. Barrett 2022 pers. comm. 4 Jan). If fires occur within this period, they are likely to cause the decline or extinction of subpopulations by killing juvenile plants before they are able to replenish the soil seed bank (DAWE 2021a). Fires are likely to become more frequent, particularly considering the predicted increase in fire danger meather and fire frequency as a result of climate change (Enright et al. 2015; Nolan et al. 2021; Table 2). Th
				rapid elimination of the species, if climate change drives increased pressure via higher fire frequency, while also reducing resilience via slower rates of maturation, lower fecundity or higher post-fire seedling mortality through post- fire drought (Enright et al. 2015; Henzler et al. 2018).

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification		
				The effects of interactions between dieback from <i>P. cinnamomi</i> and fire on Stirling Range beard heath are not well understood, but fire has been demonstrated to increase the severity and extent of <i>P. cinnamomi</i> disease in Koikyenunuruff/Stirling Range (Moore et al. 2014) and is likely to accelerate the population decline currently observed due to dieback from <i>P. cinnamomi</i> . Therefore, Stirling Range beard heath is likely to have a single location based on the threats of dieback from <i>P. cinnamomi</i> , inappropriate fire regimes, and interactions between dieback from <i>P. cinnamomi</i> , inappropriate fire regimes, herbivory and climate change.		
Trend	stable As the number of locations is estimated at one, it is unlikely to decline any further unless the species becomes extinct in the wild.					
Basis of assessment of location number	See justificatio	on under 'No.)	locations' abo	ve.		
Fragmentation	Not severely f (>50%) of its support a viab distance, suffi All subpopula last monitored al. (2014) as b threats associ However, sub emu) are know it is possible t seed. Emu are (S.J.J.F. Davies between five l Cansela et al. 3 Seven of nine relatively line between the m distance of the As a result, the	Not severely fragmented. A taxon can be considered to be severely fragmented if most (>50%) of its total AOO is in habitat patches that are (1) smaller than would be required to support a viable population, and (2) separated from other habitat patches by a large distance, sufficient that gene flow among subpopulations is unlikely (IUCN 2019). All subpopulations of Stirling Range beard heath contained less than 1000 individuals when last monitored in 2020–2021 (Table 1), a rudimentary estimate suggested by Frankham et al. (2014) as being a general minimum viable subpopulation size for resilience to genetic threats associated with small subpopulations. However, subpopulations are unlikely to be genetically isolated. Ants and birds (including emu) are known to disperse seed of other <i>Leucopogon</i> species (Tagney 2013; Ooi 2019), and it is possible that they also play a role in infrequent dispersal of Stirling Range beard heath seed. Emu are capable of moving 13.7 km per day (Davies et al. 1971) or 0.5–1 km per hour (S.J.F. Davies pers. comm. in He et al. 2009), and capable of retaining seed in their gut for between five hours and four days, although most seed is excreted after one day (Calviño- Cansela et al. 2006; 2008). Seven of nine subpopulations are located in the Eastern Stirling Range, within a stretch of relatively linear mountain range approximately 10 km in length. Therefore, the distance between the majority of subpopulations is likely to be less than the potential dispersal distance of the species, and gene flow among most subpopulations could occur occasionally. As a result the species is unlikely to be covered fragmented				
Fluctuations	Not subject to mature indivi- magnitude fol persistent see fluctuation do	As a result, the species is unlikely to be severely fragmented. Not subject to extreme fluctuations in EOO, AOO, number of subpopulations, locations or mature individuals. Less than half the subpopulations may fluctuate by close to an order of magnitude following fire (Table 1). In addition, as fires can stimulate recruitment from persistent seed banks when there were few mature individuals before the event, the fluctuation does not fall within the definition of 'extreme fluctuations' (IIICN 2019)				

Criterion 1 Population size reduction

Redı	Reduction in total numbers (measured over the longer of 10 years or 3 generations) based on any of A1 to A4					
		Critically Endangered Very severe reduction	Enda Sever	ngered re reduction		Vulnerable Substantial reduction
A1		≥ 90%	≥ 70%	6		≥ 50%
A2, A	3, A4	≥ 80%	≥ 50%	6		≥ 30%
A1 A2	Population reduction observed, estimat past and the causes of the reduction are understood AND ceased. Population reduction observed, estimat past where the causes of the reduction be understood OR may not be reversibl	red, inferred or suspected in e clearly reversible AND red, inferred or suspected in may not have ceased OR ma e.	the the the the		(a) (b) (c)	direct observation [except A3] an index of abundance appropriate to the taxon a decline in area of occupancy, extent of occurrence and/or quality of habitat
A3	Population reduction, projected or susp to a maximum of 100 years) [(<i>a</i>) cannot	vected to be met in the futur t be used for A3]	e (up	Based on any of the following	(d) (e)	actual or potential levels of exploitation the effects of introduced
A4	An observed, estimated, inferred, projected action where the time period must is future (up to a max. of 100 years in future reduction may not have ceased OR may be reversible.	cted or suspected populatio nclude both the past and th ire), and where the causes o not be understood OR may	n e of not			taxa, hybridization, pathogens, pollutants, competitors or parasites

Criterion 1 evidence

Eligible under Criterion 1 A4bce as Critically Endangered

Generation time

The length of the primary juvenile period has been observed to be about six to seven years based upon 50 percent flowering although browsing may have influenced this estimate (S. Barrett 2022 pers. comm. 3 February). The minimum longevity of adult plants is at least 20 years, probably longer in the absence of disease (S. Barrett 2022 pers. comm. 4 Jan).

Minimum estimate, using longevity of 20 years:

Generation time = age of first reproduction + [0.5 * (length of reproductive period)]Generation time = 6 + [0.5 * (20 - 6)] = 13 years

Maximum estimate, using longevity of 40 years:

Generation time = age of first reproduction + [0.5 * (length of reproductive period)]Generation time = 6 + [0.5 * (40 - 6)] = 23 years

Therefore, the generation length of Stirling Range beard heath could be 13–23 years. This gives an estimated three-generation period of approximately 39–69 years.

Population trend

The projected population size of Stirling Range beard heath in 2027 when the current cohort of post-fire recruits reach maturity is 649 mature individuals (see justification in Table 5). Most

subpopulations were surveyed in 2011 (Table 1). The 2011 monitoring occurred 11 years postfire, while the 2027 projection is 8–9 years post fire. Stirling Range beard heath is long lived (at least 20 years) and frequently recruits in the absence of fire, suggesting substantial population senescence from 8–9 years post-fire to 11 years post-fire is unlikely. Therefore, 2011 and 2027 can be considered to be at more or less equivalent stages in the species' life cycle. In 2011, there were estimated to be 972 mature individuals (Table 6). This suggests the population of Stirling Range beard heath will have declined by 33 percent over the 16 years from 2011 to 2027. Assuming exponential decline, this equates to an exponential decay rate of: ln(0.67)/16 = -0.02503 per year (where 0.67 is the percentage survival, and 16 is the time in years).

Subpopulation	Number of mature individuals	Comments
Subpopulation 1	300	
Subpopulation 2	136	The 2011 estimate was 25 mature individuals. However, new areas containing plants were found at this subpopulation pre-fire in 2019. Therefore, the 2019 estimate of 136 mature plants is used. This is plausible, as threats of <i>P. cinnamomi</i> and herbivory are lower at this subpopulation than at most other subpopulations, suggesting substantial decline may not have occurred between 2011 and 2019.
Subpopulation 3	500	
Subpopulation 4	0	No 2011 estimate, extrapolating from a 2020 estimate of 0 mature individuals and a 2002 estimate of 0 mature individuals.
Subpopulation 5	0	No 2011 estimate, extrapolating from a 2021 estimate of 3 mature individuals and a 2007 estimate of 0 mature individuals.
Subpopulation 6	30	No 2011 estimate of mature individuals, extrapolating from a 2015 estimate of 45 mature individuals and a 2002 estimate of 6 mature individuals.
Subpopulation 7	1	
Subpopulation 8	5	No 2011 estimate, extrapolating from a 2015 estimate of 30 mature individuals and a 2004 estimate of 0 mature individuals.
Subpopulation 9	0	No 2011 estimate, extrapolating from a 2012 estimate of 0 mature individuals.

 Table 6 Estimated subpopulation sizes in 2011 (source: Table 1)

To calculate the decline in the Stirling Range beard heath population over a three generation period (min: 2011–2050; max: 2011–2080) it is necessary to project the number of mature individuals using the above rate of exponential decay.

Minimum three generation period

Using the above rate of exponential decline, the number of individuals present at the end of a minimum three generation period from 2011–2050, can be estimated with the equation: $972 * e^{-0.02503*39} = 366$ plants, where 972 is the number of mature individuals present in 2011 and 39 is the minimum three generation period in years. This equates to a minimum decline over this period of 62 percent (100-[366/972*100] = 62 percent).

Maximum three generation period

Using the above rate of exponential decline, the number of individuals present at the end of a maximum three generation period from 2011–2080, can be estimated with the equation: $972 * e^{-0.02503*69} = 366$ plants, where 972 is the number of mature individuals present in 2011 and 69 is the maximum three generation period in years. This equates to a maximum decline over this period of 82 percent (100-[366/972*100] = 82 percent).

Conclusion

The maximum and minimum estimates straddle the boundary between Endangered (50–80 percent decline) and Critically Endangered (≥80 percent decline). In the case of Stirling Range beard heath, a precautionary approach would suggest using the upper estimate of population decline of 82 percent over a three generation period, meaning the species would meet the threshold for Critically Endangered. This is justified because the minimum estimate of generation length is likely to be influenced by threats including dieback from *P. cinnamomi*, which result in premature mortality of individuals that if not exposed to the threat would likely be longer lived. The IUCN Guidelines stipulate that the "more natural, i.e. pre-disturbance, generation length should be used" (IUCN 2019). In addition, all subpopulations are exposed to very high risk threats (Table 4), several of which (inappropriate fire regimes and climate change impacts) are likely to increase in severity over the course of the species' three generation period. Therefore, projecting a future population size based on population trends in the past may be likely to underestimate the extent of decline. Finally, the species has a very restricted geographic distribution that increases the likelihood that threats could cause the decline or extinction of the species' entire population (see additional justification in Criterion 2 below) and cause a contraction in EOO, AOO and quality of habitat (Table 5). Therefore, Stirling Range beard heath appears to be eligible for listing as Critically Endangered under this criterion.

However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Criterion 2 Geographic distribution as indicators for either extent of occurrence AND/OR area of occupancy

		Critically Endangered Very restricted	Endangered Restricted	Vulnerable Limited		
B1.	Extent of occurrence (EOO)	< 100 km ²	< 5,000 km ²	< 20,000 km ²		
B2.	Area of occupancy (AOO)	< 10 km ²	< 500 km ²	< 2,000 km ²		
AND	AND at least 2 of the following 3 conditions:					
(a)	Severely fragmented OR Number of locations	= 1	≤ 5	≤10		
(b)	(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)	(c) Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals					

Criterion 2 evidence

Eligible under Criterion 2 B1ab(i,ii,iii,iv,v) as Critically Endangered

Extent of occurrence (EOO) and area of occupancy (AOO)

The EOO of Stirling Range beard heath is 63 km² and the AOO is 28 km² (Table 5).

The EOO appears to meet the requirements for Critically Endangered under B1, while the AOO appears to meet the requirements for Endangered under B2.

Severely fragmented

Stirling Range beard heath is not considered to be severely fragmented. Although all subpopulations appear to be smaller than a rudimentary estimate of minimum viable population size (e.g. 1000 individuals as per Frankham et al. 2014), there is likely to be occasional gene flow among most subpopulations, which are clustered in the Eastern Stirling Range, across which occasional dispersal may occur (see justification in Table 5). Therefore, the species does not appear to meet the severe fragmentation requirement for listing under this criterion.

Number of locations

The most significant threats to the species are dieback caused by *P. cinnamomi*, inappropriate fire regimes, herbivory, climate change and interactions among these threats.

Phytophthora cinnamomi is present in all subpopulations and Stirling Range beard heath is highly susceptible (Barrett et al. 2008; S. Barrett 2022 pers. comm. 4 January). The species recorded 100 percent mortality in experimental inoculation trials (Barret et al. 2008). The pathogen is present across all of the species' habitat (S. Barrett 2022 pers. comm. 4 January).

Phosphite has been applied to subpopulations 1, 2, 3, 6, 7, 8 and 9 on a regular basis to limit the impacts (S. Barrett 2022 pers. comm. 4 January). Dieback from *P. cinnamomi* infection is a major cause of observed population decline, and it is plausible that it could cause the rapid elimination of all subpopulations within one generation (14–21 years). For example in subpopulation 5, three plants were rediscovered in 2021 after having been thought extinct (DOEE 2017), but by October of 2021 two of the three were dead due to *P. cinnamomi* (S. Barrett 2022 pers. comm. 4 Jan). The small number of plants in most subpopulations leaves them at high risk of extinction due to dieback from *P. cinnamomi*. Even larger subpopulations are at risk, for example if the application of phosphite was to cease without any additional measures taken to limit the impact of dieback from *P. cinnamomi*. Therefore, it is plausible that the number of locations due to dieback from *P. cinnamomi* is one, as the disease may cause the elimination of the entire population of Stirling Range beard heath within the next 13–23 years.

Inappropriate fire regimes is another threat to Stirling Range beard heath that could cause the rapid elimination of any or all of the species' subpopulations. Stirling Range beard heath is an obligate seeder (S. Barrett 2022 pers. comm. 4 January), and relies on post-fire germination from soil-stored seed and adequate time for recruits to mature and restore the soil seed bank. All subpopulations were burnt or part-burnt by either the 2018 or 2019 fires, illustrating the capacity for fire to affect the entire population of the species in a short space of time. The primary juvenile period of Stirling Range beard heath is likely to be about six to seven years, although constant herbivory is keeping the majority of plants in a juvenile state well beyond this length of time at some populations (S. Barrett 2022 pers. comm. 4 Jan). If fires occur within this period, they are likely to cause the decline or extinction of subpopulations by killing juvenile plants before they are able to replenish the soil seed bank (DAWE 2021a). Multiple fires 18 months apart have recently occurred in Koikyenunuruff/Stirling Range, with some species such as Banksia montana being burned by both fires (DAWE 2021b). This illustrates the possibility of high fire frequency in Koikyenunuruff/Stirling Range and it is possible that similar extremely short intervals between fires could occur again in the future and affect the species' entire population, particularly considering the predicted increase in fire danger weather and fire frequency as a result of climate change (Enright et al. 2015; Nolan et al. 2021; Table 2). Therefore, it is plausible that the number of locations due to inappropriate fire regimes is one.

Climate change is another threat to Stirling Range beard heath that could cause the elimination of the species. Stirling Range beard heath occurs on the highest peaks of Koikyenunuruff/Stirling Ranges that are cooler and wetter than the surrounding landscape. The CSIRO & Bureau of Meteorology (2020) predict southwest Western Australia will experience decreased precipitation and increased average temperatures, as well as greater frequency of droughts due to climate change. This is likely to reduce the area of suitable habitat for the species (Monks et al. 2019). The species' habitat occurs in the highest elevational niche possible in Koikyenunuruff/Stirling Ranges, and therefore, the drier, hotter conditions projected under climate change are likely to render much or all of its current habitat unsuitable (Monks et al. 2019). However, it is unlikely that climate change alone would cause the rapid elimination of the species within one generation (14–21 years), particularly as Stirling Range beard heath has soil-stored seed that can survive drought conditions. Therefore, climate change probably cannot be used to define the number of locations for Stirling Range beard heath on its own. Instead, the interactions between climate change and fire are a more significant threat (see below).

Seven of the nine subpopulations of Stirling Range beard heath are substantially impacted by herbivory due to quokka (DOEE 2017; Rathbone & Barrett 2017; S. Barrett 2022 pers. comm. 4 Jan). Subpopulations 1 and 2 are least impacted by browsing, with approximately 9% of plants flowering in quadrats in subpopulation 1 in 2021 in the absence of heavy browsing (S. Barrett 2022 pers. comm. 4 Jan). In contrast, at Bluff Knoll from 2002 to 2012 no plants became reproductive due to browsing by quokka (Rathbone & Barrett 2017; S. Barrett 2022 pers. comm. 4 Jan). Herbivory by quokka is severely limiting the transition of juvenile plants to adult plants, and therefore likely reducing the quantity of seed stored in the soil and the potential for subpopulations to recover from fire or other threats. However, by itself, herbivory is probably unlikely to cause the extinction of any (or possibly the smallest) subpopulations, and thus probably cannot be used to define the number of locations on its own. Instead, the interactions between herbivory and fire or herbivory and dieback from *P. cinnamomi* are a more significant threat (see below).

The interactions among the threats of dieback from *P. cinnamomi*, inappropriate fire regimes, climate change and herbivory could cause the rapid elimination of the species' entire population. The interaction between herbivory and inappropriate fire regimes is probably the most likely to contribute to the rapid elimination of subpopulations of the species. This is illustrated best at subpopulation 3 (Bluff Knoll), where at least 2000 seedlings germinated following the 2000 fire, but the majority were kept in an immature state due to browsing by quokka. When the subpopulation was impacted again by fire in 2018, post-fire germination was an order of magnitude less than after the 2000 fire, likely due largely to constant herbivory during the interfire period (Table 1). The interaction between climate change and inappropriate fire regimes could also cause the rapid elimination of the species, if climate change drives increased pressure via higher fire frequency, while also reducing resilience via slower rates of maturation, lower fecundity or higher post-fire seedling mortality through post-fire drought (Enright et al. 2015; Henzler et al. 2018). The effects of interactions between dieback from P. cinnamomi and fire on Stirling Range beard heath are not well understood, but fire has been demonstrated to increase the severity and extent of *P. cinnamomi* disease in Koikyenunuruff/Stirling Range (Moore et al. 2014). Fire stimulates the germination of soil-stored seed that were not affected by P. cinnamomi when lying dormant in the soil seed bank. The germinating seedlings, however, are vulnerable to dieback from *P. cinnamomi*, so fire effectively puts the burnt subpopulations into a P. cinnamomi-vulnerable state, increasing population decline from dieback due to P. cinnamomi.

Therefore, Stirling Range beard heath is likely to have a single location based on the threats of inappropriate fire regimes, dieback from *P. cinnamomi*, and interactions among these threats, and with climate change and herbivory.

Continuing decline

The population of Stirling Range beard heath is estimated to decline by 33 percent from 2011–2027 (see Criterion 1). At least five subpopulations are very close to extinction (Table 1). If any of these subpopulations were to go extinct, it would cause a contraction in both EOO and AOO, and decline in number of subpopulations. Therefore, there is an observed or projected continuing decline in number of mature individuals, EOO, AOO and number of subpopulations.

Habitat quality is also observed and projected to continue declining due to inappropriate fire regimes, climate change and dieback caused by *P. cinnamomi* (Table 3). *Phytophthora cinnamomi*

is present in all subpopulations of the species and continues to cause declines and local extinctions of susceptible plants, including Stirling Range beard heath. Dieback caused by *Phytophthora* spp. may also have indirect negative impacts on Stirling Range beard heath (e.g. through impacts on insect pollinators; Wills 1993). The species occurs on the highest peaks of Koikyenunuruff/Stirling Ranges in montane heath. This habitat is likely to be negatively impacted by observed and projected declines in rainfall and increasing frequency of drought due to climate change. The habitat of Stirling Range beard heath is also susceptible to inappropriate fire regimes. For example, fires in 2018 and 2019 double-burned parts of Koikyenunuruff/Stirling Ranges, causing declines in other obligate seeder shrubs (e.g. DAWE 2021b). Further declines in habitat quality are projected to occur in future if similarly inappropriate fire regimes impact its habitat. Herbivory by quokka is very high in the majority of subpopulations, and is likely to be causing continuing decline of habitat quality by causing declines of palatable species like Stirling Range beard heath.

Accordingly, the species appears to meet the continuing decline requirement for listing under this criterion.

Extreme fluctuations

There are no known extreme fluctuations in EOO, AOO, number of subpopulations, locations or mature individuals. Subpopulations may fluctuate by close to an order of magnitude following fire (Table 1). However, as fires stimulate mass recruitment from large persistent seed banks when there were few mature individuals before the event, the fluctuation does not fall within the definition of 'extreme fluctuations' (IUCN 2019). Therefore, Stirling Range beard heath does not meet the threshold for listing as Endangered under sub-criterion (c).

Conclusion

The data presented above appear to demonstrate that Stirling Range beard heath is eligible for listing as Critically Endangered under this criterion.

However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Criterion 3 Population size and decline

	Critically Endangered Very low	Endangered Low	Vulnerable Limited
Estimated number of mature individuals	< 250	< 2,500	< 10,000
AND either (C1) or (C2) is true			
C1. An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future)	Very high rate 25% in 3 years or 1 generation (whichever is longer)	High rate 20% in 5 years or 2 generation (whichever is longer)	Substantial rate 10% in 10 years or 3 generations (whichever is longer)
C2. An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions:			
(i) Number of mature individuals in each subpopulation	≤ 50	≤ 250	≤ 1,000
(ii) % of mature individuals in one subpopulation =	90 - 100%	95 - 100%	100%
(b) Extreme fluctuations in the number of mature individuals			

Criterion 3 evidence

Eligible under Criterion 3 C1 as Endangered

The population of Stirling Range beard heath is estimated at 649 (398–719) mature individuals, when the current cohort of juveniles reaches maturity (Table 5). Therefore the population appears to be low.

The generation length of Stirling Range beard heath could be 13–23 years, giving a two generation period of 26–46 years. The population is projected to decline by an estimated 33 percent from 2011–2027 (see evidence presented for Criterion 1). Using a rate of exponential decay of -0.02503 (see Criterion 1), the number of individuals present at the end of a minimum two generation period from 2011–2037, can be estimated with the equation: $972 * e^{-0.02503*26} = 507$ plants, where 972 is the number of mature individuals present in 2011 and 26 is the minimum two generation period in years. This equates to a minimum projected decline over this period of 48 percent (100-[507/972*100] = 48 percent). The number of individuals present at the end of a maximum two generation period from 2011–2057, can be estimated with the equation: $972 * e^{-0.02503*46} = 307$ plants, where 972 is the number of mature individuals present at the end of a maximum two generation period from 2011–2057, can be estimated with the equation: $972 * e^{-0.02503*46} = 307$ plants, where 972 is the number of mature individuals present in 2011 and 26 is the minimum two generation period from 2011–2057, can be estimated with the equation: $972 * e^{-0.02503*46} = 307$ plants, where 972 is the number of mature individuals present in 2011 and 26 is the minimum two generation period in years. This equates to a maximum projected decline over this period of 68 percent (100-[307/972*100] = 68 percent). Both estimates exceed the 20 percent population decline required for listing in the Endangered

category. Therefore, Stirling Range beard heath meets the requirements of subcriterion C1 for listing as Endangered.

The Isongerup subpopulation (subpopulation 1) is currently the largest with 75 mature and 900 immature plants in 2021 (Table 1). Monitoring at Isongerup shows that there were 300 mature plants and 500 juveniles in 2011, and six years later in 2017 there were 550 mature plants and 70 juveniles. Assuming no mortality of mature plants and no new germination of seed during this period, this indicates that of the 500 juveniles in 2011, 50% (250) had matured, 36% (180) had died, and 14% (70) remained in a juvenile state. If these trends continue, then based on the 2021 monitoring data, by the time the current cohort of immature plants matures in 2027 (i.e. in six years' time), there will be 525 mature individuals (75+[900*0.5]=525) and 126 immature individuals. Therefore, the size of the Isongerup subpopulation is >250 individuals, but <1000 individuals, meeting the threshold for Vulnerable under subcriterion C2.

Therefore, Stirling Range beard heath appears to meet the requirements for listing as Endangered under this criterion.

However, the purpose of this consultation document is to elicit additional information to better understand the subspecies' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Criterion 4 Number of mature individuals

	Critically Endangered Extremely low	Endangered Very Low	Vulnerable Low
D. Number of mature individuals	< 50	< 250	< 1,000
D2. ¹ Only applies to the Vulnerable category Restricted area of occupancy or number of locations with a plausible future threat that could drive the species to critically endangered or Extinct in a very short time			D2. Typically: area of occupancy < 20 km ² or number of locations ≤ 5

¹ The IUCN Red List Criterion D allows for species to be listed as Vulnerable under Criterion D2. The corresponding Criterion 4 in the EPBC Regulations does not currently include the provision for listing a species under D2. As such, a species cannot currently be listed under the EPBC Act under Criterion D2 only. However, assessments may include information relevant to D2. This information will not be considered by the Committee in making its recommendation of the species' eligibility for listing under the EPBC Act, but may assist other jurisdictions to adopt the assessment outcome under the <u>common</u> <u>assessment method</u>.

Criterion 4 evidence

Eligible under Criterion 4 D as Vulnerable

As per the evidence presented above for Criterion 3, the number of mature individuals is estimated at 649 (398–719) mature individuals (Table 5). Therefore, the species appears to meet the requirements for listing as Vulnerable under this criterion.

However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Criterion 5 Quantitative analysis

	Critically Endangered Immediate future	Endangered Near future	Vulnerable Medium-term future
Indicating the probability of extinction in the wild to be:	≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)	≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)	≥ 10% in 100 years

Criterion 5 evidence

Insufficient data to determine eligibility

Population viability analysis has not been undertaken. Therefore, there is insufficient information to determine the eligibility of the species for listing in any category under this criterion.

However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Adequacy of survey

The survey effort has been considered adequate and there is sufficient scientific evidence to support the assessment.

Listing and Recovery Plan Recommendations

A decision about whether there should be a recovery plan for this species has not yet been determined. The purpose of this consultation document is to elicit additional information to help inform this decision.

THREATENED SPECIES SCIENTIFIC COMMITTEE

Established under the Environment Protection and Biodiversity Conservation Act 1999

The Threatened Species Scientific Committee finalised this assessment on DD Month Year.

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